Norwegian University of Life Sciences

THE SIGNIFICANCE OF POSTHARVEST MAIZE HANDLING TO FOOD SUFFICIENCY IN SUBSISTENCE FARM HOUSEHOLDS IN AFRAMSO; EJURA-SEKYEREDUMANSI DISTRICT, GHANA.

A THESIS SUBMITTED FOR THE AWARD

OF

MASTERS DEGREE IN AGROECOLOGY

SUBMITTED

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Dedication

This work is dedicated to the Almighty God whose support makes all things possible for me in life and to my parents, Alex Owusu-Sarpong and Agnes Opoku Frimpong for their support during my entire education. To my brothers, Frank Owusu-Sarpong and Charles Sekyere I do say thanks for your encouragement in difficult times.

I dedicate this to my beloved wife, Amma Obiyaa Adu-Gyamfi for been there for me in every moment to show her tender care and love, I will always appreciate all you do for me in life. A special feeling of gratitude to Nicholas & Daniela Adu-Gyamfi, Yvonne Boatenmaa for being a tower of strength to me throughout my time in Stuttgart and here in Oslo.

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Abstract

The study concentrated on the role postharvest maize handling in subsistence farm household's food sufficiency in Aframso, Ejura-Sekyeredumansi District, located in the middle belt Ghana. Maize remains an integral crop for subsistence farm households and plays a vital role in safe guarding food security in the country as a whole. It is the most widely consumed staple food in the district and Ghana in general, it happens to be the most important cereal grain in the country. Subsistence farmers in this district are involved in substantial quantity of maize production in each farming season therefore it was prudent to undertake this case study to explore the food sufficiency status of the farmers themselves at the grassroots who are involved with the maize productivity. A total of sixteen subsistence farmers were interviewed with the aid of an interview guide I prepared earlier in order to help obtain information regarding the farming and postharvest activities associated with maize production. In addition, the interview guide was designed to extract information from other stake holders such as extension service officers and the director of the ministry of agriculture of the district. Personnel from institutions such as the Ghana statistical service and council for scientific and industrial research were also contacted for information. The farmers involved with the study used a normal traditional method of maize storage, which is the act of storing the harvested maize with the husk on in a locally constructed cribs as well as using an improved traditional method of storage in which farmers manually dehusk maize cobs, shell them, bag and pack them on pallets in well ventilated store rooms in their houses. Various farmers incurred maize losses with the different types of storage method used but it came to bear that most farmers involved with the use of the normal traditional storage method experienced food insufficiencies at different part of the year in both 2011 and 2012, since they incurred higher quantity of maize loss than farmer who used the improved traditional method. Though the normal traditional storage method fail to give good protection to the stored maize, farmers are unable to switch to the improved traditional method because of its easiness to use, the low cost involved as well as the norms and heritage of the rural subsistence farmers attached to this method (normal traditional method).

Abbreviations

CSIR	Council for Scientific and Industrial Research
CIMMYT	International Maize and Wheat Improvement Center
ESDA	Ejura- Sekyeredumasi District Assembly
FAO	Food and Agriculture Organization
GGDB	Ghana Grains and Legumes Development Board
GNA	Ghana News Agency
GSS	Ghana Statistical Service
IITA	International Institute of Tropical Agriculture
MoFA	Ministry of Food and Agriculture
NGOs	Non-Governmental Organizations
NRADU	Northern Region Agricultural Development Unit
PHA	Postharvest Activities
SWOT	Strengths, Weakness, Opportunities, Threats
USAID	U.S. Agency for International Development
S2	Improved Traditional Storage Method4
S3	Normal Traditional Storage Method

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1.0 Introduction

The main aim of every subsistence farmer who engages in farming activities in each farming season is to be food sufficient throughout the whole year. In several countries, including Ghana, this goal is sometimes not achieved because of crop failure or high postharvest loss. It is very important for such countries to implement or introduce policies and technologies geared towards achieving food sufficiency, (World Bank, 2000). Food security is fully achieved when the whole population at all times have physical and economic access to sufficient, safe and nutritious food that meet their dietary needs and food preference for active and healthy life (Mechlem, 2004). Ghana has the potential to be self-reliant in terms of food and therefore, needs to work toward that by advocating subsistence farm households to adopt good farming methods and engaging in efficient postharvest practices. The country's population currently stays at 24million according to the last census (GSS 2012), and to ensure the country does not suffer any decline in its present level of food sufficiency, the ministry of agriculture has initiated policies at national, regional and community levels which aim at increasing the production of cereal, starchy staples and animals to ensure adequate nutrition and food security (MOFA, 2011). The livelihoods of most farms household are sometimes threatened as results of modern day climatic change with frequent drought, floods and rampant cases of fire out breaks. In fact huge production loss has been the main causal component of farmers with limited and constrained resources in rural farm households in Sub-Sahara Africa (Hodson, 2002). A classic example is a maize farm that is not far away from rivers, it tends to be flooded when rivers overflow its banks due to torrential rainfall and these floods go a long way to affect productivity, resulting to high risk of food insecurity. Also, the number of people at risk of becoming food insecure may increase at the onset of natural or man-made disaster such as bush fire, floods and earthquake. In such times, the 3 northern regions namely Upper West, Upper East and Northern regions are most vulnerable to food insecurity. Furthermore, subsistence household farmers do not get real value for their produce due to the losses that occur during postharvest handling resulting from physical factors (temperature, humidity and water) or biological factors (molds, fungi, insects and rodents) as well as technical factors such as method of storage, state and duration of storage. Postharvest

loss could be a big threat to the food sufficiency of the country as a whole; the high quantity of maize loss incurred by some subsistence farmer is worth addressing. About 48% of Ghana's population is engaged in Agriculture production (MOFA 2008) and the country produces enough for it to be food sufficient in a way to safe guard food security but Ghana loses about 20 -40 % of her fruit, vegetable, root and tubers as well as 20-30 % of cereals and legumes annually as a result of inadequate and ineffective postharvest handling (GNA, Sherry Ayitey June 2012). Other starchy staples that is supposed to supplement maize to boost the food security of the country is not worth relying upon as cassava records 45.7% loss of its harvested produce due to inefficient postharvest handling and storage techniques, the highest losses among food crops in the country. With this figure of general losses for the country as a whole, it is vital to find solutions to reduce losses as well as weighing the importance of the loss reduction to the food security of the farmers themselves. Maize has been cultivated in Ghana for several hundred years. After being cultivated in Ghana for the first time in the late 16^{th}century; it soon established itself as an important food crop in the southern part of the country. Previously, maize also attracted the attention of some commercial farmers, although it never achieved the economic importance like other traditional plantation crops such as oil palm and cocoa; it has always been grown on subsistence basis and for local markets. Maize is the number one crop in terms of area planted. It accounts for about 50-60% of cereal produced, represents the second largest commodity crop in the country apart from cocoa (GGDP, 2010), and is the most widely consumed staple food in Ghana. A nationwide survey carried out in 1990 revealed that about 94% of all households had consumed maize during an arbitrarily selected two-week period (Aldernan and Higgins, 1992). Maize is used for three main purposes: as a staple for households, feed for livestock and a raw material for many industrial products. Maize is consumed in many forms in different parts of the world, from maize grits, polenta and corn bread to popcorn and products such as maize flakes (Rooney and Serna-Saldivar, 1987). In Ghana, it is frequently used to prepare porridges and more solid maize meal dishes made from fermented or unfermented dough. Maize is also the main energy component in poultry and pig feeds in the country. The production of maize has been stable under traditional methods, which solely depend on rainfall. Average maize yield in most communities in Ghana is 1.5 $Mghg^{-1}$ under rainfed conditions; meanwhile the consumption or demand of maize has been forecast to grow at a rate of 2.6 per cent in the coming years (GGDP, 2010). Farmers must be encouraged and motivated to improve

the productivity per hectare ratio as the average 1.5Mgha^{-1} range at the moment could not be sufficient enough for farm household to leave surplus in case there is a crop failure in other parts of the district or country as a whole. Production of maize in West and Central Africa, including Ghana, keeps improving over time and has witnessed a phenomenal increase in the last two decades. This is due the introduction of high-yielding drought resistant and early maturing variety coupled with several collaborative researches (IITA, 1997). Yield as high as 5.0-5.5Mgha^{-1} has been achieved by farmers using improved seeds, fertilizer, mechanization and irrigation. Due to yield increase and expansion, Ghana has managed to experience 5% expansion growth rate of the agriculture sector (MOFA, 2011). However, postharvest handling has been a major challenge. Even though maize has excellent storage qualities, there are many factors contributing to its deterioration which force farmers to sell part of their maize produce for badly needed money at the harvest time (MOFA, 2006). The quantity of maize consumed in a particular year by subsistence farm households in Ghana can be severely affected if there is high postharvest loss. Postharvest loss is complex and difficult to be dealt with completely since it differs with crop, storage condition and structures used for storage. Globally, as much as one third of the food produced for human consumption is being lost or wasted. In developed countries, much of the food waste occurs at the retail, food distribution services and at household levels, where most families purchase more than they can consume in a week. In the developing countries most of the losses occur due to inefficient postharvest handling and storage facilities, which cause food to spoil or deteriorate before it reaches the market or final consumer (FAO, 2011). Due to this losses that occur in developing countries, there is the need and potential to improved food security by reducing postharvest losses. It is very important to seek solutions not involving excessive use of pesticides and insecticides, as they may have impact on the health of users, consumers and environment.

The objectives of the current research are to obtain an overview of factors influencing food availability in the households of subsistence farmers; investigate the relationship of postharvest loss of maize and food sufficiency and to explore possibilities for improvement. This was done by a case study of Aframso, Ejura-Sekyeredumasi District, Ghana. The case was chosen because district is notable for its subsistence farmers' involvement with high quantity of production of maize. Even though projection have been made about the food security status of Ghana as a

whole, it was important to undertake this case study to find out the food sufficiency status of the farmers themselves at the grassroots.

1.1 Research Questions

The following research questions were asked:

- How does the postharvest loss of maize influence the food sufficiency of farm households throughout the whole year?
- How does method of postharvest handling influence storage loss?
- What supports and hinders the farmers' adoption of more effective storage methods?
- Are there trade-offs of implementing more effective storage methods?

2.0 Study Area and Methods

2.1 Study Area

The area chosen for the study was Aframso a farming community in the Ejura-Sekyeredumase district; the district is one of the areas of highest maize producing within the Ashanti Region. It is located within longitudes 1˚5W and 1˚39' W and latitudes 7˚9' N and 7˚36'N. It has a large land size of about 1,782 km^2 and is the fifth largest district in the Ashanti region. It constitutes about 7.3% of the region's total land area with about one third of its land area lying in the Afram Plains. The district has its capital as Ejura which is located approximately 98Km Northwest of Kumasi, the capital of Ashanti Region (ESDA, 2008). The district lies within the transitional zone of the semi-deciduous forest and Guinea Savannah zones. Thus, it experiences both the forest and savannah climatic conditions. The natural vegetation and climate of Ejura-Sekyeredumase Districts which exhibits rainy and dry spells during the year has suited production of maize for many years. However, it cannot be firmly pointed out that, the production of maize has lifted the status of the socio-economic development of the farmers in this area. The improvement of maize production and it postharvest handling in the Aframso (Ejura-Sekyeredumase District) is essential since most farmers solely depend on maize as main potential source of income and preparation of all their dishes. It must therefore be pointed out that despite the effort put into any maize farming project, its achievement will depend on the level of enthusiasm shown by the farmers. Most subsistence farmers put in much effort in their quest to achieve food sufficiency throughout the whole year. The farmer's interest can only be sustained if they can increase the level of productivity as well as reducing the magnitude of maize loss throughout the whole year. Below is figure 1, the map of Ghana locating Ejura-Sekyeredumansi district.

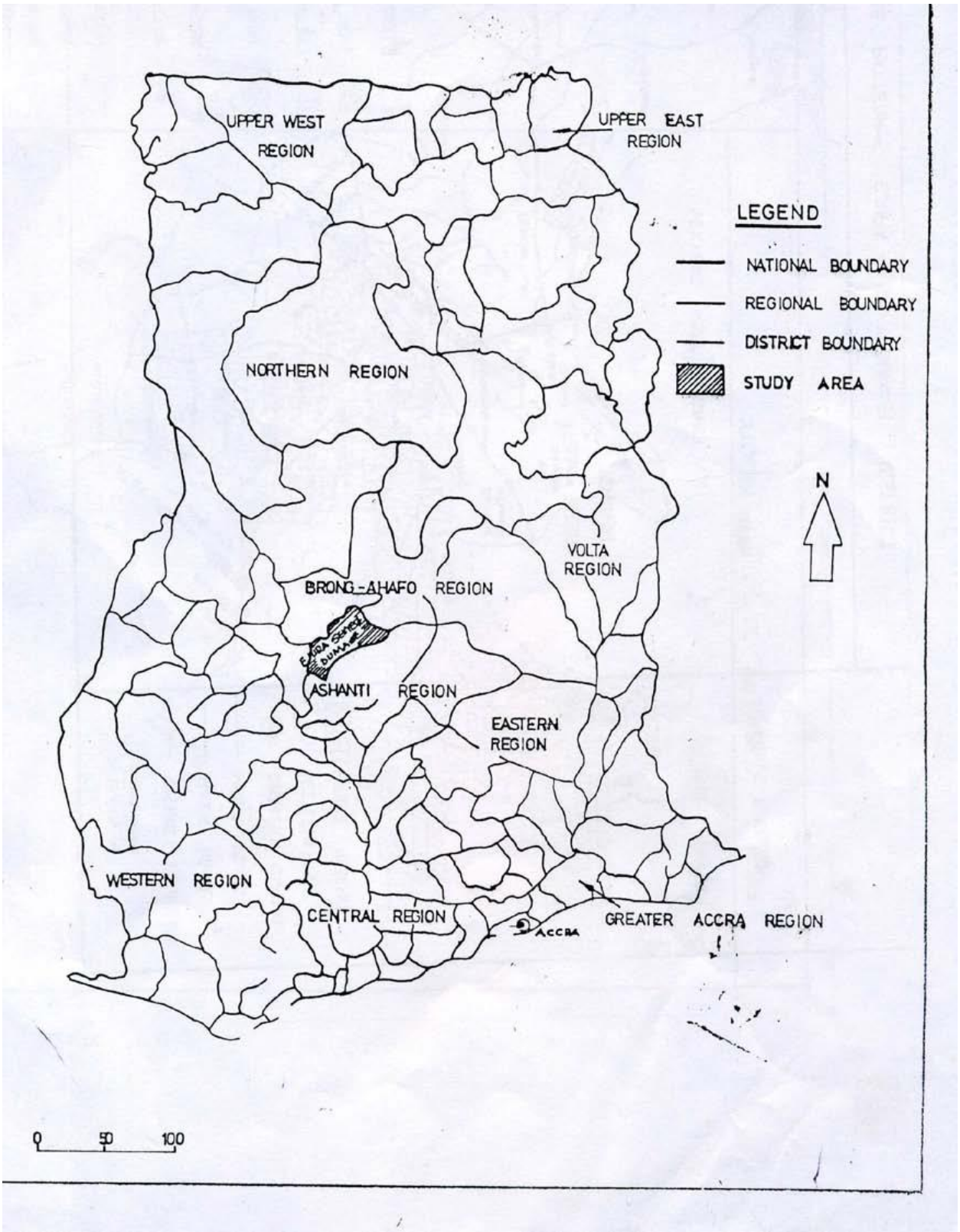

Figure 1: The map of Ghana locating Ejura-Sekyeredumansi District

Temperatures within the district are generally high with a monthly mean of about 21^{o}C to 30^{o}C.The district experiences a mono-modal rainfall pattern, beginning in April and ending in October, with annual rainfall ranging between 900 and 1200 mm, January to April is the warmest months while July to August is coolest months (ESDA, 2008). Below is figure 1, a table indicating the climatic conditions at Ejura-Sekyeredumasi District.

Table1: Annual climatic data for Ejura-Sekyeredumasi District

Climatic factor	Minimum	Maximum	Average
Rainfall (mm)	**900**	**1200**	**1000**
Temperature (*C)	**21**	**30**	**25**

Source: Meteorological Service Department, Ghana 2008.

In assessing manpower availability and requirement in the district, population of Ejura-Sekyeredumase for the years 1984, 1997 and 1998 has been 50,977, 60,705 and 63,516 respectively. The district estimated population in 1999 was 66,414 with a growth of 3.1percent, which is slightly above national average of 3.0 percent. (Ghana Statistical Service, Population and housing census of Ghana, 2000). The topography of the district is gently undulating without hills which are good for mechanized farming. Farming is the major occupation of the people of Aframso in the Ejura- Sekyeredumase District and the main crop grown is maize which is inter cropped or mixed with yam, vegetables, cowpea . Already, there are several large-scale agricultural ventures operating in the district. These are Ejura Farms Limited and Ghana Food Distribution Corporation. The most outstanding investment potential on offer in the district revolves around agriculture and agro-processing. In the area of crop farming, the Ejura-Sekyeredumase District stands out as one of the most fertile areas in the Ashanti Region. Particularly it is good and lucrative for investors in the agricultural sector who are in crop farming in maize, cashew and cowpea. Livestock and poultry farming are also highly

recommended because the topography of the district favors this activity as there is ready access to the needed raw materials such as animal feed.

2.2 Methods

Information for the case study was gathered from subsistence household farmers, extension service workers, the ministry of food and agriculture of Ejura Sekyeredumansi district and institutions such as Ghana statistical service and council for scientific and industrial research. Farm household that were sampled for the study is part of the Aframso farming community which is made up of about 26 farm households; the deputy director of operations of the district extension services helped in the selection of farmers since he had dealt with most farmer for many years. On my first day of meeting the farmers, I familiarized myself with them and shared the thoughts about postharvest loss and the rationale behind my study. Scheduled appointment for each individual farmer was followed as I took that opportunity to ask relevant questions associated with the farming system, postharvest practices employed as well as the food security status of various farm households.

The study employed interview with the aid of interview guide I prepared earlier (an illustration of the interview guide I used for the interview can be found in the appendix 6.1) as well as direct observation of farm field, produce and storage structures available to subsistence household farmers. The interview guide was structured in a way to extract information about issues such as sources of finance for agricultural activities and postharvest handling, subsides on agro-chemical, the quantity of maize loss and quantity harvested, household size, types of maize produced or stored, storage structure etc. In all, 16 subsistence household farmers and 3 Ministry of Agriculture officers were interviewed. Out of the 16 farmers interviewed, 11 farmers used the normal traditional method of storage (S3) in 2011 while 9 farmers used the normal traditional storage method(S3) in 2012, also 5 farmers used an improved traditional method of storage(S2) in 2011 and 7 farmers used an improved traditional method of storage(S2) in 2012. The interview was done in accordance with the role played by the subsistence farmer being the main agent to effect change in the postharvest practices in maize production, while the other stakeholders act as the catalyst for improvement. The interview did not follow any formal pattern

and exhibited slight flexibility that created a conversational background which gave the client the willingness to open up to me. It offered me the opportunity to ask extra relevant questions on unknown issues that cropped up during the session. Upon gathering all the needed information, I translated them into a rich picture in order to reduce the level of abstractness of the work to make it more visual, the rich picture is a diagrammatic means of identifying deferring world views with the aim to share understanding of a situation (Tessa Berg 26th June 2006). SWOT analysis was made to gain an overview of the situation and identify key issues in the perspective of improving it.

Tables showing the quantity of maize harvest, quantity of maize loss as well Percentage of harvested maize loss by each individual farmer were drawn. Mean loss incurred by the farmer and standard deviation for the 2 methods of storage were determined. A one-way analysis of variance on the difference between the mean losses of the two storage methods used by subsistence farmers was also determined while a bar graph was also used to illustrate the quantity of maize harvested and the quantity of maize loss. All the tables for analysis of variance standard deviation and the mean as well the bar graph can be found in the appendix 6.2 and 6.4 Some of the photographs I took was also used in the discussion to illustrate the state and conditions under which harvested maize are stored in the study area.

3.0 Results and Discussion

3.1 The Rich Picture

The direct interaction with farmers, observation of their farm activities, the assessment of their storage methods and other postharvest activities coupled with interviewing all stakeholders involved helped me to understand their plights and point of view there by allowing me to translate their statements together with what I observed visually in a rich picture. The rich picture serves as a medium for learning about ill-defined problems by drawing detailed ('rich') representation of them. (D. E. Avison, 1992). The farming activities involved with maize production and its postharvest handling which result in substantial quantity of maize loss has been a complex problematic situation for farm households. The rich represents how I related various perceptions and experience about the farming activities and postharvest handling of maize through a thorough observation and assessment of the current situation. This was capped with direct interaction and interview with all the stakeholders involved with the research. In fact, the rich picture creates a clear understanding of a complex problem situation facing farm households by picking on every information associated with maize production up to the end of storage period and then goes further touching on the food sufficiency status of farm households. This created harmonious situation which enabled me and all the stakeholders involved with the case study to delve more into the current problems associated with maize production and its postharvest handling as a whole. The interaction with the stakeholders helped me to get familiar with the issues at stake and understood the present situation.

In short the rich picture that was been created after piecing every little information gathered, tells a thousand of words. Figure 3 below illustrates the rich picture about the farming activities and the postharvest handling of maize by farm households in Aframso, Ejura-sekyeredumasi district.

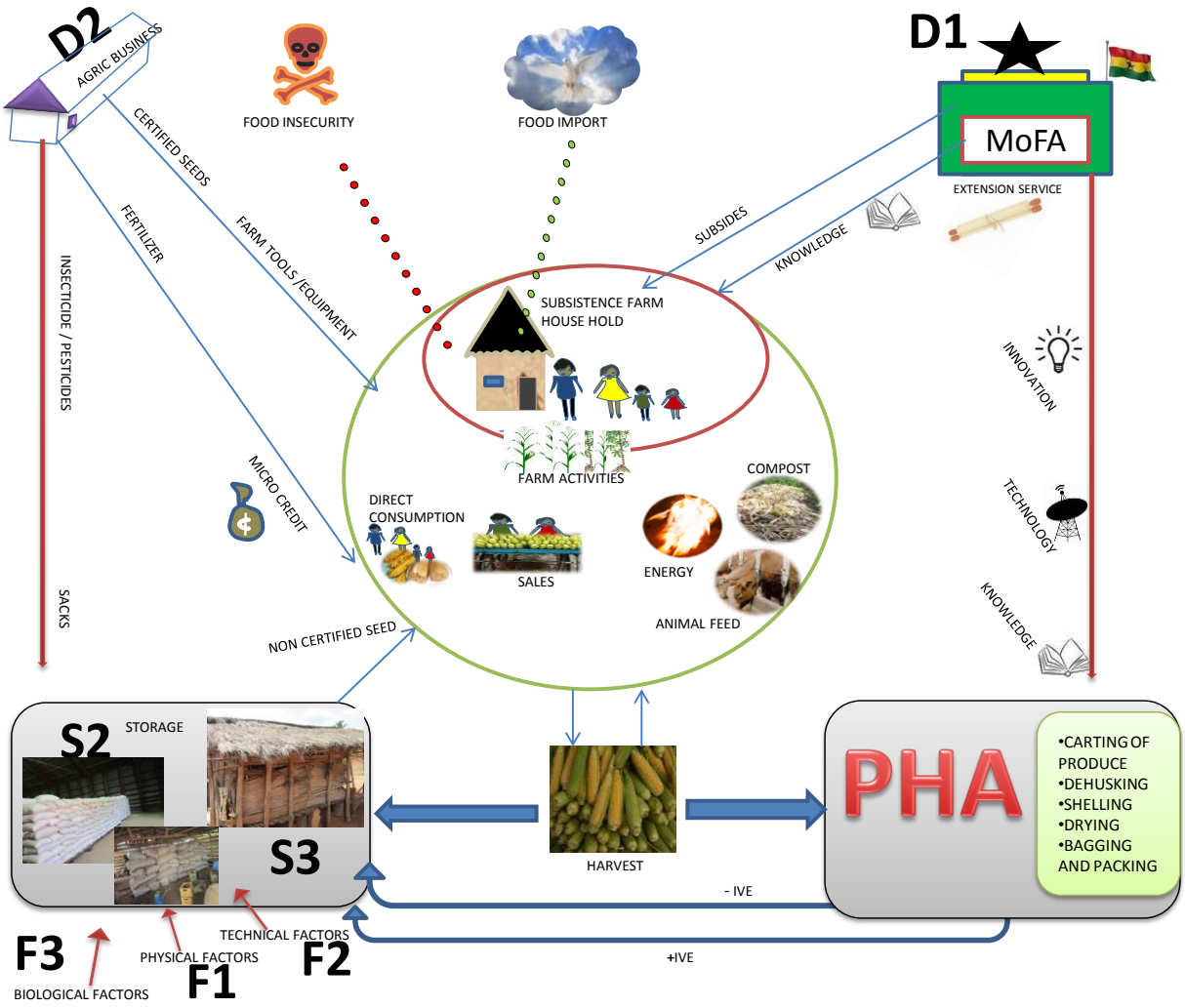

Figure 2: The rich picture of the farming activities and postharvest handling of maize in Aframso, Ejura-Sekyeredumasi district.

Source: own source.

3.2 Rich Picture Description

From the rich picture the two main driving forces that give life line and influence maize production as well as efficient postharvest handling in subsistence farm household are the Ministry of food and Agriculture (MoFA) and Agric- Business (labeled D1 and D2 respectively). The Ministry of Agriculture provides funding for research and the results are disseminated to farmers in a form of innovation and improved knowledge by the extension service department of the ministry as indicated by arrows from MoFA. Subsides on agricultural inputs help promotes the development of agriculture in poor rural economies of Sub-Sahara Africa (Kwarteng , 1994). The ministry provides subsides on farm inputs that are used by subsistence farm households every season. Apart from advocating for improved technology on farms, the Ministry of Agriculture also import maize and other cereals such as rice and wheat to cater for the food deficit each year in order to reduce the high risk of food insecurity on subsistence farm households. The Agric. Business sector act as the wheel that grind the farm activities and postharvest activities (PHA) by providing micro credit to farmers through Micro Finance Schemes as well as the sales of inputs such as certified seeds, farm tools and equipment, pesticides, insecticides, weedicides, fertilizer and storage sacks. The middle part of the rich picture features farm households engaging in farm activities (in which they practice either mono cropping, that is only maize production or mixed cropping, that is the growing of maize with either cassava or cowpea). After harvesting the produce on farms, some farmers transport their produce from the farm to storage place manually and employ other postharvest techniques such as dehusking, shelling, drying bagging and packing, whiles other farmers store the harvested cobs directly in barns (cribs). Farm households then directly consume part of their produce throughout the year, sell some for monetary purposes as well as using part as animal feed (normally the deteriorated maize is used to feed for domestic poultry and livestock). By-products such as corn cobs and maize husk are use as compost and however they are sometimes combined with fire wood as a source of energy for cooking purposes in farm households. The effectiveness of the postharvest activities employed by farm households affect the stored maize either negatively or positively which is indicated by the Positive and Negative Blue arrows joining from PHA to storage.

The storage techniques used by a farmer determines the susceptibility of the stored maize to insects, rodents, and other agents such as bad weather conditions that may cause the maize to deteriorate. Most subsistence farm households engage in the use of a normal traditional method of storing maize by directly keeping harvested maize with its husk in locally constructed cribs which is labeled S3 in the picture while others use an improve traditional method labeled S2 for maize storage. Farmers believe in this normal traditional method since it is perceived that, rodents and other insects find it difficult to get access to maize seeds because of the husk covering the cobs as they are stored on the locally constructed cribs and thereby reducing the infestation of insects such as large grain borer (Prostephanus truncatus). Locally constructed barns and cribs are the most popular traditional structures widely used in various parts of Tropical Africa for the storage of maize (Kordylas, 1990). The structure labeled S3 in the rich picture is a typical example of cribs that are used in storing maize by subsistence farm households in Ejura-Sekyeredumasi district. Normally it is been constructed by farmers themselves using locally acquired materials and if not well built and secured, any rodent that enters the crib tends to destroy substantial quantity of the maize since they may stay in the crib during the whole period of storage and this result in a massive loss of produce in terms of quality and quantity in many farm households leading to a reduction of household income and a threat of their food security throughout the whole year. Maize produce at storage level are affected by various factors such as biological factors (F1), physical factors (F2) and technical factors (F3). The impact of F1, F2, F3 on the postharvest handling of maize is discussed extensively in the discussion.

On the other hand, subsistence farmers manually dehusk maize cobs, shell them, bag and pack them on pallets in well ventilated store rooms in their houses (labeled S2). Farmer choosing this type of storage incurs other cost by buying the sacks and treating the maize with chemicals to maintain quality of the grains. Shelled maize may be treated with different type of recommended chemicals at the appropriate rate of application (GGDB 1996) eg. Permthrin 0.5% dust is applied to maize, Fenvalerate 1.0 dust is applied to maize.

3.3 Food Sufficiency in Farm Households

The inability of farmers to produce high quantity of maize due to basic constraints which prevent them to expand their farm size coupled with high postharvest loss normally push most farmer on the brink of food insufficiency. Due to farmers' low purchasing power for farming inputs such as fertilizer and certified hybrid seeds as well as efficient postharvest materials, farmer loose substantial amount of their already low quantity harvested maize during the period of storage which makes some farm households experience food insufficiency at certain part of the year. The quantity of maize loss by farm households become higher as the maize is exposed to the various physical, biological and technical factors while in storage. About eleven farmers (DS, JA, FY,*DM*, AM, *AG*, DD, AS, AA, AB and DA) lost as higher as a quarter of their produce in 2011 leaving them a small quantity of maize at times, yet, they still have to sell part of the quantity left in November for monetary purpose while six farmers (DS, JA, FY, AM, DD and AS) lost a quarter of their produce in 2012 farming season. Farm households have substantial quantity of maize at their disposal in August when all the maize has been harvested. The harvested cobs are been stored based on the type of storage method adapted by a particular farmer and in the month of November some farmers have to dispose part of their produce to traders at the district market in order to get enough money to be spend on basic household needs for Christmas and other equipment to be used on the farm. One farmer with initial BB stated that "the fear of loss as results of pest and insect attack; I am forced to sell about half of my produce at the district market in November when the maize is fully dry". Another farmer with initial DM also stated that "ideally he would love to store his maize throughout the whole year so that his family will have enough maize to consume all year, but due to the occurrence of high loss, the family are left with very little or nothing between the month of June-July and are force to rely on other starchy food crops such as cassava. After disposing part of the produce in November, the part of the maize harvest left to be consumed throughout the whole year is then expose physical factors such as humidity and water resulting in mold formation which causes the maize to lose it viability and nutritional qualities, the trickling down effect of the high quantity of maize loss on

farm household becomes bear in the month of July when some household experience food deficit. Experience from all the farmers interviewed pointed out that "the longer the time, the maize spend in storage structures, the higher the quantity of maize deteriorated". In 2011 the total output of the 16 farmers was 358.5bags while they lost 97bags representing 27% of the total maize harvested and in 2012, the total maize harvested was 411bags while the farmers lost 84bags representing 20% of the total output. In all 6 farmers (with initials AA, AB, DD, DM, DS and JA.) reported of food insufficiency at different parts of the year in 2011 farming season while 4 farmers (with initials FY, DS, DD and DD) reported food insufficiency in 2012 farming season. Farmer AB pointed out that in 2011 farming season, 'as early as January I had no maize left for household consumption so I struggled to feed my family therefore I had to live my family and travel to work as a casual laborer at a timber sawmill in the district capital in order to earn extra money to fend for my whole family'. Furthermore farmer FY in 2012 farming season had total output of 22bags of maize, used storage method S3 and recorded as high as 7bags of loss which represent 31.82% of his total harvest. In fact this farmer indicated that "when I experience higher loss of such nature, my maize stock dry up by April and usually borrow 2 bags of maize from a neighbor in order for my household to be guaranteed maize meal (food) between May and July'. Then I will replace the 2 bags I borrowed right after harvest in August. Furthermore the family has to change our eating habit and switch to the eating of other starchy tubers such as cassava and yam instead of their preferred maize meals. This indicates that the magnitude of maize loss in a particular storage period have an ideal impact on the food sufficiency and nutritional status of some farm household. It is therefore paramount for farmers to try and control the entire factors that contribute to deterioration of harvested maize during the period of storage. In fact 14 out of the 16 farmers who kept domestic animals that I interviewed attested that, they fed their deteriorated maize to their farm animals which in other sense might not be classified as 'maize loss' during the period of storage; but they pointed out that, the maize produced is meant for household consumption and partial sales for monetary purpose only and under no circumstance they would feed their domestic animals with maize if not deteriorated because there is abundance of foliage and roughages for animals to graze on; therefore deteriorated maize during the period of storage is a big loss for farm household.

3.4 Magnitude of Maize Deterioration with Traditional and Improved Storage Levels:

The quantity of maize loss incurred by a particular farmer is influenced by the type storage method use in a particular farming season. The tables indicating the quantity and percentage of harvest loss can be found in appendix 6.2, the table illustrates a substantial quantity of postharvest maize loss in some subsistence farm households (especially farmers with normal traditional method of storage S3). The statistical computations (Kahn 2010) show a percentage mean loss of 32.20% of total number of harvested maize bags for the normal traditional storage method (3) while that of the improved traditional storage method (S2) is 14.60% of total number of harvested maize bags. It is evident from the percentage mean loss that, subsistence farmers who used storage method S2 (which involves dehusking, shelling, bagging, etc.) before storage incurred lower magnitude of loss during the period of storage. Furthermore the standard deviation (SD) for the normal traditional storage method (3) is 6.04 and that of the improved traditional storage method (S2) is 2.21. A table illustrating the above percentage mean loss and standard deviation can be found in the appendix 6.4. The district MoFA officer pointed out that 'S2 is more improved method of storage than the normal traditional method S3 and happen to give good protection to the stored maize'.

Meanwhile T-Test analysis for the percentage loss is t (30) = 7.86, P = 0.000. This implies that, the P-value 0.000 which is less than 0.005 shows a significant difference between S2 and S3 storage methods. This significant difference between the S2 and S3 storage methods showed when some individual farmers switched to the improved traditional method of storage and manage to achieve good results, example when farmers with initial DM* and AG* switched from S3 method of storage to S2 in 2012, their magnitude of maize loss was a different story to tell. When both farmers used storage method S3 in 2011 which is indicated in appendix 6.2, the total output of both *DM* and *AG* was 22bags and 27bags respectively whiles they lost

8.5bags and 9bags apiece in 2011 (which represents 38% and 33% of their produce respectively), but when they switched from storage method S3 to S2 the following year (2012 farming season), farmer *DM* had total output of 28bags and lost just 3.5bags while farmer *AG* had 33bags and lost 6bags (which is 12% and 18% apiece). There was a decrease in the magnitude of loss of maize during the period of storage and this was as result of other factors as well as the switch from the normal traditional storage method S3 to an improved method of storage S2. This indicates that, these farmers could save many bags of maize from been lost if they manage to implement an improved method of storage S2, while these saved bags could also go a long way of boosting the food security and nutritional status of their households and relief them off the pressure of been food insecure between the months of May to July. To sum it all, the breakdown in the difference of the total maize harvested loss in 2011 faming season for storage method S2 and S3 was 7%. This loss is quite substantial and can be among the other reasons for the causes of food deficit in some farm household, if the loss is reduced to a minimum level, the saved maize bags could have help to negate the food insecurity status of some farm household in the month of June-July as other farmers revealed.

3.4 Constraints and Possibility of Improvement of Postharvest Handling of Maize

Apart from farmers eagerness to work hard to achieve food sufficiency there are various factors such as sources of finance, source of information, the type of maize produce and stored, subsides and source of lobor (household size) which serves as a constraint as well as a possible ingredient for improvement in the production and postharvest handling of maize.

3.4.1 Household Size

The male farmer, his wife, children and in some real cases nephews or nieces constitutes a farm household. The farm household provides most, if not all the labor requirement of the farming activities involved in the production and postharvest handling of maize. The size of the farm household and their hard working capabilities determine the size of their farm as well as the quantity of maize produced in a farming season. A farmer with the initial DS said that, "I and my family always work over time during the land preparation and harvesting period, we leave home for the farm as early as 6am and work till 6pm in the evening".

Only one farmer stated that "he hired two people for few hours during the day (7am-12noon) during harvesting period since he always wanted to harvest early to prevent matured dry maize from lodging". Apart from this farmer, Majority of the farmers depended on their household for every farming operation due to reliability coupled with financial constraints because they don't have much to pay for labor cost and also the difficulty in mobilizing of labor. This was the major factors that prevent farmers from expanding the size of their farm and could go a long way of affecting the food sufficiency of farm house hold throughout the whole year. The food deficit in certain farm household could be reduced to a minimum if farmers manage to expand their farms and increase the quantity of maize produced as well as reducing losses during the period of storage. But due to inadequate labor supplied by farm household, farmers are confined to smaller piece of farm land each farming season and there by produces less, this is even further decreased through postharvest loss during the period of storage resulting in the decrease of maize available for consumption throughout the whole year.

3.4.2 Types of Maize Produced and Stored

There are two types of maize produce and stored by farm households, these are the local or traditional varieties and the hybrid or improved varieties. The hybrid variety is high yielding quality and its seeds are normally sold by the agri-business. The use of the hybrid varieties must be concurrent with adequate use of fertilizer before their high yielding potential could be achieved since they are fertilizer dependent. The hybrid maize are normally susceptible to insect

damage because the grains are soft, furthermore, its cobs develop less husk thereby the cobs are only partially covered. Due to the high cost involve with planting material (seeds) and over

dependence on NPK fertilizers in achieving good results in terms of production, most farmers interviewed said “they were not in a position to plant the improved variety”. Production of maize in West and Central Africa has witnessed a phenomenal increased in the last two decades. This is as a result of the introduction of high-yielding drought resistant and early maturing variety coupled with several collaborative researches (IITA, 1997), the local or traditional varieties are hardy, drought and disease resistant. Even though it is low yielding, it has the ability to store for a long period under favorable conditions. The respondents attested to the growing of the local variety due to its palatability as well as the easiness in marketing them. Most farmers normally get planting materials for the local variety by retaining part of the seeds from the previous season to be used in the next one, as indicated in the rich picture, these are the Non-Certified seed used by farm households for planting. The selected maize cobs to be used as a planting material are normally stored separately in a metal can or pan which is covered tightly, it was observed that the sealed metal can or pan that was used to store the planting material served as a shift-made mini silo when protected the seeds very well and prevented any deterioration or insect attack. Below is a picture which illustrated stored seeds to be used for planting.

Picture 2: Local maize stored separately in Can and pan to be used as planting material.

Source: Own source. Most farmers interviewed were used to cultivating the local variety of maize, upon interaction with them, it was revealed that "the local variety provides security against huge yield losses because they very tolerant to harsh climatic and poor soil conditions.

The local variety when compared with some improved and high yielding hybrids such as the yellow maize, it was realized that, the local varieties are more preferred because it is palatable and more suitable for the preparation of traditional dishes. Because the production of maize is rain fed, the food security of farm household is highly at risk when there is failure of the rain (or persistent drought) in a particular farming season. In response to this challenge, Ghana introduced drought tolerant local maize which is quite affordable to manage to help improve the food security status of farmers (CSIR, 2010). The CSIR in partnership with international institute of tropical agriculture bred and developed these varieties. Some of the local varieties are CSIR-Omankwa (giver of life), CSIR-Aburohemaa (Queen of maize), and CSIR-Abontem (extra early

maturing maize). These names are local names given drought resistant and hardy maize to denote their characteristics. The hardy and drought resistant nature of these CSIR varieties enable farm household produce enough maize for consumption even if the rain fails in a particular farming season. Therefore, if good postharvest efforts are adhered to, farm household will have maize to consume throughout the whole year in an ill-rainy season of a particular year.

3.4.3 Sources of Finance

There is a major problem associated with the finance of agricultural activities in Ghana especially when it comes to subsistence farmers. With reference from the rich picture, it is the agri-business sector that acts as the wheel which grinds the farm activities and postharvest activities and therefore provides micro credit to farmers through Micro Finance Schemes when they feel subsistence farmers satisfy their business proposal on offer. Banks find it difficult to assess the ability of subsistence farmers to repay credits because bankers find it very difficult to ascertain the personal integrity of most subsistence farmers.

There were two main forms of credit or finance detected in the study area. They are formal/institutional and informal/ non-institutional source of credit were been outsourced by farmers. Both types of credit source play a major role in the finance of agriculture, particularly just at the beginning of every growing season. However, the informal source has been the most outsourced and reliable finance facility that has gone a long way in assisting subsistence farmers as I observed from the study. The table which illustrates the sources of finance for subsistence farmer interviewed can be found in the appendix, from the table, institutional source of credits were outsourced from banks while non-institutional credit was provided by traders (traders who buy the maize directly from farmer, transport it to the city and sell), friends and relatives. From the study, formal credit source accounted for 18.75% while the informal finance source (relatives, friends, personal finance and traders) accounted for 81.25%. The inability of these subsistence farmers to increase their production and implement an improved postharvest handling method is as result of poor access to loan or credit, this meant that subsistence farmers who wished to switch to the improved method of stored (which gives good protection to stored maize and reduce harvest loss) had no choice that to adapt the traditional method choice due to

financial constraint. Administration procedures from banks deter subsistence farmers from seeking credit since loans from banks are not granted at the time they are needed most. (Ref collaterals) Farmers are also asked by banks to provide collateral security which most farmer do not really have, thereby been refused the loans out right. On the other hand farmers who are granted the loan are always given lesser than the money they requested and do not manage to meet their budget for most farming seasons.

Due to this subsistence farmers prefer to finance their farming and storage activities through their own source of income or to obtain credit from friends/relatives and traders as interest rate for such credits are lower than that of the bank. Credits from close friends and relatives are at times given to farmers at interest free. The lack of collateral demand, nearness of the farmer to the informal credit source, the flexibility of repayment, apparently no transaction cost may be the reasons for the high usage of the informal finance source. It was found that most subsistence farmers greatly relied on their personal savings to finance their farming and storage activities due to the bureaucracies in the banks. About 56.25% of the farmers financed their farming and storage activities personally. The life line for most farmers in financing their farming at the beginning of each growing season is by personal means. Most subsistence farmer interviewed had a backyard livestock or domestic poultry which normally sold to help supplement their source of capital. The proceeds gained or obtained from the sales of the poultry or livestock are used in situations where farmers fail to acquire credit at the beginning of a particular farming season. Credits taken by subsistence farmers from informal source are granted based on agreed contract that are verbal with witness or written. This depends on the level of intimacy between the lender and the farmer. The period of payment for such credits is short with about 12.25% acquiring credits from relatives and friends. Some subsistence farmers opted to acquire credit from traders as this accounted for 12.25%. It was noted that some traders did not always give cash instantly to subsistence farmers but rather supply them with farming inputs at the beginning of the farming season. The financial constraints encountered by farmers is as a results of inadequate capital of credit facility to support farming and storage activities lead to the construction of poor storage structures as well as non-treatment of maize due to high cost involved. This leads to increase in the quantity of maize loss incurred by farm household because if farmer happens to be financially sound, they will manage to afford to construct good and efficient storage structure which will give good protection to stored maize and reduce the

quantity of maize loss in these farm households. The availability of credit as a whole is a big setback in the quest for farmers to reduce postharvest loss of maize because they are not able to implement an improved storage method. This causes farmers loose higher magnitude of their maize at storage level. For example, a farmer with initial DA testified about losing almost a quarter of maize he stored leaving him almost nothing to feed on as early as April, therefore the only choice he had was to rely on he borrowed from his brother in-law till he grew and harvested new maize. The losses incurred by farm house holds at storage level push them further down to the brink of been food insecure and this could be reduced if farmers secure better source of finance for their farming activities and implement an improved method of storage each year.

3.4.4 Sources of Information on Post-Harvest Management

Information on postharvest handling of maize plays vital role in the reduction of harvest loss but inadequate information on postharvest maize handling available to subsistence farmer household result in improper handling of the maize each farming season. The same mistakes are ben repeated by farmers which lead to substantial quantity of loss. Ideally the extension service officers are responsible for the dissemination of information on postharvest handling to farmer but it was noted that the extension officers are stretched. From the subsistence farmers' point of view, it is the cash crops farmers who receive the most of the attention of the extension officers while they do not get the chance to meet them more often. These subsistence farmer do not receive information easily from the extension officers and even the ones they receive is not readily adaptable since it attracts extra cost in addition to the usual other storage cost. The study took into consideration the source of information or extension services on postharvest handling that were available to farmers. From the study 75% of the respondents (subsistence farmers interviewed) received information on postharvest handling of maize from relatives and other farmers. It was found out that, officers from the ministry of Agriculture or extension service workers were not contributing enough in terms of the dissemination of information on postharvest handling of maize to farmers because only 25% of the respondent assessed information from this source. This indicates that information on improved postharvest handling of maize and new technologies were limited which encouraged farmers to be over reliant on the traditional method of storage. But the traditional method of storage has some deficiencies associated with it that lead to high quantity of maize loss which in a long run affects the food

security status of most households. There is the need for extension officers in the district to intensify their activities to educate farmers on the impact of the reducing maize loss on the food sufficiency of various households. The extension officers should focus on helping subsistence maize farmers and organize group seminars or forum at least twice every farming season to get farmers more informed on newer and improved findings on postharvest handling. When farmers become abreast with the implementation of the various techniques involved with the improved postharvest handling or operations associated with maize production, then postharvest loss of maize will be ideally reduced.

3.4.5 Subsides on Farm Inputs

From the rich picture, one of the main support subsistence farm households receive directly from the ministry of agriculture if subsides. The government of Ghana through the Agricultural ministry provides subsidy on farming inputs such as fertilizer and agro-chemicals used in the production and storage of maize. In spite of this subsides, majority of the farmers could not afford to buy these subsidized inputs because they feel it costs high (beyond farm household budget).

Based on farmer's responds, hardly can most farmers afford the very chemicals and other inputs such as sacks and other basic equipment such as spraying machines which are used for the implementation of an improved storage method even though they were subsidizes by the ministry of agriculture. Therefore most farm households are hooked on to the use of traditional method of storage which gives very poor results in terms of prevention high quantity of maize loss during the period of storage. Normally the quantity of maize loss at the end of storage is nothing good to write home about as it has already been discussed earlier. As a result of the excesses in the quantity of maize loss at the end of the storage period, these farmers are further plunged into food (maize) deficit at certain time of the year (May-July). The tables below show the response subsistence farmers gave when asked how often they manage to afford the agricultural inputs which is subsidized by the ministry of agriculture in the farming years of 2011 and 2012.

Parameters	Number of farmers 2011	Number of farmers 2012
Affordability	5	7
Could not manage to afford	11	9

Table 2: Responses of farmers' affordability of subsidized inputs in 2011 and 2012 farming seasons.

Source: Own source.

Subsistence farmers interviewed were asked whether subsidized agricultural inputs were affordable and the responses I got was not that encouraging as table 3 and 4 exhibits/illustrates. It came to bare that some of the subsistence farmers even wanted the Government to give the subsidized input to them on credit while they pay for them at the end of the farming season, on the contrary the MoFA officer's answer to the inputs on credit basis was that, "subsistence farmers cannot be trusted to repay the cost of inputs back to the government or the ministry and if care is not taken the whole subsidy system on agricultural inputs may collapse".

From the two tables above, there was a bit of improvement in the use of subsidized agro-chemicals or fertilizer in 2012 as farmers could as farmers could afford to buy these inputs than in 2011. This explains once more why most farmers adapt the traditional storage method of maize every year. If the government or the ministry can come up with policies to increase the amount of subsides on agro-chemicals and other inputs so that farmers who do not have enough could afford them, then the number of farmer who can adapt the an improved method of storage will definitely increase since it involve the use of these subsidized inputs. If there is an increase in the number of farmers who adapts the improved method of storage, there will be huge reduction in the quantity of maize loss during the end period of storage and this will go a long way to boost the food security status of farm household.

3.4.6 Type of Storage Facilities

From the study, the commonest problem confronting subsistence farmers was inadequate and inefficient storage facilities available for the storage of maize. Most farmers rely on traditional method of storing harvested maize which is flawed with deficiencies. Subsistence farmers tend to loose large quantities of maize owing to these deficiencies during the period of storage. The quantity of loss depend on the number of deficiencies associated with a particular storages structure and how it exposes the stored maize to insect and harsh weather conditions during the period of storage. For instance a farmer with initial AG harvested 27bags and lost as high as 9bags of maize which represent one third of his produce while another with initial DS harvested 19.5bags and lost 7bags which is close to a quarter of his produce. These farmers lost heavily and this could be as a result of the poor storage infrastructure used in the traditional storage method, assessing quantity of maize loss on this occasion, there is a higher probability that, these households will be under the threat of food insecurity in such a year of heavy loss.

Ideally shelled maize should be packed in a properly sewn sack and stored above ground level on pallets or platforms. But not all farmers adapt this method because of the extra cost which comes with it since most farmers are not in a position to afford.

Below are the different types of storage structures used by subsistence farmers to stores their harvested maize. As I observed carefully, I found a lot of inefficiencies been associated with these structures. Some of these structures were even built for farmers by NGOs through the USAID more than 6 years ago and need to be repaired while some structures were self-constructed by farmers themselves.

Figure 7: Wrecked structure used for traditional storage.

Figure 8: Storage structure for traditional storage method

The unsecured nature of Fig 7 and 8 also leave the stored maize prone to insect attack leading to high insect infestation making the maize unwholesome and unfit for human consumption. The capacity of insects to multiply rapidly in a very short space of time makes it possible for thousands of them to attack stored maize (CIMMYT, 1992). Due to this reproductive prowess or ability of insect such as the maize weevil, they usually contribute to large quantity of maize loss especially under favorable weather conditions for breeding. The high quantity of loss sustained by farm households affect the food sufficiency of households at certain stage of the year as some farmers pointed out earlier.

Figure 9: A standard structure used for traditional storage

Figure 10: A secured traditional storage structure.

Source: Own source.

Figure 9 and 10 are standard and secured cribs used for traditional storage of maize; these were constructed by farmers themselves with locally acquired raw materials. Even though the cribs secured and rose above the ground, there is a problem with the roofing as drops of water can get in contact with the stored maize which may lead to the development of molds.

Figure 11: Deteriorated maize cobs at the end of period of storage for S3 method.

Source: Own Source.

Figure 11 illustrates the poor results obtained by farmers at the end of storage period when they used the normal traditional storage method (S3), owing to the fact that these traditional storage structures had failed to g0ive good and efficient protection to stored maize, there is a substantial quantity of maize that got deteriorated at the end of storage period. It is beyond norm and quite surprising when a farmer with initials DS harvested 19.5bags of maize and lost 7bags while farmer AA harvested 15bags and lost 6bags,the quantity of loss follows a similar trend for the traditional storage method. The percentage of the total harvest that is been loss is too high and no wonder these farmer reiterated that, they had no maize for household consumption as early as January and February respectively instead of normally experiencing such food deficit from mid-June to July just before harvesting. This massive loss incurred further put more pressure on farm house budget as they strive to be food secured throughout the whole year. Farmers have to spend extra money on the purchases of other cereal such as rice (Oryza sativa) and tubers such as Yam (Disocoria spp).

Unlike the traditional storage method, the adaptation the improved storage method (which involves shelling, separation of debris, bagging and packing) tends to give an encouraging result in terms of the percentage of the quantity of harvested maize loss. Figure 9 below shows the illustration of an improved storage method (S3) employed by some farmers interviewed.

Figure 12: An improved traditional storage method (S2)

Source: own source.

Even though subsistence farmer who adapt this method of storage incur extra cost and labor in terms of the cost of sacks, spraying machines, chemicals, as well as shelling, bagging and packing respectively, its pays of at the end of storage period as the number of bags loss is very minimal as compared to the normal traditional storage system. Farmer took the pain to dry the grains few days after shelling to reduce the moisture content to a minimal level before the grains are bagged, sealed and packed nicely on pallets in a dried ventilated room. The results at the end of storage is kind of encouraging as a farmer with initial KF harvested 45bags and lost just 6bags and another farmer EA harvested 34.5 and lost only 4bags. The quantity of loss follows a similar trend for the improved traditional storage method. Few farmers who adapt the use of this storage method attested that, "they are able to store their grains for long period and manage to wait till April-May when the prize of a bag of maize is sky high before they sell part of their produce for more than 100% profit as compared to been sold in November" as well as getting maize for household consumption throughout the whole year. Hardly did they experience food (maize) deficit throughout the whole year. Therefore subsistence household farmers need to move from

traditional methods of postharvest handling which makes maize produce more susceptible to spoilage and adapt the improved traditional method that protect produce from insects, rodents, molds and moisture that are the major agents of postharvest losses.

3.5 Trade-off involved Postharvest Handling Method

The traditional maize storage method has been passed on to subsistence farmers from generations as most farmers are used to practicing this method. It is easy to use and does not attract any other postharvest cost therefore some farmers find it difficult to break claimed 'tradition and norms' by making a trade-offs in adopting a new improved method of storage. The extension service officer in charge of the district pointed out that, most farm household attach a bit of importance to the traditional storage method, It is a tradition and heritage thing and most farmer feels they are ditching their tradition and norms to adapt an improved storage method. For example, he cited a scenario that intrigues me, "he said there is a traditional maize meal, (a delicacy called 'kenkey') which is made from the dough of maize, by which the dough is been wrapped in the dried Husk of the maize before it is boiled to be ready for consumption, some farmers believe if they practiced an improved method of storage, they will lose their maize husk and will find it difficult to get assess to husk to prepare their delicacy. The officer said farmers have been advised to store the husk separately after dehusking when switching to an improved method of storage so that it can be used for food preparation purposes but most farmer still prefer to practice the traditional storage method in order to have their maize husk intact to be used to prepare their local traditional delicacy ('kenkey'). The picture of the maize meal made from maize dough that is been wrapped in the maize husk ready to be boiled for consumption is illustrated in appendix 6.3 Surprisingly some farmers indicated that "In their generation, a man's hard work on the farm is measured by the size of his traditionally constructed cribs filled with maize as he dully earns recognition for it". From what they meant, such farmers may find it low self-esteemed to switch improved storage methods which do not involve visible locally constructed cribs filled with maize for community members to witness in order to gain recognition. From the results, observation, and opinion of all stake holders involved in the study, the improved storage method gives desirable results than that of the normal traditional storage

method but subsistence farmers are not willing to trade off their norms and heritage, the low cost involved with the normal traditional storage, it's simplicity and easiness to use and switch to the improved method of storage (S2). Meanwhile the traditional storage method is not in the position to give the stored maize the needed protection to prevent insects and pest infestation.

3.6 Swot Analysis

Swot analysis happen to be the framework that assisted me to point out the strength, weakness, opportunities and threats associated with the farming and postharvest activities involved with maize production as a whole. Subsistence farm households engage in different type of practices that is perceived to be tried and tested by them and they find it difficult to switch to new innovations and improved research output. The swot enabled me to analyze these practice and zoom on the opportunities available to farmers to explore and also adapt a potent postharvest management that will help reduce losses and boost the food security status of farm households. The swot threw more light on the strength, weakness, and threats challenging the farming and postharvest activities involved with maize production. The table below illustrates the swot analysis undertaken during the study.

Strength	**Weakness**
1. Land ownership, subsistence farm households own farm lands which are pass on to them from generation. 2. Diversity, farmers practice mixed cropping as well as keeping animals 3. Assess to both scientific and traditional postharvest management techniques for storing produce 4. Governmental Support trough subsides of fertilizers, certified seeds and farm tools and materials for postharvesthandling 5. Availability of old traditional maize varieties which are hardy, resistant, adaptable and more palatable to locals.	1.Difficulty on the part of subsistence farmers to assess credit to improve storage facilities as bankers demand collateral and Normally gives loans to commercial farmers. 2. Inadequate extension services 3. Bad storage facilities making stored maize susceptible to pest n rodents during storage period. 4. Difficulty in transporting produce from farm to storage place for postharvest treatment .
Opportunities	**Threats**
1. Opportunity to combine both traditional and scientific information to reduce postharvest loss. 2. Opportunity to introduce legumes in the mixed cropping system to help replenish soil fertility and also a good source of plant protein. 3. Opportunity to improve farmers' knowledge in postharvest handling activities in drying and storage techniques to reduce postharvest loss. 4. Opportunity to feed domestic livestock with damage and infested produce. 5. Opportunity to use the vegetative plant parts to prepare compost to help replenish soil fertility.	1. Vulnerability of produce physical factors such as humidity, rainfall and temperature. 2. Farmers not willing or prepared to implement new research findings on postharvest handling of maize due to financial constraints and other factors . 3. The threat of food insecurity in from months of May to July due to substantial postharvest loss.

Table 2: swot analysis
Source: Own source

3.7 Swot Summary and Key Issues

The major Key issues that were developed out of the swot analysis, the key issues gives a summary of the major problems facing subsistence farmers in maize production as well as its postharvest management. Below are the main 3 key issue pointed out of the study.

- Poor storage infrastructure
- The threat of High infestation and deterioration rate leading to food insecurity in from months of May to July.
- Opportunity to combine both traditional and scientific knowledge to increase productivity and reduce postharvest loss.

3.0 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The study was to examine the significance of postharvest maize handling to food sufficiency in subsistence farm households. It identified constraints and possible factors for improvement such as type of storage structures and methods, the type of maize produced and stored as well as source of information, subsidy on agro-inputs and source of finance that were available to the farmers in the district. It also analyzed the percentage loss, mean loss and standard deviation of the two storage methods used by farmers as well as a one-way analysis of variance on the difference between the mean losses of the two storage methods used by subsistence farmers to determine the statistical significance of the difference between the two storage methods (the standard error and P-level was reported).

On the basis of the type of storage methods used, farmers who used the normal traditional method (S3) incurred higher loss than that of those who used an improved traditional storage method. This was evident as the same trend run through the results obtained, not a single farmer who use the normal traditional storage method incurred a lower quantity of loss than farmers who used the improved traditional method of storage.(when farmer *AG* and *DM* changed their method of storage from S3 to S2 in 2012, the quantity of loss incurred reduced). In all 10 farmers reported of food insufficiency at different parts of the year in 2011 and 2012 farming seasons and almost all of these farmers were the ones that used the traditional method of storage.

The t-test analysis made showed a significant difference between the normal traditional storage method (S3) and the improved traditional Storage method (S2).

The norms and heritage of the rural subsistence farmers, simplicity of usage as well as the low cost involved with the normal traditional storage method (S3) made farmer to get hooked to this method and have refused to trade-off these factor for an improved traditional method of storage (S2). Yet the improved traditional method of storage (S2) gives a better protection to the maize during the period of storage than the normal traditional storage method (S3).

This paper will serve as a working document for agricultural extension officers and other departments of the ministry of agriculture to have a fair view of the postharvest loss of maize and food sufficiency of rural subsistence farmers in the district.

4.2 RECOMMENDATION

Here are some of the recommendations that were drawn from the study.

1. For farmers to overcome some of the constraints involved in the postharvest handling of maize, it is suggested that they form co-operatives which will obtain institutional loan as a group to purchase necessary inputs to be use by its members. The distribution of farm supplies such as seeds and fertilizers and other subsidised inputs could be channelled through such co-operatives.

2. They should be coordination between the Farmers, Extension Department of the Ministry of Food and Agriculture so that workshops on the production and postharvest handling of maize is organised for farmers at least twice in a year.

3. There is the need for the ministry of agriculture to increase the number of extension agents in the district so that farmers can be well updated on postharvest handling of maize and other agricultural activities.

4. There is the need to create awareness of the benefit of cultivating improved maize varieties especially to farmers who are still cultivating local maize varieties in terms of high yielding capacity, which will help increase their farm income thereby enhancing their household welfare.

5. Farmers need to be educated to come to terms that the improved traditional method of storage (S2) gives a better protection to the maize during the period of storage than the normal traditional storage method (S3) and there for need to switch to the improved traditional method.

6. In future a research should be done to find the significance of an improved storage method on storage loss on commercial farm households.

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6.0 APPENDIX

6.1 Interview Guide

- What are the type of maize varieties grown by farmers
- Difference in types
- What are the methods used for the storage of maize
- Why do you chose to use this method
- How do you store your maize?
- Do you dry the maize before storage
- Do you treat maize with chemicals before storage
- What are some of the problems confronting you in the production and postharvest handling of maize
- What the total quantity of harvest for both this year and last year
- How much did you lose during the period of storage
- What the deteriorated maize are used for
- What other Staple food do you normally consumes apart from maize
- What is your main source of finance for farming and postharvest activities
- What is the source of labour for farming and postharvest activities
- What is the type of farming do you practice
- Do you keep any domestic animals
- Do you afford to buy subsidized agro-inputs
- How often do you get subsides on farm inputs
- What are the other challenges do you face in the postharvest handling process
- How serious pest infestation during the period of storage.
- How do you deal with rodents
- How often do you organize workshop on postharvest handling for farmers
- How is information on postharvest handling of maize disseminated

- Do farmer readily accept and apply your new findings

6.2 Raw Data

Famers' Initial	Storage Method	Type of Animal Kept	Number of Animals
DS	S3	Poultry	25
KF	S2	Livestock(sheep)	35
JA	S3	Poultry	21
FY	S3	Livestock(Goat)	17
EA	S2	Poultry	16
BO	S2	Livestock(sheep)	15
DM	*S3*	Livestock(Goat)	12
AM	S3	Poultry	18
BB	S2	Livestock(Goat)	13
OM	S2	Livestock(sheep)	28
AG	*S3*	Livestock(sheep)	23
DD	S3	-	-
AS	S3	Livestock(sheep)	12
AA	S3	Livestock(sheep)	11
AB	S3	-	-
DA	S3	Livestock(sheep)	15

Table 1: table 1 illustrates the type and the number of animals kept by farmers

Famers' Initial	Storage Method	fertilizer application	Chemical (insecticides) application during storage
DS	S3	no	no
KF	S2	yes	yes
JA	S3	yes	no
FY	S3	Yes	no
EA	S2	yes	yes
BO	S2	yes	yes
DM	*S3*	yes	no/yes
AM	S3	no	no
BB	S2	yes	yes
OM	S2	yes	yes
AG	*S3*	yes	no/yes
DD	S3	no	no
AS	S3	yes	no
AA	S3	no	no

AB	S3	no	no
DA	S3	yes	no

Table 2: table 2 illustrates fertilizer and chemical application by farmers

Famers' Initial	Storage Method	Type of farming Practiced	Timing of Harvesting of maize
DS	S3	Mixed (maize with cassava)	Late (fully Dried)
KF	S2	Mono cropping	Late (fully Dried)
JA	S3	Mixed (maize with yam)	Late (fully Dried)
FY	S3	22Bags	Early (half dried)
EA	S2	Mono cropping	Early (half dried)
BO	S2	Mono cropping	Early (half dried)
DM	*S3*	22Bags	Late (fully Dried)
AM	S3	Mixed (maize with cowpea)	Late (fully Dried)
BB	S2	Mixed (maize with yam)	Late (fully Dried)
OM	S2	Mono cropping	Early (half dried)
AG	*S3*	Mono cropping	Late (fully Dried)
DD	S3	Mixed (maize with yam)	Early (half dried)
AS	S3	Mon cropping	Late (fully Dried)
AA	S3	Mixed (maize with cassava)	Late (fully Dried)
AB	S3	Mixed (maize with cassava)	Late (fully Dried)
DA	S3	Mon cropping	Early (half dried)

Table 3: table 3 illustrates farming system practiced and timing of harvest

Famers' Initial	Storage Method	Type of maize variety grown	Form of maize stored
DS	S3	Hybrid/improved	Cobs (unhusk)
KF	S2	Hybrid/improved	shelled(bagged)
JA	S3	Local/traditional	Cobs (unhusk)
FY	S3	Local/traditional	Cobs (unhusk)
EA	S2	Local/traditional	shelled(bagged)
BO	S2	Hybrid/improved	shelled(bagged)
DM	*S3*	Hybrid/improved	(unhusk)/shelled(bagged)
AM	S3	Local/traditional	Cobs (unhusk)
BB	S2	Local/traditional	shelled(bagged)
OM	S2	Hybrid/improved	shelled(bagged)
AG	*S3*	Hybrid/improved	Cobs (unhusk)/shelled(bagged)
DD	S3	Local/traditional	Cobs (unhusk)
AS	S3	Hybrid/improved	Cobs (unhusk)
AA	S3	Local/traditional	Cobs (unhusk)
AB	S3	Local/traditional	Cobs (unhusk)
DA	S3	Local/traditional	Cobs (unhusk)

Table 4: table 4 illustrates farming system practiced and timing of harvest

Famers' Initial	Storage Method	Sources of finance	Sources of information
DS	S3	Personal	Other Farmers
KF	S2	Rural bank	MoFA
JA	S3	Personal	Own Source/Personal
FY	S3	Traders	Own Source/Personal
EA	S2	Relatives/Friends	MoFA
BO	S2	Rural bank	MoFA
DM	*S3*	Personal	Own Source/Personal
AM	S3	Personal	Other Farmers
BB	S2	Personal	Own Source/Personal
OM	S2	Rural bank	MoFA
AG	*S3*	Personal	Other Farmers
DD	S3	Personal	Own Source/Personal
AS	S3	Traders	Other Farmers
AA	S3	Relatives/Friends	Own Source/Personal
AB	S3	Personal	Own Source/Personal
DA	S3	Personal	Other Farmers

Table 5: table 5 illustrates the sources of finance and source of information for farmers.

Famers' Initial	Storage Method	Use of subsidized inputs	Source of labour
DS	S3	no	household
KF	S2	yes	Hired
JA	S3	no	household
FY	S3	no	household
EA	S2	yes	household
BO	S2	yes	household
DM	*S3*	no/yes	household
AM	S3	no	household
BB	S2	Yes	household
OM	S2	yes	household
AG	*S3*	no/yes	household
DD	S3	no	household
AS	S3	no	household

AA	S3	no	household
AB	S3	no	household
DA	S3	no	household

Table 6: table 6 illustrates source labour and affordability of subsidized inputs.

Farmers' Initial	Storage method	Total Output (2011) Bags	Harvest Loss (x) (2011) Bags	Percentage harvest Loss (%L)	
DS	S3	19	7	36.84	
KF	S2	33	5.5	16.66	
JA	S3	21	8	38.09	
FY	S3	22	6	27.27	
EA	S2	27	4	14.81	
BO	S2	30	4.5	15	
DM	S3	22	8.5	38.63	
AM	S3	18	5	27.77	
BB	S2	22	3	13	
OM	S2	30	5	16.66	
AG	S3	27	9	33.33	
DD	S3	12	4.5	37.5	
AS	S3	25.5	8	31.37	
AA	S3	15	6	40	
AB	S3	11	5	45.45	
DA	S3	24	8	33.33	

Table 7: table 7 illustrates the percentage of quantity of maize loss in 2011

Farmers' Initial	Storage method	Total Output (2012) Bags	Harvest Loss (x) (2012) Bags	Percentage harvest Loss (%L)	
DS	S3	27	8.5	31.48	
KF	S2	45	6	13.33	
JA	S3	23	7	30.43	
FY	S3	22	7	31.81	
EA	S2	34.5	4	11.59	
BO	S2	31	5	16.12	
DM	S2	28	3.5	12.5	
AM	S3	19	5.5	28.94	
BB	S2	22	2.5	11.36	
OM	S2	37.5	6	16	
AG	S2	33	6	18.18	
DD	S3	13	4.5	34.61	
AS	S3	20	5.5	27.5	
AA	S3	17	4	23.52	
AB	S3	13	3	23.07	
DA	S3	26	6	23.07	

Table 8: table 8 illustrates the percentage of quantity of maize loss in 2012

6.3 Appendix

The picture below describes a maize meal made from maize dough that is been wrapped in the maize husk.

6.4 Appendix

A table of group statistics and sample test report for the data.

Group Statistics

	Storage method	N	Mean	Std. Deviation	Std. Error Mean
Percentage loss	improved trad	12	14.60	2.214	.639
	normal trad	20	32.20	6.045	1.352

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Percentage loss	Equal variances assumed	7.858	.009	-9.650	30	.000	-17.598	1.824	-21.322	-13.873
	Equal variances not assumed			-11.769	26.184	.000	-17.598	1.495	-20.670	-14.525