UNIVERSITY OF GHANA

COLLEGE OF HUMANITIES

SOCIO-ECONOMIC EFFECTS OF GRAIN LOSS: EVIDENCE FROM MAIZE PRODUCTION IN THE NSAWAM ADOAGYIRI MUNICIPAL ASSEMBLY

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BY

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THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MA DEVELOPMENT STUDIES DEGREE.

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DECLARATION

I, Gabriel Mevemo Ganyo Boso, hereby declare that, this study titled "Socio-economic Effects of Grain Loss: Evidence from Maize Production in the Nsawam Adoagyiri Municipal Assembly" is my work in design and in execution, and that all other materials contained herein have been duly acknowledged. To the best of my knowledge, this work has neither in full nor part been submitted for any other degree in any institution.

………………………………………… Date…............13th March, 2023

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(Student)

………………………………………. Date…...........13th March, 2023

Dr Ralph Armah

(Supervisor)

DEDICATION

This study is dedicated to God almighty for His continuous blessings and protection in my life. I also dedicate this study to my brother, Prof. Nathaniel Boso for being an inspiration and supporting me in my academic journey.

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LIST OF ABBREVIATIONS

FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
KII	Key Informant Interviews
MCE	Municipal Chief Executive
MMDAs	Metropolitan, Municipal and District Assemblies
MOFA	Ministry of Food and Agriculture
NAMA	Nsawam Adoagyiri Municipal Assembly
PICS	Purdue Improved Cowpea Storage
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
UN	United Nations

ABSTRACT

Agriculture remains one of the major sources of income and food in most economies of the sub-Saharan Africa (SSA). Various efforts in the form of government support and investment have been injected into agriculture in Africa to increase food production. However, the continuous cases of grain losses recorded continue to threaten food security and the economic wellbeing of actors within the food supply chain. Maize, just like other grains is an important food crop in the Ghanaian society where it is used in the preparation of a variety of meals. It is cultivated in almost all the sixteen (16) regions in Ghana. The study was conducted in the Nsawam Adoagyiri Municipal Assembly in the Eastern Region of Ghana. The study examines the socio-economic effects of grain loss with evidence from maize production within the municipality. The qualitative method was adopted for this study to explore and understand the socio-economic dynamics of the municipality and the effects grain loss have on the general population. A sample size of twenty-five (25) participants were selected for the study based on their experiences with maize farming, grain loss, marketing of grains and using maize in preparing various local food dishes. The study showed that, losses in maize production are widespread throughout the municipality. Several factors contribute to losses recorded in maize production within the municipality. The main causes include; timing of harvest, apathy and misuse of agrochemicals as well as inadequate storage options available to actors within the maize supply chain. Losses leads to the wastage of limited resources such as land and water. In addition, losses reduce the income of actors within the maize supply chain and threaten food security within the economy. Less stringent requirements for financial support from banks can help farmers secure loans to invest in modern storage facilities to reduce losses. Extension services must be intensified to train farmers on the appropriate use of agrochemicals. Government must embark on initiatives and policies aimed at addressing losses in agriculture production within the economy.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The quest to meet the ever-growing food demand of an increasing global population is a major problem to mankind. By 2030, the worldwide food system and agriculture is expected to feed approximately 9.7 billion people with limited land and water resources (Van Es & Woodard, 2017). Agriculture provides the main source of income and food for about 70% of people in sub- Saharan Africa (Abass et al., 2014). Even though the world currently produces enough food from agriculture to feed every living person, recurring problems in agriculture reduces the availability of nutritious food for human consumption. Some of the challenges facing global agriculture productions include extreme poverty, lack of investment, threats from pest and diseases and lastly food losses (Calicioglu et al, 2019).

Food losses refer to the decline in food quantity or quality, which makes it unwholesome for human consumption (Gustavsson et al., 2011; Parfitt et al., 2010). The reduction in quantity and quality also diminishes farmers' food supplies, the safety and market value which causes significant economic losses (Odjo et al., 2022). Globally, about 1.3 billion tons (Approximately one-third of all food produced for human consumption) of edible food is either lost or wasted in the food supply chain every year (Ishangulyyev et al., 2019). Also, the annual food value loss of $4 billion surpasses the value of total food aid ($6.1 billion) sub-Saharan Africa (SSA) received between 1998-2008 (FAO, 2011). Food loss in agriculture occurs at different stages of the food supply chain between harvest and consumption. Thus, food loss happens at the production, postharvest, distribution and processing stages of the food supply chain (Gustavsson et al., 2011). Any food lost at the consumer level can be described as food waste (Sheahan & Barrett, 2017)[1]. The quantity losses which are

[1] Food waste is predominant in developed countries and is mainly driven by consumer behaviour, values andattitude whereas food loss mainly occurs in developing countries.

usually the main focus of food losses occur when the actual amount of food often measured in kilograms reduces over a period of time. Nevertheless, quality losses are more important as micronutrients deficiencies are widespread around the world as compared to undernourishment (Barrett & Bevis, 2015).

Globally, around 14% of food produced is lost from the post-harvest stage up to, but excluding, the retail stage (FAO, 2019). This situation gravely affects people involved in food production especially farmers with various economic and social implication to their livelihood. Furthermore, this situation is even direr for farmers in the SSA as a result of inadequate credit and lack of crop insurance facilities. Farming in SSA serve as a source of revenue and most importantly food for most people in the rural areas who heavily depend on small-scale crop production for their survival. Food losses in developing countries usually occur in the initial stages of the food supply chain where continuing agricultural challenges exacerbate the plight of farmers. Some of the challenges experienced by farmers in the SSA includes poor harvesting technologies, lack of transport, poor storage facilities and most especially extreme climate conditions (Papargyropoulou et al., 2014). In many developing regions (e.g., sub-Saharan Africa and South-East Asia), about 29% of food is either lost or wasted during the first two stages (i.e., production, and handling and storage) (Ishangulyyev et al., 2019).

Maize is one of the most important crops cultivated in Ghana as it is grown in the forest and coastal savannah zones, transitional zone and northern savannah areas. It serves as an important component of most Ghanaian dishes among the various ethnic groups in Ghana. For instance,the Ga and Fante ethnic groups use maize to prepare the renowned *kenkey*[2]. Also, the Ewe ethnic group uses maize to prepare *akple*[3] whiles the ethnic groups across Northern Ghana use it to prepare *tuo zaafi4*.

[2] A typical Ghanaian staple dish made from fermented corn.
[3] A popular Ghanaian dish made from a slightly fermented mixture of corn-dough and cassava-dough
[4] Similar to akple, made from corn dough and a little cassava dough but quite softer and sticky in texture.

Regardless of its importance in the Ghanaian economy, maize cultivation is faced with a number of challenges that lead to losses in the field, during harvesting, processing and in storage (Wongnaa et al., 2019). This situation has affected the social and economic wellbeing of most farmers in Ghana including the ones in the Nsawam Adoagyiri Municipal Assembly (NAMA).

1.2 Problem Statement

As already established, maize is one of the most important and consumed food crops in Ghana. Maize in Ghana is estimated to be cultivated on an area of about one million hectares and makes up about 50-60% of the total number of cereals produced in the country (Wongnaa et al., 2019). Maize producing areas in Ghana includes Eastern, Brong Ahafo, Ashanti regions which account for approximately 80% of production whiles the three Northern regions account for the rest. The Eastern Region of Ghana is considered one of the top maize-growing regions in the country (MOFA, 2019) See appendix 1.

Maize farmers in Ghana experience grain loss on the farmland as poor harvesting, handling and drying techniques mean some grains are already lost on the farmland before it is transported to homes and market centres (Darfour & Rosentrater, 2016). Storage facilities employed by small-scale farmers lack innovations which expose their produce to conditions that lead to attacks from pest and diseases (Afzal et al., 2017). Birds, rats and insect infestation also pose a threat to the quantity and quality of stored produce. These problems affect the economic wellbeing of farmers as they are unable to store their produce for a long time for favorable prices (Wongnaa et al., 2019). This does not make maize production attractive for farmers and also limit investments which may eventually reduce the supply of grains to the market for consumption. As maize demand keeps increasing due to domestic and poultry consumption, a decline in supply will create a food security situation in Ghana.

This also affects Ghana's efforts in meeting the SDG goal of no poverty and zero hunger (Wongnaa et al., 2019). Grain loss have social and economic implications as it threatens the survival and the source of income for families involved in subsistence farming (Papargyropoulou et al., 2014). The Nsawam Adogyiri Municipal Assembly is a major agricultural area in the Eastern Region of Ghana where numerous food commodities are produced by mainly smallholder farmers for consumption and also the generation of income. Some of the crops cultivated within the municipality includes; maize, plantain, cassava, oil palm, citrus, yam, pineapple, cocoyam, pawpaw, cashew and vegetables such as okro, tomatoes, pepper and garden eggs (NAMA, 2014). Specifically, maize is one of the leading crops cultivated by farmers within the municipality (See appendix 2).

Farmers and other actors who are involved in maize production within the municipality encounter various challenges that expose grains to losses. There are limited agricultural mechanization available within the municipality that forces smallholder maize farmers to manually undertake pre-harvest and post-harvest operations, such as drying, dehulling, shelling, winnowing, transportation and storage. Other factors which include; insect activities, mould growth and mycotoxins, moisture and temperature, and social factors, on the selection of grain storage systems increases grain loss in maize production.

The cultivation of maize within NAMA provides a sustainable source of income for many farmers, enabling households to consistently afford their basic needs. It also serves as a business venture, as aggregators and market women buy maize from the farmers and sell in the market centres within the municipality. Food vendors within the municipality also use maize in preparation of several local dishes to feed the population. This evidently show that, maize is one of the most important economic and nutritional crops within the municipality which contributes immensely to the food security and sustainable incomes of households. Considering the massive importance of maize within NAMA, the persisting grain loss in maize production pushes households into poverty due to loss of income and investments. It also has the tendency to affect food security within the municipality. Thus, the study seeks to establish the effects of grain loss in maize production on the socio-economic wellbeing of people within Nsawam Adoagyiri municipality.

1.3 Scope of the study

The increasing population, urbanization, growing poultry and animal rearing sectors in Ghana have contributed to increased demand for maize (Ragasa et al., 2014). To satisfy this demand, maize farmers must maintain adequate supply which is impeded by grain loss. The main focus of the study is to assess how grain loss among maize farmers in the NAMA affect their socio-economic wellbeing. Also, the causes of grain loss will be identified with recommended solutions on how it can be minimized. Lastly, how grain loss affects the economic wellbeing of farmers will be analysed together with the impact it has on the society and social relations.

1.4 Research questions

1. What factors contribute to grain loss in NAMA?
2. What are the socio-economic effects of grain losses on the inhabitants of NAMA?
3. What are the constraints in addressing grain losses in NAMA?

1.5 Objectives of the study

The main objective of the study is to explore the socio-economic effects of grain loss in maize production within the Nsawam Adoagyiri municipality. Specifically, the study sought to:

1. To identify the major causes of losses from maize production in the NAMA.
2. To assess the socio-economic effects of grain loss on the inhabitants of NAMA.
3. To examine the constraints in addressing grain loss in the NAMA.

1.6 Significance of the study

The findings of the study are of great importance to the society and the economy. It adds knowledge to the literature on grain loss in maize production. With limited research done on grain losses in NAMA, this study will serve an important point of reference for further academic research on related topics. The important areas in agriculture that need additional support and investment are identified and measures that can be implemented to reduce grain loss are illustrated.

Despite the immense economic benefits of maize production, Ghana's maize yield is considered one of the lowest worldwide (Wongnaa et al., 2019). It is therefore imperative that more knowledge is gained on how grain losses among other issues in maize production can be addressed to improve yields in Ghana.

1.7 Organization of the study

The study is organized into chapters:

- **Chapter One 'Introduction'** gives a general overview of the study, states the problem of the study and establishes the various research questions and significance of the study.The objectives of the research are also outlined to explain what the study seeks to achieve.
- **Chapter Two 'Literature Review and Conceptual Framework'** gives an outline of ideas, theories and important literature published on food losses specifically in maize farming. Relevant literature will be reviewed to build a theoretical framework for the study. This also establish evidences of grain loss in Ghana, Africa and the world as a whole.
- **Chapter Three 'Methodology'** gives the specific techniques adopted to establish, select, process and analyze the information gathered during the study. The specific sampling method used to select participants from the population and the data collection instrument are stated.
- **Chapter Four 'Data Analysis and Presentation'** presents in-depth details on data analysis, assessments, discussions and interpretations of the findings during the study.
- **Chapter Five 'Summary, Conclusions and Recommendations'** provide detailed summary from the study and recommendations in the effort to reduce grain loss in Ghana.

CHAPTER TWO

LITERATURE REVIEW

Throughout the world, food is lost and wasted across all stages of the food value chain (Lipinskiet al., 2013). Deliberate efforts in the form of government support and investment have been injected into agriculture in Africa to increase food production and ensure food security on the continent. However, these attempts are hindered by the incessant cases of post-harvest losses which reduces the amount of food available and in good conditions for consumption and generation of income. With increasing urbanization, climate change, growing population and the use of available land for non-agricultural purposes, developing countries are threatened by food insecurity and hunger (Kumar & Kalita, 2017). This situation is further worsened by recurring postharvest losses in the SSA agricultural sector. Efforts toward addressing postharvest losses has been low as investments are rather geared towards other areas such as, those aimed at increasing production yield on the farm (Obeng-Ofori, 2011; Kumar & Kalita, 2017).

Food security is a major social and political concern for most countries in the SSA. Grain production is a major sub-sector of agriculture in the SSA that supplies critically needed source of food to people. The major grain crops grown in the sub-region are maize, rice, sorghum, millet, groundnut, cowpea and beans. Maize is considered as a major food staple in SSA which contribute immensely to ensure food security (James & Zikankuba, 2018). Also, maize is an important food crop in the Ghanaian society where it is used in the preparation of a variety of meals (Wongaa et al., 2019). Maize production also provides employment opportunities and income to farmers both on a small-scale and large-scale and also those involved in food businesses.

2.1 Overview of maize production in Ghana

On February 21, 2021, the Minister-designate for Food and Agriculture in Ghana identified maize as one of the most important grain foods cultivated in the country. According to Dr Owusu Afriyie Akoto, "maize is the only crop that grows in the four corners of the country" and is also "a staple crop of most ethnic groups in this country." (myjoyonline.com, 2021). This assertion made by the Minister-designate signified the immense role the cultivation of maize plays in the livelihoods of citizens in Ghana.

The cultivation of a particular species of maize is highly determinant by the taste, location and culture of people. The most commonly cultivated types are the white, yellow and red maize. In Africa, initially the yellow maize was the most predominant choice for both producers and consumers. In spite of the earlier inception of the yellow maize in the African society, the white maize continues to be the most popular type of maize produced and consumed in Africa (McConville, 2020).

Notwithstanding the fact that other major grain foods such as sorghum, millet, rice along with grain legumes such as ground nut and cowpea are cultivated in Ghana, maize production remains the biggest with an annual production of about 2,306.38 metric tons in 2018 (MOFA, 2019). Maize production ranks first based on the area cultivated and is only second to cocoa as the most important crop in Ghana (Wongnaa et al., 2019). Ghana's agricultural policy interventions are primarily aimed at raising the productivity of smallholder farmers especially in the rural areas. Since 2000, interventions such as Agricultural Mechanization Services Enterprises Centres, the Fertilizer Subsidy Program (FSP), and the Block Farms Program havebeen rolled out to assist farmers increase their yield (Benin et al., 2013). Subsequently, these individual interventions have been combined under the Planting for Food and Jobs (PFJ) initiative (2017-present). Maize production is one of the main priorities of the PFJ initiative where diverse support is provided to farmers. Subsidized fertilizers and seeds are provided under the initiative to reduce the cost-burden on maize farmers.

According to reports from International Food Policy Research Institute (IFPRI) and Ministry of Food and Agriculture (MOFA), current yields in Ghana stand at 1.73 metric ton/ha and 1.92 metric ton/ha respectively (Wongaa et al., 2019).

2.2 The Maize Supply Chain

Farming has served as a major occupation for people in SSA for centuries and continues to be the source of food for so many economies within the region. Agriculture constitute one of the main branches in economies that provides raw materials for industries such as cotton for clothing and textile manufacturers in addition to safeguarding food security in countries. It is estimated that more than 70% of people in the SSA are directly involved in agricultural activities as their main source of income and food (Abass et al., 2018). Agricultural activities involve planting food crops such as rice, millet, sorghum, maize and yam to feed people in thecountry. In addition, activities such as the rearing of poultry, cattle and pigs provide food products like eggs, milk and meat which is an important source of protein. Thus, agriculture in SSA is not only responsible for the provision of food and income but contribute immensely to the Gross Domestic Products (GDP) of the economy.

The food supply chain serves as the connection between food leaving the farmlands and reaching the final consumer. During this transition from the farm to the final consumer, food (grains) passes through several stages such as harvesting, threshing and cleaning, drying, storage, transportation and processing (Kumar & Kalita, 2017). For this process to be successful, an effective post-harvest system must be in place to ensure that harvested food reaches consumers in the right and safe conditions with regards to consumer satisfaction in quality, safety and volume. However, agriculture in SSA is faced with challenges that impedes the efficiency of post-harvest systems. Several factors such as improper handling, ineffective storage options and activities of micro-organisms within the food supply chain result in food losses. Hence, the value of food produced may keep dwindling after harvesting as a result of poor post-harvest handing.

2.2.1 Harvesting

Grains are usually harvested when their stalks begin changing colour from green to brown. Harvesting is considered as the first and important step in the food supply chain as it may significantly determine the overall quality of grains. Hence, it is one of the most critical stages of maize production. Generally, there are two ways of harvesting grains on the farm; mechanical and manual methods (Kumar & Kalita, 2017). The mechanical method which is common in developed countries involves the use of machines such as combine harvester and tractor for harvesting grains on the field. The manual method which is regularly used by smallholder farmers in developing countries involves the use of tools and equipment such as cutlass, sickle and cutter for harvesting. It must be noted that some large-scale farms in developing countries also employ the use of mechanical methods during harvesting.

Adequate measures must be in place to ensure losses are reduced during the harvesting stage. Harvesting the grains too early may result in high moisture content exposing them to mould growth and insect infestation and also prolonging the drying process (Kumar & Kalita, 2017).It may also increase the cost and time involved in the drying process. On the other hand, prolonging the harvesting period may expose the matured grains to attacks from insects, rodents, birds and other natural disasters such as bushfires and floods. In developing countries, as manual methods are usually used in harvesting it makes the process highly labour intensive and time-consuming. The unavailability of labour can result in delays of harvesting matured grains which increases the chances of grain loss on the field.

2.2.2 Threshing and Cleaning

Threshing involves loosening the grain to detach from the panicle of the crop by stripping, impact action, rubbing or the combination of the preceding actions. This process can either be done manually or by using machines. Akin to the harvesting methods, farmers in developing countries largely use manual methods of threshing which involves trampling and beating. Manual threshing may result in grain spillage and breakages which is a major contributing factor to grain loss in SSA

(Abass et al., 2014). Also, delays in threshing after harvesting resultsin quantity and quality losses as grains are exposed to the atmosphere, rodents, birds, insects and domestic animals. Unavailability of manual labour can be major reason for delays in threshing harvested grains.

The threshing machine minimize all the problems associated with manual methods of threshing. It saves time, reduces the quantity of wastage and minimizes the dependency on intensive manual labour for threshing purposes. However, smallholder farmers in SSA may face some constraints accessing threshing machines as a result of the cost involved in procuring these technologies. Besides, it may not be cost-effective for a smallholder farmer to purchase such large-scale machines. In Ghana, maize kernels are mostly shelled by using fingers which can cause pains and injuries. With huge harvest, the maize cobs are loaded into sacks where they are beaten with sticks which may result in physical damage to the grains. In recent times, some individuals have acquired shellers which they use in rendering services to maize farmers.To reduce the financial burden on smallholder farmers, these individuals offer their services in a barter system where a portion of the grains is taken as payment for shelling (Darfour & Rosentrater, 2016).

The next stage after the threshing process is cleaning which involves separating grains from other foreign materials such as stones, weed, sand, chaff, dead organism and straw. Winnowing and screening methods are mostly used in SSA for separating grains from unwanted debris. Women usually undertake this activity in most farming communities in SSA (Abass et al, 2014). These activities are done manually with intensive labour which may be expensive, time consuming and bring low monetary returns. According to the World Bank (2011), “there is little incentive for smallholders to provide well-cleaned grain for marketing, as there is usually no premium for quality; rather, there is every incentive to leave foreign matter in the grain, especially at the bottom of sacks, so that profits from sales can be maximized”. This has some consequences as inadequate cleaning results in contamination from insect infestation, mould growth and other foreign materials.

2.2.3 Drying

Grains are usually harvested at a moisture content of about 18-25%, although several factors (weather condition pattern and maturity stage) can make it significantly higher or lower (Mrema et al., 2012). The moisture content of harvested grains can be a major concern for producers as it may determine the sale weight, quality and the ability to be stored over a period of time. Such is its importance that, those who are both involved in the cultivation and selling of grains frequently check and control the moisture content in grains at all times.

In Ghana, small-scale farmers who are regarded as major maize producers greatly depend on sunlight and atmospheric air in drying grains (Obeng-Akrofi et al., 2021). Crops ready for harvesting may be left on the field without threshing to reduce the moisture content. After threshing, the grains may be spread over the floor for sun drying to further reduce the moisture content. This method of drying result in losses as the grains are exposed to insect, rodents, domestic animals and sudden rainfall. Grains left on the bare floor may also get contaminated with sand, stone, animal droppings and other foreign materials. Farmers may use mats and other polythene materials to minimize contamination and ensure easy collection of grains.

Mechanical drying addresses some of the problems associated with the natural methods of drying grains such as handling losses and the use of minimal space. Solar dryers are a mechanical drying option which can be used to dry grains to the perfect moisture level. Heinz (1995) noted, solar dryers have the ability to reduce moisture to the safest level for storage period to be extended. However, the high cost and technical training involved in acquiring these mechanical dryers may be a hindrance for individual smallholder farmers in SSA. To minimize losses from mould growth, the moisture content of grains must be kept under 13% to be in the right condition for long term storage (Kumar & Kalita, 2017; Bradford et al., 2020). The drying process after harvesting ensure the quality of grains as well as being in the right state for storage.

2.2.4 Maize Storage in Ghana

The availability of sufficient, safe and nutritious food at all times is determinant on how best food is carefully stored for a certain period of time for prolonged consumption. The use of various storage facilities and methods play a major role in the supply chain of agriculture production regardless of the specific food and geographic location. Farmers adapt a wide range of methods in using storage facilities with the aim of keeping food fresh for the market. This gives food producers the ability to keep food for a certain period in order to sell or consume at a latter period. The choice of a particular storage method is dependent on a number of factors that may ultimately influence the prices of agricultural goods on the market. Farmers take into consideration the cost in procuring and using a particular storage method as well as the risks and benefits that comes with their choices (Edwards, 2017). The affordability of these storage methods influences their choices in adapting a particular system regardless of its effectiveness.

In addition, the availability of such methods in the specific agricultural system also determines its use by the farmers. For instance, metal silos are being promoted in SSA, but the level of adoption by smallholder farmers is still low due to their relatively high initial investment cost and limited availability (Farnworth et al., 2021). These constraints faced by farmers in the SSA region has created an apathy towards the use of innovative and efficient storage facilities capable of ensuring the lifespan of harvested produce for a longer period. Some of these methods have been used for centuries without any new modifications to enhance its capacity to accommodate large farm produce.

A storage system does not only serve as a space for keeping harvested food. It also aids in preservation which is the process of keeping agricultural product in its original state after harvest to avoid deterioration usually caused by activities of micro-organism such as bacteria and fungi (yeast). According to Gustafson & Wilkinson (2005, p. 343), "food preservation protocols are in part designed to kill or inhibit the growth of microbes and can be divided into physical and chemical methods”. The physical methods of food preservation include dehydration, refrigeration and freezing, the use of radiation and high hydrostatic pressure.

The chemical method includes the use of chemicals as preservative agents. In this method, chemicals such as insecticides and pesticides are used in the storage system to control the activities of insects and pest respectively. In spite of its use in limiting food losses, the excessive and (or) inappropriate use of these chemicals can be hazardous to humans and other mammals. The application of these chemicals requires special training and knowledge with regards to the time to apply and the amount to apply in achieving efficient results (Mrema et al., 2012; Kumar & Kalita, 2017). The limited availability of extension officers with the technical knowledge on the use of chemicals in SSA is a major concern for farmers (Poku et al., 2018). Without the direction and guidance from extension officers, inappropriate use of these chemicals on food preservation can be harmful. These chemicals are in the form of fumigants which are applied to harvested grains for protection against insects and pests.

Thus, preservation in maize production involves the process of adopting a specific storage technique to aid in the handling of food to halt or slow down the process of deterioration in order to sustain the quality, edibility, weight and nutritional value (Edward, 2017). Storage and preservation constitute a critical stage for grain cultivation as its effectiveness determine the lifespan and economic worth in the market. Maize is a seasonal crop that is usually cultivated twice in a year. The season in which it is cultivated particularly depends on the variety of maize and other prevailing conditions necessary for the ideal growth and thriving of the crop.

Thus, it is critical to have an effective storage and preservation systems in place for annual crops such as maize to be stored for gradual consumption (Mrema et al., 2012; Kumar & Kalita, 2017). It is meant to ensure the availability of food for both humans and animals as maize serves as one of the main components of animal feed in poultry farming as well as animal rearing. Another purpose of storage and preservation is to save the seedlings of maize during the off-seasons and make them readily available for planting in the next season.

There are numerous storage options available to farmers in the SSA region. The choice of the specific storage option to use is particularly influenced by factors such as the climate of the locality, affordability, technical know-how and availability. Grain loss in SSA is usually associated with the poor conditions of existing storage facilities utilized by farmers, especially smallholder farmers. Typically, a storage system aims to serve three distinctive purposes for farmers with the intention of preserving harvested grains for an extended period of time for future consumption or sale.

First, it is intended to provide a dry, well-ventilated space for further drying of grains especially if they contain a significant amount of moisture. This is required for moisture regulation to limit mould growth on the grains, thereby preserving its quality for safer consumption. Second, it is intended to protect the grains against rainwater and underground water. Third, it is also aimed at protecting the grains from rodents, birds, insects and other domestic mammals. The activities of these organisms can greatly reduce the quantity of stored grains as they feed on them. There is also the possibility of soiling the grains, as some pests contaminate stored food with their body parts, faecal matter and webbings (Oduro-Owusu, 2016).

Stathers et al. (2020) indicated that, the activities of insects in grains can lead to chemical changes which decrease carbohydrate content and subsequently leads to weight loss. Rodents such as mice and rats are also notoriously known for feasting on stored grains and depositing their faecal droppings in storage spaces. These organisms are already known for their role in transmitting diseases and destroying crops on the field. There are many storage methods used by farmers in storing their grains after harvesting. In many instances the facility or technique used for storage is also used for drying purposes and both can be found in the same facility to reduce the cost of procurement (Mrema et al., 2012). In general, the size and type of storage used by farmers around the world is likely to be influenced by factors such as:

i. the total volume of produce to be stored;

ii. the storage requirements of the produce to be stored;

iii. the unit cost of the storage;

iv. the form in which the produce is stored (Mrema et al., 2012).

There are many indigenous (traditional) and modern techniques used for storing harvested grains by farmers. The smallholder farmers in Africa are typically known for using traditional storage methods for storing their grains on the farm and in their respective homes. The hot (and humid) climate conditions usually influence their choice of using very open storage structures to allow free airflow and continuous drying (World Bank, 2011). Also, those in very hot and dry regions tend to adopt sealed storage with no airflow to prevent pest and insect infestation. The indigenous structures are constructed by the farmers using ordinary materials and locally available materials in their vicinity. The materials used includes; mud, grass, wood and branches of trees. These local materials are used in the construction of the structures without any scientific guidelines and design, which does not guarantee its effectiveness against pest, insect and rodent attacks as well as the right temperature to prevent the growth of mould. It is estimated that about 50%-60% of losses are recorded when indigenous storage structures are used in storing harvested maize grains beyond a 90-day period (Costa, 2014).

In spite of the staggering statistics on losses with indigenous storage methods, it continues to be the familiar option to most farmers especially in the SSA. Studies confirm that about 60% of harvested grains are still stored in indigenous storage structures in developing countries (Kumar & Kalita, 2017).

2.2.5 Indigenous (Traditional) Storage Options

2.2.5.1 Mud Silos

Generally, silos are constructed for the purposes of holding bulk agricultural produce meant to be used at a latter period. These are mostly cylindrical in shape and used by farmers for storing excess grains which are not consumed. The purpose is to keep the excess grains in good shape free from all sort of contamination from pest and in the right temperature and aeration to block the growth of yeast and mould. Mud silo is a type of storage facility available to farmers in SSA. In Ghana, mud silos are predominantly found in the northern part of the country where farmers use it to store harvested grains (Darfour & Rosentrater, 2016). It is normally constructed with clay soil on three or four stones that serve as the base of the structure. The materials used for the roofing section are usually straw grass and palm tree branches for protection against the rain. Considering the cost, this storage option is very convenient to choose as it is cheaper to construct with materials that are readily and naturally obtainable in the environment. However, farmers using this storage system continue to record relatively highlosses.

2.2.5.2 Cribs

It is an enclosed structure which is rectangular in shape and about 1m above ground level. The structure is supported by pillars with a well-ventilated side usually made of straw, palm leaves and bamboo netting. Materials such as bamboo, wood and wire mesh can be used for the entire construction of the storage structure. The roof is usually made of iron sheets or straw grass and carefully constructed in a way to the prevailing winds blow perpendicular to the length (Mobolade et al., 2019). The legs of the structure are fitted with rat-traps to prevent rodent infestation in the space where the grains are stored.

Cribs are a multipurpose facility as it is not only meant for storage but can also serve as space for drying grains. It is designed in a way for the drying process to continue as a result of good ventilation which allows efficient circulation of air. Again, this storage option is cheap and easy to construct in SSA by farmers, especially smallholder farmers. Regardless of their low cost, Mobolade et al. (2019) contend this storage facility offer minimal protection against insect, pest and disease which results in losses as much as 40% being recorded.

2.2.5.3 Open air/Aerial Storage

This is another storage option available to farmers involved in the cultivation of grains and cereals especially in SSA region. Grains and cereals such as sorghum or millet panicles and maize cobs are tied together in bunches or sheaves, which are then suspended on ropes or tightlines from poles or posts, or tree branches (Ofor, 2011). This option also serves as a drying space as the grains dry in the sun and open air to reduce their moisture content. High temperature from the sun may also help destroy developing larvae to impede insect infestation in the grains. In order to protect the grains against rainfall in the open space, the farmers use polythene to cover them. Similarly, this option is also easy to make and does not involve additional cost in securing extra materials for construction. Adopting this storage method has its drawback as the harvested grains are exposed to the harsh open environment in addition to pest infestation, rodents, birds and thieves.

2.2.5.4 On the floor

One of the most convenient ways of storing grains after harvest is simply spreading it out on the floor. This method does not involve building of any sophisticated structure to accommodate the grains. All that is needed is an open space (indoors or outdoors) where the grains can be spread out. This method also enables for the drying process to continue as the sunlight outdoors help reduce moisture content in the grains. This method of storage is provisional and requires constant supervision as grains are critically exposed to all types of pests including domestic animals such as goats, chicken and sheep. Furthermore, grains on the bare floor could absorb moisture and also swept away when there is a sudden downpour. There is also the possibility of contamination from insect, animal droppings, stones, soil and other small debris (Darfour & Rosentrater, 2016).

2.2.5.5 Underground pit

This type of storage system is normally used for long-term storage in grain production. The underground pit is ideal for farmers in areas with low water tables. To construct this facility, a hole is dug between 1–3 m deep and 1–3 m diameter in a round or square form which is then insulated with straw mat or corn husk (Mobolade et al., 2019). There are two types of this storage structure. The two options are; bell-shaped underground pit which has a huge space used as storage chamber and a small entrance. The cylindrical ones are wide opening with walls supported by mats (Gronenborn, 1997). With the sides and bottom of the pit fitted with straw and husk, the threshed grains are filled in bags and loaded into the pit and covered with planks of wood and thereafter iron sheets.

In addition, a heap of sand or mud is used to conceal the pit and thorns, or spikes attached to ward off animals. This storage structure protects grains against insect and pest infestation as a result of reduced oxygen levels in the pit. Storage duration can range from 1 year to 5 years and once it is opened, all the stored grains must be emptied from the pit (Mobolade et al., 2019). The main advantage associated with this structure is its effectiveness against protecting grains from common threats such as insects, fire, termites, theft and domestic animals. Besides, the cost involved in constructing and operating this structure is relatively low. The main drawback of using this option is increased moisture content over time which can result in the growth of mould on the grains. This leads to grain quality, reduction in viability, and some nutritional value.

2.2.5.6 On platform storage

This is another simple storage option available to farmers in the SSA region. These structures are usually built to store grains in a state to reduce moisture, prevent insect and pest infestation. The platform is built with four or more sticks fixed into the ground and crossed with bamboo and other hard sticks about 3 or 4m high above. Straw or bamboo mats may be spread on the bamboo sticks to prevent the grains from spilling to the ground. The legs of the structure are fitted with traps to prevent rodent infiltration.

According to Mobolade et al, (2020), there are two types of the platform storage: Open raised platform and shaded platform. Using this storage requires spreading the unthreshed food grain evenly or piled together on the main platform. Direct solar radiation constantly heats up the grain to reduce the moisture content as well as killing insect larvae to prevent infestation. In other places, the space under the platform serves as a kitchen or cooking space where the firewood pit is situated. Fires that are lit also produce heat to speed up the drying process of the grains whereas the smoke from the fire drive away any rodents and insects in the platform. There is a roof usually made of straw, palm branches or iron roofing sheets to prevent the grains against moisture from dew and rainfall.

2.2.5.7 Storage bags

This is one of the most commonly used storage options for many individuals involved in grain production (Mrema et al., 2012). It is mostly used in farms, households and commercial storage centres for short term storage of grains. Depending on the specific area, the respective storage bag may be made of different materials that includes; sisal, jute or rubber. Using this storage option is very convenient for smallholder farmers as bags of grains can be kept under good shelter for protection against weather, thieves, domestic animals and other rodents. Farmers pile the sack of grains on pallets or raised platform to prevent accumulation of moisture from the floor. This option also helps in protecting the grains with fumigants and other chemicals against insects and pest.

Furthermore, storage bags are easy to be handled and transported which immensely help farmers in conveying their produce from the farm or home to market centres. However, pest such as rodents can create holes in delicate bags which can result in loss of grains. Also, dirty bags can lead to contamination that can reduce the quality of grains on the market.

2.2.6 Modern Storage Options

2.2.6.1 The use of metal silos

One modern storage option available to farmers for bulk storage of grains is the metal silo. A metal silo is a storage structure which is cylindrical in nature and constructed from a galvanized iron sheet. The metal silo technology has proven to be effective in protecting the harvested grains from attack not only from the storage insects but also from rodent pests (Tefera et al., 2011). Thus, it is one of the most effective storage options that provides adequate protection for stored grains against pests, insects and unfavourable weather conditions. It is usually used in developed countries such as Australia where large scale of grains are stored for future use or consumption.

On how it functions, metal silos are hermetically sealed which prevent the infiltration of pests,insects and rodents. It also depletes oxygen in the tank thereby by killing any remaining insects or other harmful organisms (Kumar & Kalita, 2017). This gives farmers the ability to store greater quantity of grains during peak seasons and sell them later for more profits during leaner periods. Metal silos are durable and offers a long-term solution to grain loss by keeping large quantities of grains for an extended period of time relative to other available options. However,the high cost required for the installation of the structure may be a hindrance to smallholder farmers especially in SSA (Baral & Hoffmann, 2018; Darfour & Rosentrater, 2016). Besides, it may not be economical for farmers in areas where there is difficulty accessing ready grain markets. Also, if farmers are not able to take advantage of price variations as a result of their ability to store grains for longer periods, this option may not be fully beneficial.

2.2.6.2 Hermetic Bags

The meaning of the word "hermetic" is "of complete and airtight seal". The hermetic bag is a typical storage method that makes use of the dehydration process by keeping out undesired contaminants and moist air. The most notable hermetic bag is the "Purdue Improved Cowpea Storage" (PICS) bags which were originally created for farmers in the western and central part of Africa for the purpose of protecting cowpeas against beetles (Baral & Hoffmann, 2018). The PICS bags consist of two sealed plastic (polyethylene) bags placed inside a third woven nylon or polypropylene bag for strength.

Hermetic bags are tight air bags that prevents air and water from getting into the grains stored in them. They are known to maintain grain composition and physical parameters during storage thereby maintaining quality and safety for consumption (García-Lara et al., 2019). Similar to the metal silos, the bags prevent the infiltration of pests such as insects in addition to depleting oxygen supplies levels and producing carbon dioxide which prevents the development of fungi as well as killing of any remaining insects. Other benefits include; the capacity to keep excess grains fresh for longer periods. This reduces the pressure on farmers to sell all their produce right after harvesting due to fear of losses. Stored grains can still be sold at higher prices months after harvest. For the technology of the hermetic bag to be effective, grains must be adequately dried, and the moisture content reduced to favourable levels for storage. Examples of bags used in SSA includes Supergrain and Zerofly bags produced by GrainPro Inc. and Vestergaard Company respectively.

2.2.6.3 Silo Bags

Comparably to the metal silo, these bags allow medium term storage of grains. The bags are made of polythene with three layers which provides adequate protection for stored grains. To reflect solar radiation, the outer coating of the bag is usually white in colour. Additionally, the inner layer of the bag is black in colour to help block sunlight. The silo bag is typically 60 meters long and about 3 meters wide in diameter with the capacity to hold 200 tonnes of harvested grains. Ultimately, the bags are waterproof as well as airtight to cut oxygen supply to prevent the survival of insects and fungal activities. For the silo bags to be effective, it must be kept on an even floor which is not waterlogged and free from any sharp fragments.

2.2.7 Transportation

Transportation facilitates the movement of grains from the farm or home to the various market centres. It is a difficult task in which if proper measures are not taken may result in quantity losses and contamination of grains. First, the harvested maize cobs are transported from the farm to the home. Subsequently, the shelled grains are then conveyed to the market centres. This function is usually performed by women and children who carry the grains on their head or shoulders (Darfour & Rosentrater, 2016). In areas where there are accessible roads, farmers who can afford may use trucks, bicycles or tricycles to convey the grains to the various destinations. Mather et al (2013) noted, there is a relationship between farmers owning vehicles and their participation in the market. It was established that, households which owned or had access to transportation assets such as bicycles, carts and other types of vehicles have a positive relationship with market participation.

In addition, the means of transport may also depend on other factors such as the quantity of harvested grains, the distance to the various locations and access to vehicles. During transportation, grains may be exposed to some threats such as birds, insect and thefts which may result in losses. Poor road infrastructure and poorly maintained modes of transport may result in high spillage and contamination of the grains. In SSA, poor quality sacks which easily get torn and loose are used for transportation of grains which mostly results in high spillages (Kumar & Kalita, 2017). Using these sacks without proper care can result in increased humidity which may cause mould growth and insect infestation. The increase in postharvest grain loss can be attributed to the use of sacks for transportation and storage purposes (Kaminski & Christiaensen, 2014).

2.2.8 Marketing

The grain market in SSA is mostly informal and dynamic with underlining factors influencing the behaviour of farmers in the grain market (World Bank, 2011). Smallholder farmers usually sell to shallow markets within their locality whiles excess grains are used in barter trade or gifted to their neighbours in the community. This behaviour is influenced by factors that are related to the production, consumption and marketing of grains within the region (Mather et al., 2013). On the production factors, getting access to credit from financial institutions has been one of the major challenges for farmers in SSA. This hinders their ability to invest in the acquisition of machinery to increase productivity and storage. Also, the smallholder farmers are sellers during peak harvest time but may be forced to buy from the market during lean periods to feed their household. In certain situations, the cost involved in buying grains during lean periods may exceed the farmer's willingness to pay which can lead to malnutrition. Market related factors include poor road accessibility to maize production areas which increases transportation cost ultimately reducing the total revenue for farmers.

2.3 The economic impact of grain loss

All efforts geared towards tackling grain loss is mostly aimed at reducing hunger and food insecurity in households. Nevertheless, grain production continues to serve other purposes directly and indirectly, such as providing a range of employment opportunities and also providing income for families. Economically, every part of the maize crop is significant in the Ghanaian society (Wongaa et al., 2019). An array of food and non-food products are derived from the leaves, grains, tassel, cob and stalk of the maize crop. Maize production serves as an important source of food in most Ghanaian households which ensures food security. It is also an integral ingredient used in poultry and livestock feeds among farmers.

Grain loss significantly affects millions of smallholder farmers through reduced food volumes and quality (Kumar & Kalita, 2017). Smallholder farmers are unable to get the maximum returns out of resources invested in maize production as a result of grain loss (Ishangulyyev etal., 2019). Low returns in maize production can render the venture unattractive to farmers thereby reducing supply which threatens available food for human consumption and poultry and livestock feed. The inability of smallholder farmers to properly dry and store grains often force them to sell their produce immediately after harvest, when supplies are greatest and prices are low (Bradford et al., 2020).

In general, postharvest losses present not only economic and social consequences but also has an impact on the environment, as resources such as land, water and other agricultural inputs (e.g., fertilizer, time and energy, machinery and equipment) which are used in producing grains are eventually lost. Globally, 33%-50% of food loss and waste is equivalent to wasting 23%-35% of freshwater withdrawals, wasting 10%-15% of energy consumption, and contributing to 8%-13% of global carbon dioxide emissions (Sun et al., 2022).

Grain loss may result in loss of investment which many farmers desperately struggle to get from formal financial institutions. Accessibility to credit facilities helps grain producers counterpoise some of the dire effects of grain loss (Koester, 2017). As farmers are already faced with lack of credit access, grain loss exacerbates their financial status as the collateral required to obtain financial assistance may result in long term indebtedness. A wasted investment reduces farmer's income and trickle down to customers who may be forced to paymore for the available grains. For instance, lack of capacity to store excess farm outputs may increase post-harvest losses and reduce profitability, thereby making investments in agriculture less rewarding (Sugri et al., 2021). Agriculture provides diverse economic opportunities for individuals within the economy to participate in income-generating activities. This provides employment to people especially those in the rural areas. Grain loss may result in low returns as the various resources invested in the production process are not recouped making farming unattractive to individuals within the economy. This situation has the tendency to worsen the increasing unemployment problem in the Africa, as three-fifth of the youth population are currently unemployed (Ackah-Baidoo, 2016).

The UN aims at tackling factors creating barriers to individual and household food access across the world. For example, the UN 2030 Agenda for Sustainable Development main goal is “ending hunger and ensuring access by all people, in particular, the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round” (Gebre & Rahut, 2021). In lower-income SSA countries, their agricultural sector is already faced with continuing low productivity, climate change and financial difficulties which causesfood insecurity (World Bank, 2011). Grain loss may also exacerbate the food insecurity situation within the economy. According to the FAO (2018), grain loss impact food insecurity, and also affect smallholder farmers and the nation as a whole.

Grains, especially maize is an important crop which is mostly cultivated for food and income (Tabe-Ojong et al., 2021). It is an important means through which individuals within the economy can earn decent income to cater for their daily basic needs for survival. Grain loss affect their day-to-day livelihood as losses may reduce their overall income (FAO, 2018). Studies conducted in Ghana reported that, insect infestations and attacks especially from *Sitophuilus spp* result in about 5%-10% loss in the market value of harvested grains. Furthermore, the larger grain borer (*Prostephanus truncates*) which is considered as one of the major pests in maize production in Ghana causes about 15%-45% market value loss (Kumar &Kalita, 2017).

Damaged grains are often not in good conditions for human consumption because of their reduced quantity and quality and do not attract good prices because they are often discounted in the market (Adomi et al., 2023). Basic needs such as good healthcare, shelter, food and quality education is required to ensure the human development of individuals in a country. As grain loss affect the income of farmers, it may hinder their ability to have access to their basic needs to ensure their overall wellbeing. The maize supply chain does not only ensure food security for the various households and the overall economy but provide critical source of cash income to individuals involved in the production and marketing of maize (FAO, 2018).

Grain loss may also affect the prices of other essential food products on the market as grains such as maize is a major source of food for people. Maize also serves as an important ingredient of animal feed for livestock and poultry farmers in SSA region (Wongnaa et al., 2019). Grain loss affect the livestock and poultry industry which may in turn have an impact on the prices of chicken, cows, pigs and other animal products on the market. Furthermore, grain loss may create grain scarcity in the economy which can result in increased prices for poultry and livestock products in the economy (FAO, 2018).

2.4 The social impact of grain loss

According to American psychologist Abraham Maslow, every individual in the society can only attempt to address high-level needs when their basic needs are sufficiently met. These basic or physiological needs which are required for human survival includes water, shelter, clothing, healthcare and food (Gawel, 1996). Food is an essential basic need that provide both macro and micronutrients that are needed by our body for different functions such as growth, energy for activity as well as the repair of tissues and a healthy immune system. The availability of food ensures the existence of societies as it helps prevent chronic food insecurity in households.

Globally, the population of various societies keeps growing and that means more people are going to require more water, more jobs, more shelter and more food. More than half of the world's undernourished are found in Asia (418 million) and more than one-third in Africa (282 million)

(FAO et al., 2021). Satisfying the food demand as a result of an increasing population is not an easy task and continues to be a burden on developing countries. The rise in population can mainly be associated with developing countries where they continue to tackle issues of hunger and food insecurity (Kumar & Kalita, 2017).

Several bodies and individuals around the world have been involved in the fight against food insecurity and hunger. Bodies such as governments, international organizations and non-governmental organizations have put up measures and plans to enable the continuous food production in various regions. Certain individuals have also set up developmental foundations (e.g., Bill & Melinda Gates Foundation) to work closely with other organizations by addressing poverty levels and other issues that can lead to hunger and food insecurity. Thus, efforts are being made to improving agricultural production, land management and population control as policies to tackle the rise in food demand. In spite of this effort, attention towards alleviating food losses continue to be low as food production in farming areas continues to be ravaged by incidence of food losses.

Generally, food losses continue to be a critical issue in our society that does not receive much attention and funding, as it has only been allocated less than 5% research funding in previous years (Kumar & Kalita, 2017). Food grains such as cereals and legumes are among the most important crops that provide the rural poor with food as well as employment and sustainable source of income. Maize serves a socio-cultural importance to many African societies where they are used for preparing a variety of food dishes, packaging of other foods such as *Ga Kenkey* and as a source of fuel in some rural areas.

However, the prevalence of grain loss continues to pose a serious threat to the survival of people especially the poor in developing countries with regards to food and nutrition security and income levels. According to Mobolade et al., (2019), a substantial amount of essential food grains continues to be damaged and lost as a result of grain loss especially during the processing and storage stages of the grain supply chain. Grain losses potentially reduces the available food for human consumption. Thus, the food security of so many households in both rural and urban areas in Africa depend on the constant availability of grains. Farmers are often times forced to sell immediately after harvesting which at the point may reduce the economic value of grains. One major reason behind this decision is the poor available storage options which can increase grain losses. Instead of selling immediately after harvesting, it may be prudent for farmers to store excess grains and sell later when supplies are low for maximum profit. Unfortunately, farmers do not have improved and modern storage facilities capable of preventing grain losses. Thus, grain losses significantly affect food security and income of households.

2.4.7 Gender and grain loss

In situations where food crises are paired with other socio-environmental constraints, it leads to permanent food insecurity, worsening the livelihoods of many vulnerable households, particularly small-scale farmers and women (Beyene et al., 2023). As the food production in SSA is highly characterised by a manual labour-intensive process, it requires the participation of all individuals in the family if there is a low financial resource to hire external labour. Men, women and even children are all expected to be involved in farming activities to generate income and food for the family. In grain production, both men and women perform various roles which includes cultivation, harvesting, transporting, processing and marketing.

In Ghana, there are traditional labour agreements that has been practiced within farming communities in the various societies. One of the most common practices are the *abusa* and *abunu* share tenancy agreements where a labourer is hired and a part of the harvested crops used as a form of payment (Tsikata & Darkwa, 2013). The *abusa* agreement allows for the labourer to be paid with one-third of the harvest whereas the *abunu* contract requires the owner of the farm to pay the labourer with half of the overall harvest. Other forms of these labour agreements include a more casual labour known as *nkontokuano* where the labourer is paid perload of the harvested crops at the end of the season (Sutton, 1983). These arrangements explain how most farmers struggle to raise money beforehand to invest in labour and also acquire modern technology to increase production as well as protecting harvest against losses. There are several impacts grain loss has on individuals and it usually as a result of range of distinctive reasons found in the structures of societies.

Maize is cultivated by both men and women in SSA countries. Nevertheless, women in SSA are faced with several social and economic obstacles that impedes their ability to tackle grain loss. Societal biases constrict women's access to vital resources such as lands, inputs (fertilizer and disease resistance seeds), machinery and labour (Cairns et al., 2021). In other instances, information and extension services critically needed by farmers to address grain loss are usually not available to women. Fisher et al (2019) noted, there is an unequal access to information and extension services as women tend to be excluded as beneficiaries and staff of extension units. At times restrictions from societal norms, traditions and religion render women unable to access important agricultural information and technical knowledge in agriculture. Women also have less control over household resources as compared to men.

For instance, men tend to own farmlands which in turn can be used as a collateral in a contract to have access to credit to improve their farming operations. These credit facilities aid in acquiring inputs such as fertilizers, seeds and machinery. Women, especially those in the rural areas, do not typically own lands and the ones allocated to them are small and mostly infertile (Wongnaa et al., 2019). These shortcomings faced by women in the society influences their inability to invest in effective technology to tackle grain loss (Abass et al., 2014).

In addition, typically men and women perform distinctive roles during grain production within the supply chain. Men are usually involved in the planting and harvesting stages whiles women undertake the processing activities which includes winnowing, dehulling, drying, sorting and shelling (Abass et al., 2014). Women are also engaged in the storing and marketing of grains. These manual processes are hectic and requires a considerable amount of time to undertake which limit the time available for women to be involved in other productive activities. Women are also required to combine these manual intensive activities with other crucial roles at home such as cooking, washing and provision of childcare. Manandhar et al (2018) noted that, losses recorded at the processing and storage stages could be significant to the economic and social wellbeing of people. The time invested by women during the processing of grains can bring little returns which may worsen poverty levels especially in rural areas.

2.5 Conceptual and theoretical framework

This section expounds on the conceptual framework and theories associated with the study of the causes and socio-economic effects of grain loss. The conceptual framework illustrates the various losses that occurs within the maize supply chain and the key factors that are responsible for these losses.

2.5.1 Conceptual Framework

The conceptual framework in this study explains the various factors that cause grain loss within the food supply chain. Also, the significance of grain loss is highlighted to show its impact on the society, economy and the environment. The food supply chain is the various activities and stages that ensure the production of food on the farmland and its movement to the final consumer. A target has been set by the UN on food supply loss and waste with the aim of addressing food security issues especially in developing countries. The aim is to "halve the per capita global food waste by 2030 at the retail and consumer levels and reduce food loss and waste along the production and supply chains" (Luo et al., 2021 pg. 1). Understanding grain loss requires analysis of the various stages through which grains are moved from the farmland through processing, storage, transportation stages to the final consumer.

There is the need to search for a viable solution to augment the availability of food amidst the increasing growth of population around the globe. Exploring ways to reducing postharvest losses, especially in developing countries could be a sustainable means to increasing food availability, limiting pressure on natural resources, eradicating hunger and improving the livelihood of farmers

(Kumar & Kalita, 2017). The increasing population growth in SSA may lead to an increase in demand for food in the various economies within the region. It is estimated that in the next 30 years the population of SSA is expected to be doubled (Prasanna et al., 2021). Other environmental threat such as climate change also continue to hinder the overall output of agricultural production. Climate change has two major consequences on smallholder farmers which includes low agricultural productivity and high post-harvest losses.

Grain loss can be categorized according to the conditions that the losses occur within the food supply chain. Grain loss occur as a result of weight loss due to damage, quality loss, dietary loss, seed viability loss and market loss. In general, having an efficient food supply chain can reduce post-harvest losses, generate income, enhance food quality and safety and ensuring food and nutritional safety (World Bank, 2011). To better understand grain loss, the various factors that influence these losses within the grain supply chain must be analysed to establish the existing trend. The practices within the grain supply chain must be understood in cultural, economic, social and technical perspectives. The handling of grains within the supply chain is important in determining the quality and standard of grains produced by farmers. According to Darfour & Rosentrater (2016), post-harvest handling includes the management of food produce before processing which involves drying, storage, protection against pests, and moisture regulation.

In SSA, more than half of the entire population consume more than 100g of maize each day (Cairns et al., 2021). It is a staple crop that is not only depended on for food but also serves as an important source of income for producers especially smallholder farmers in rural areas. Maize is an important crop in Ghana that accounts for more than 50% of the total cereal production in the agricultural sector of the economy (Ragasa et al., 2014). It is a major ingredient in dishes of almost all the numerous ethnic groups in the Ghanaian society. In the Nsawam Adoagyiri Municipality, it is grown throughout the area and serves as an important source of food and income-generating activity.

The conceptual framework illustrates the movement of maize through the grain supply chain from the farmland to the final consumer. Grain supply chain ensures the transition of maize from the farm to the consumer through a set of stages that includes; harvesting, threshing and cleaning, drying, storage, transportation and marketing. During the movement, several factors such as poor storage and processing facilities, improper handling, limited market and pest and diseases leads to grain loss in maize production.

Maize is usually harvested manually with a cutlass, sickle or by hands in most SSA regions. Grains not harvested at the appropriate period may be exposed to attacks from pest especially birds and rodents when they are kept too long on the farm. Also, harvesting too early results in a high moisture content which may result in mould growth if not dried appropriately. Limited mechanization in SSA, means grain producers resort to manual threshing which involves packing maize in sacks and beating or trampling to remove the grains from the panicle. Grains may be broken and scattered which contributes to losses.

Grains dried in the open are also exposed to domestic animals and birds who eat and contaminate grains with their droppings. Indigenous storage options usually made with wood, mud among other readily available materials in farming communities cannot guarantee long- term protection. Various factors during transportation and marketing stages also contribute to significant losses. It must be noted that smallholder farmers usually in rural areas are faced with several challenges that contribute to grain loss. These factors include lack of capital to invest in improved storages, lack of training and information on good farming practices.

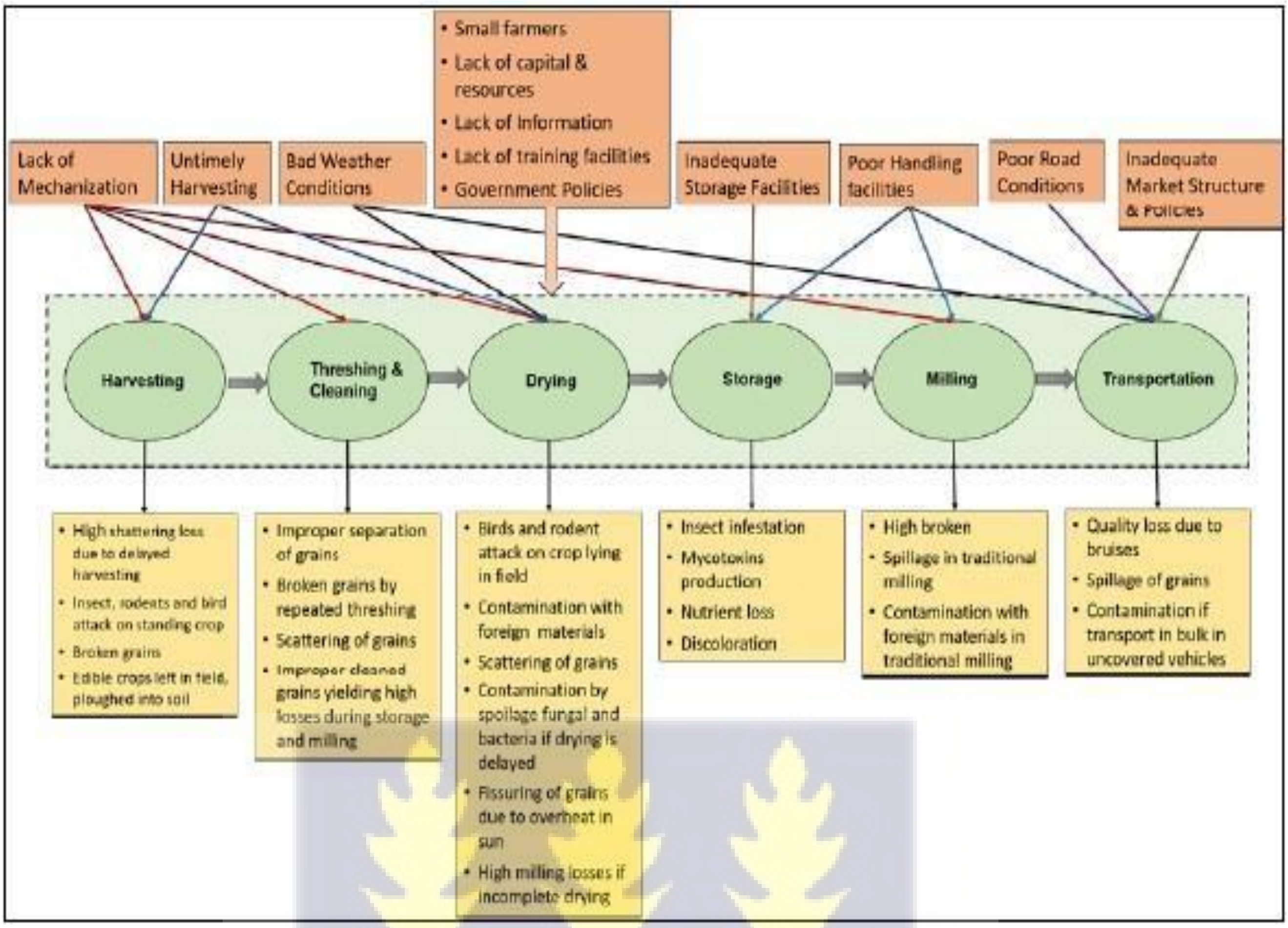

Figure 2. 1: Conceptual framework of losses within the maize supply chain

Source: Kumar & Kalita (2017)

2.5.2 Theoretical framework

In explaining the impact of grain loss, the Economic Theory of Demand and Supply is adopted to ascertain the contributing factors and effects of grain loss on grain producers as well as consumers. Agriculture requires the use and combination of resources such as land, water and labour to ensure the production of food to generate income as well as for consumption. One major problem facing agricultural production is the incessant food loss and waste recorded throughout the food supply chain which leads to a substantial waste of resources. This often results in food insecurity especially in developing countries. It has been recommended that reducing losses and waste of agricultural and food systems can play a role in reducing the pressure on scarce resources and improving food security (Rutten, 2013).

In Ghana, price plays a pivotal role on the quantity of grains demanded by consumers as well as well as quantity supplied by the producers to the market. According to Rutten (2013), if there is a higher demand for a particular good with limited supply, prices are higher. Also, a higher supply of a good with limited demand result in low prices.

Crop production in SSA is largely rain fed. There is a limited access to irrigation facilities by farmers within the region (Gebre & Rahut, 2021). This makes the onset of rains the key determinant for commencement of the growing season. Thus, farmers (producers) within the same area cultivate crops in the same period of time. During the harvesting periods, there is an influx of maize on the market which causes prices to fall significantly and minimizes gains accrued by farmers (Manandhar et al., 2018). In order to get high prices, farmers withhold the supply of grains by delaying harvesting or keeping grains in storage for longer periods (Jones et al., 2011). Delay in harvesting expose grains to birds, insects and other threats which results in losses. Indigenous post-harvest practices such as storing grains on the bare floor or in the open, moisture permeable bags and cribs expose grains to losses (Abass et al., 2014).

Low prices of food are noted to be an important cause of food losses in supply and food waste in demand (Rutten, 2013). Grains are stored in the available indigenous storage facilities in SSA which makes them susceptible to pest and disease attacks. These losses have significant effect on the wellbeing of people as many individuals in rural areas heavily depend on agriculture as a means to generate income as well as feeding their respective families.

CHAPTER THREE

METHODOLOGY

The first section profiles the geographical location of the study area. The second section handles the techniques of data collection, types of data, target population, sampling method and selection and the various methods of data analysis.

3.1 The Profile of Nsawam Adoagyiri Municipal Assembly

3.1.1 Study Area

The study was conducted in the NAMA, situated in the south-eastern part of Ghana's Eastern Region between latitude 5.45'N and 5.58'N and longitude 0.07'W and 0.27'W. The municipality is approximately 23 km from the capital, Accra. It shares common boundaries to the south with the Ga East and West Municipalities of the Greater Accra Region and bordered to the north by Akuapem South District in the Eastern Region. It also shares common boundaries in the north-west with Ayensuano District and in the south-west with the Upper West Akim District both in the Eastern Region.

The municipality covers a land area of about 175 square kilometres and also serves as a gap town along the main highway (Accra-Kumasi Road) which links the northern part of Ghana to the coastal cities and towns. Figure 3 shows Nsawam Adoagyiri Municipal Assembly in the national and municipal context.

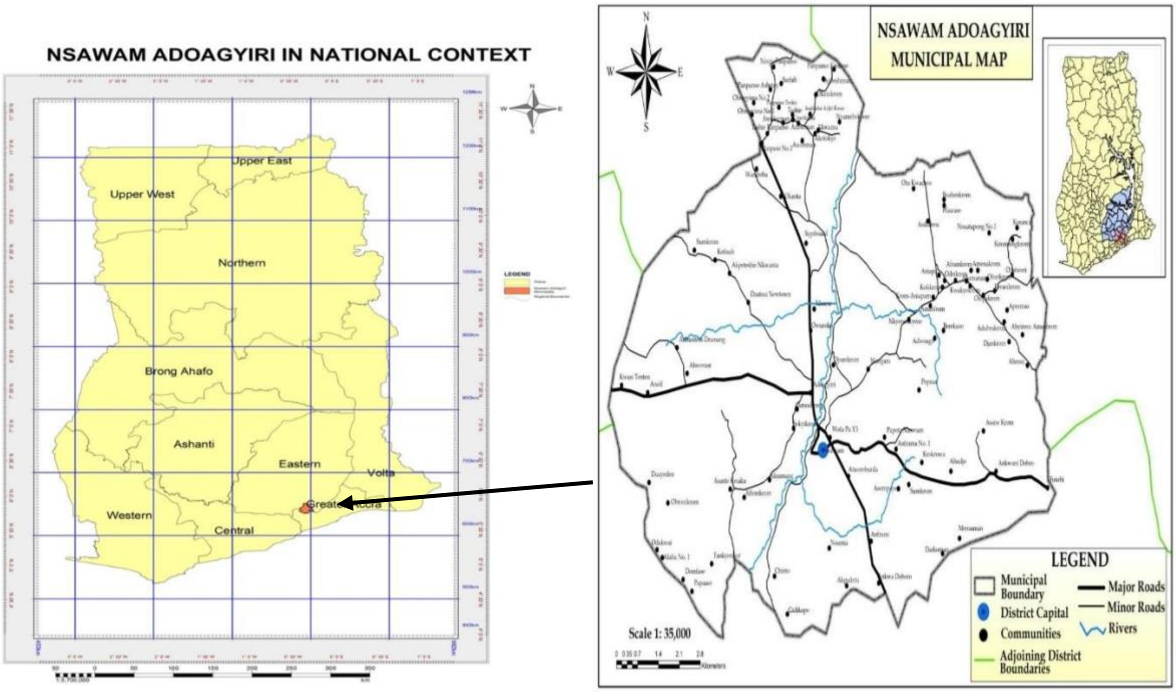

Figure 3. 1: Nsawam Adoagyiri Municipal Assembly Map

Source: Mid-Term Development Plan, NAMA, 2014

3.1.2 Demographic Characteristics

According to the 2021 population census, the population of Nsawam Adoagyiri Municipality is estimated to be about 155,597. It comprises 76,417 (49.1%) males and 79,180 (50.9%) females. Even though women constitute more than half of the total population and form an important human resource base, they continue to face socio-economic disparities within their communities and households in the municipality. About 66.5% of the population is within the active working age gap from 15-59 years old. The remaining 33.5% of the population is below 15 years and above 59 years. The population growth rate is estimated to be 1.6% per annum which is lower than that of the country at 2.7% but slightly higher than the regional population growth rate of 1.4% per annum (GSS, 2010). It has a population density of 465 per persons per square kilometre.

3.1.3 Physical and Environmental Characteristics

The municipality is located within the wet semi-equatorial climatic zone which experiences substantial rainfall. Annually, the municipality experiences a bimodal rainfall which is between 1250mm and 2000mm reaching its maximum during the peak periods of May-June and

September-October. The relative humidity is estimated to be at 50% during the dry season and 91% during the raining season. The first rainy season known as the major season is the heaviest and usually occurs from May-June each year. The second rainy season known as the minor season also occurs from September-October. Many farmers within the municipality who do not have access to irrigation facilities usually plant during the major season whiles the farmers who have the capacity to use irrigation facilities cultivate their crops in the minor season.

The vegetation in the municipality is primarily made up of Semi-Deciduous Forest and Coastal Savannah Grassland. The forest used to cover about 90% of the land area in the municipality but currently covers only 40%. The depletion of the forest areas can be attributed to varying factors that includes; quarrying, sand winning, shifting cultivation system of farming, uncontrolled timber logging and estate development. The soil types within the municipality canbe grouped into five main types: Adawso-Bawjiase-Ofin Compound Association, Ayensu- Chichiwere Association, The Fete and Nyanoa-Opimo Association, Yaya Pimpinsu-Befua Association and Dewasi Wayo Association.

3.1.4 Socio-economic Activities

Out of the total number of people who are economically active within the municipality, 92.7% are employed whiles 7.3% remain unemployed. Agriculture is the sector that employs the greatest number of people with 37%. The commercial sector employs about 28% of the labour force within the municipality. Lastly, the service and industry sector employ 20% and 15% of the labour force respectively.

As the most dominant sector in the municipality, agriculture is the major economic activity in terms of employment and any related income generating activities. Some of the major crops cultivated includes maize, plantain, cassava, oil palm, citrus, yam, pineapple, cocoyam, pawpaw, cashew and vegetables such as okro, tomatoes, pepper and garden eggs. Apart from crop production, the average farmer rears a variety of livestock and poultry. The major livestock and poultry reared in the municipality are pigs, goats, sheep and cattle. In rural areas, 71.7% of households are into agriculture whilst 28.3% of households in the urban localities are into agriculture. Commercial farms such as Forest Resources, Blue Skies, Bomart and Dansak are involved in the cultivation of crops such as pineapples, pawpaw and vegetables. Even though the municipality is endowed with a number of water bodies, limited development of irrigational facilities still forces many farmers to rely mainly on rainfall.

3.2 Research Design

The qualitative research method was used for this study to explore the socio-economic settingof the municipality and understand the impact grain loss has on their wellbeing. As Creswell (2013) noted, the qualitative method assists in deriving a deeper understanding and the meanings people ascribe to certain human or social phenomenon. In this situation, the views and experiences of people within the municipality with regards to the causes of grain loss will be sorted and analysed to establish the impact it has on their socio-economic wellbeing.

Grain loss occur throughout the various stages of the grain supply chain. This phenomenon is experienced closely by maize farmers on their farmlands and household where the grains are usually stored for a period of time. Qualitative research helps in understanding their experiences with this phenomenon and how it affects their socio-economic wellbeing in the society. Through the qualitative method, the perception of maize farmers, aggregators and extension officers are gathered and analysed to understand their views on grain loss in the municipality. It also gives the researcher the opportunity to be in the natural and real-life settings to observe how maize farmers and other actors within the municipality handle grain loss. In addition, using qualitative research is not only grounded by the worldview of the researcher, but inextricably connected to the objectives and questions of the study (Denzin & Lincoln, 2002).

The study will also employ interpretive approach (anti-positivism) to help the researcher to be closely involved and interpret the reality embedded within the social settings. The interpretive approach also helps uncover interesting and relevant research questions and issues for future research (Bhattacherjee, 2012).

3.2.1 Target Population

The target population of the study includes individuals and groups within the NAMA. They are maize farmers, aggregators and extension officers at the Agricultural Department of the NAMA.

3.2.2 Sampling strategy

In order to have access to the desired sample, the study employed non-probability sampling methods. The study employed a purposive sampling technique to select officials from the agricultural department of NAMA. The study was limited to a specific type of crop and restricted within a limited geographic area. Purposive sampling involves randomly selecting units without replacement from a particular section of the population believed to possess information and experiences vital to the study (Guarte & Barrios 2006). This technique aids in selecting elements significant to the study based on the judgement and knowledge of the researcher. The use of the purposive technique is to make available the respondents with the requisite and plentiful data required for the study (Maindonald, 2011). The agricultural department of NAMA provided the contact information of farmer's groups who helped in identifying farming communities, maize farmers and aggregators. Considering the large area size of NAMA, convenience sampling was then employed to select the farming communities, farmers and aggregators for the study. Convenience sampling is a type of non-probability sampling method that considers certain practical points, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate when selecting the target population for a study (Etikan et al., 2016). This directed the researcher to the primary data sources to achieve the aims and objectives of the study.

The study sought to identify the effect of grain loss on the socio-economic wellbeing of people within the municipality. The participants were selected based on their experiences and knowledge of maize cultivation, processing and usage. Furthermore, these methods were selected to effectively deal with the cost and time constraints involved in conducting this study. In conducting this study, a sample size of 25 participants was chosen for the study with regards to their experiences with maize farming, grain loss, marketing of grains and using maize in preparing various local food dishes. According to Bryman et al., (2012), the recommended range for a good qualitative study should be between 20-30 participants. Hence, the recommendation by Bryman et al., (2012) was considered in selecting the number of participants within the municipality for the study.

3.2.3 Data collection tools

Various forms of interviews were used in the data collection process. Focus group discussions were used to interview some of the maize farmers and the respective leaders of the farmers associations. Focus group discussions were adopted to encourage a thorough discussion and perceptions of grain loss among the maize farmers. Gundumogula (2020) noted, participants in a focus group are individuals with in-depth knowledge on a specific issue and possess the ability to contribute vital information needed for the study.

Most food in SSA is mostly produced by smallholder farmers in rural areas (Giller et al., 2021). From observations on the field, maize was mainly produced by smallholder farmers within the municipality. Smallholder farmers depend on family-labour, which makes every member of the nuclear family involved in activities on the farm. The focus group discussion gives the researcher the opportunity to engage families involved in maize production. It was also observed that, farmers gather in specific locations in the evenings to converse and rest after returning from their farms. It provided the opportunity to use the focus group discussions to interview the maize farmers.

Personal interview was also adopted to interact with aggregators who rely on the production of maize for their business. Due to the busy schedules of the aggregators, it was prudent to visit them individually to conduct the interviews as it would be difficult to organize them for a focus group discussion. Furthermore, key informant interviews (KII) give the researcher the opportunity to directly interact with expert, professionals and residents who are familiar with issues within the community of the study. The KII involves interviewing a selected group of people who are likely to furnish the researcher with the needed information, ideas and insights on a particular subject (Kumar, 1989).

In the Nsawam Adoagyiri municipality, extension officers at the Agricultural Department have in-depth knowledge on maize production and other important information which is significant to the study. Thus, KII was adopted to gather information on the maize supply chain, farming practices and agricultural management within the municipality. Officials from the agricultural department were purposively selected and interviewed. The interviews presented a chance to constantly control interactions with the participants to suit the requirements of the study through visual cues and small utterances.

3.2.4 Thematic analysis

The thematic analysis technique was employed to analyse the data collected during the interview. Thematic analysis involves going through a set of data and identifying patterns in the meaning of the data to find themes. According to Figgou and Pavlopoulos (2015), involves coding of data into clusters of identical entities, or conceptual categories and the identification of consistent patterns and relationship between themes, helping to come up with a theoretical explanation of a phenomenon under study. During the study, certain patterns within the transcribed data were identified and further developed into themes, and eventually became the categories of analysis. Themes capture the most significant ideas concerning the data in relation to the research objectives and represents responses that seem to form a pattern or meaning within the data set. Thus, the themes were obtained in line with the objectives of the study.

Both primary and secondary were used during this study. Primary data was obtained from participants that included maize farmers, leaders of farmers associations, aggregators and officials of the Agricultural Department of the NAMA. Secondary data was obtained from the official inventory of Nsawam Adoagyiri Municipal Assembly as well as the Ghana Statistical Service 2010 Population and Housing Census that provided information on the population, socio-economic activities and administrative structure of the municipality. As a way of understanding the deep issues in grain production and losses,various materials such as articles, journals, books, report, thesis and other scholarly materials were consulted to provide relevant information.

3.2.5 Organizing interviews and interview schedules

An introductory letter from Institute of Statistical, Social and Economic was presented to the Nsawam Adoagyiri Municipal Assembly to give notice to the rightful authorities. The participants were duly informed of the purpose of the study and how their responses will help in understanding the impacts of grain loss within the municipality. English was the main language of instruction used in conducting the interviews. However, the Nsawam Adoagyiri municipality is made up of individuals with different ethnic backgrounds and mostly communicate and interact only in their local dialect. Thus, the researcher recruited additional assistants who are conversant with the local languages spoken within the municipality to ensureall participants have a clear understanding of questions and the objectives of the study.

3.2.6 Limitation

The main limitation of the study was the timeframe and resources needed to reach to wider areas. At times, getting the maize farmers to interview was a problem as they usually leave very early in the morning to their farms and return later in the evening tired. Interviews were sometimes conducted late at night which was at times inconvenient for the participants.

3.2.7 Ethical consideration

The consent of the participants was sought before the interviews and assured of the protection of their personal information and views on the subject at hand. Pseudonym was assigned to all the participants as a way of protecting their identities and names. The interview was not done under duress and participants had the freedom to pull out at any time if they felt uncomfortable with the direction of the interview.

CHAPTER FOUR

ANALYSIS AND FINDINGS

This chapter present the findings and analyses of data gathered from maize farmers, aggregators and extension officers within the Nsawam Adoagyiri municipality. The chapter is divided into two main parts. The first part gives a report on the responses gathered from the semi-structured interviews and focus group discussion of participants on the field. Semi-structured interview is a method of qualitative data collection where participants are asked open-ended questions from an interview guide and probed further to explore their response on a particular topic of interest. These are arranged thematically to satisfy the main objectives of the study. The responses and accounts of the respective participants of the study were grouped into themes according to their perspectives and experiences of grain loss in maize production within the municipality. In the second part of the chapter, the data is thematically analysed and examined to answer the research questions of the study.

4.1 Demographics of participants

The demographic information (*Table 4.1*) provides data on research participants in the Nsawam Adoagyiri municipality such as their age, marital status, dependents, and number of years involved in their corresponding economic activities. To ensure confidentiality, a generic naming system was used and specified labels assigned to each participant who was interviewed (A1, A2, A3….).

Table 4. 1: Demography of participants

Participant	Age	Gender	Main Occupation	Other occupation	Level of Education	no. of children	Other dependents
A1	52	Male	Maize farmer	Teacher	1st degree	4	5
A2	54	Male	Maize farmer	no	JHS	3	2
A3	60	Male	Maize farmer	no	Technical School	1	2
A4	41	Female	Maize farmer	Trader	Primary	6	2
A5	44	Female	Maize farmer	no	JHS	3	1
A6	48	Female	Aggregator	Farmer	no formal education	4	none
A7	55	Female	Maize farmer	no	JHS	4	2
A8	32	Male	Maize farmer	no	JHS	1	none
A9	68	Male	Maize farmer	no	JHS	2	none
A10	50	Female	Maize farmer	no	no formal education	3	none
A11	67	Male	Maize farmer	no	no formal education	3	3
A12	62	Female	Maize farmer	no	no formal education	2	2
A13	57	Male	Maize farmer	no	JHS	3	1
A14	36	Male	Aggregator	no	JHS	5	2
A15	53	Male	Maize farmer	no	JHS	2	2
A16	42	Female	Aggregator	no	Primary	4	2
A17	35	Female	Maize farmer	no	Primary	2	1
A18	37	Male	Maize farmer	no	Primary	3	1
A19	35	Female	Aggregator	no	Primary	6	none
A20	43	Male	Maize farmer	no	no formal education	1	2
A21	47	Female	Aggregator	no	JHS	4	1
A22	58	Male	Maize farmer	no	JHS	2	3
A23	39	Male	Maize farmer	no	JHS	3	3
A24	46	Female	Aggregator	no	Primary	5	2
A25	52	Male	Maize farmer	no	no formal education	3	1

Source: Author's construct

4.1.1 Age of participants

A total of twenty-five (25) participants were sampled within the municipality for the study. From observation within the study area and interactions with the participants, it emerged different age groups are involved in the production, processing and marketing of maize within the municipality. The minimum age of the participants recorded was 32 years with the maximum age being 68 years. The average age of the nineteen (19) maize farmers interviewed was 50.5 years. This indicated the low choice of farming as the main occupation of the youthful population within the municipality.

4.1.2 Sex Distribution

Both men and women are actively engaged in agricultural activities within the municipality. However, the study revealed that, men dominate enormously in the maize farming. According to GSS (2010), 60% of the people within the municipality who are involved in agricultural activities are men whiles women constitute the remaining 40% of people in that sector. This disparity may be attributed to varying factors within the society. Gyasi et al., (2014) noted that, men owned and controlled most undeveloped lands which are required for agricultural purposes. In various African societies including Ghana, men are regarded as the heads of households who are entrusted with resources such as land. In Ghana, local chiefs who are predominantly males are the custodians of traditional lands and possess the authority to sanction its usage for any purpose. This cultural arrangement may contribute to the male dominance within the society.

Agriculture in SSA is largely labor-intensive and strenuous and requires financial resources to hire additional labour to undertake activities on the farmland. The disparity in resource availability between men and women possibly affects the ability of women to employ additional labour thus, preventing more women from engaging in crop production (Obuobie, 2004). This situation leaves women with limited choices in crop production and instead involved in other economic activities such as aggregators. The aggregators interviewed during the study were largely made up of women who purchase both fresh and dried maize from farmers and subsequently sell to traders in the various markets.

4.1.3 Occupation Description

Agriculture serves as the main occupation for many individuals in SSA especially in rural areas. In Nsawam Adoagyiri municipality, agriculture is a major economic activity which provides employment and other essential income-generating activities for several households. Majority (17) of farmers who participated in the study are full-time farmers who mainly cultivated maize in their respective farms. A small number of farmers keep alternative occupations as a way of generating additional income for the wellbeing of their various households. The farmers also had other measures of increasing their income by cultivating other crops. All the farmers interviewed indicated that, focusing all resources and efforts into the cultivation of a single crop comes with a greater risk. Thus, maize farmers within the municipality also cultivate two or more additional crops to diversify risk and sustain their income. The mixed method farming system is dominantly adopted where maize is combined with other crops such as cassava. Other crops cultivated by the maize farmers included pepper, garden eggs, okro, tomatoes, onions, green pepper, oranges, pawpaw and pineapple.

4.1.4 Level of education

In terms of attainment of education, majority of the participants interviewed had achieved some form of formal education. Education is an essential basic need in every economy which plays an important role in the lives of people. It facilitates dissemination of information and acquisition of knowledge and training especially for farmers. Of the twenty-five (25) participants interviewed, nineteen (19) had some level of formal education with the remaining six (6) having no form of formal education. However, only two (2) participants had technical school and tertiary education respectively. Eleven (11) of the participants had attained junior high or middle school education with the remaining six (6) had attained basic primary school education.

4.1.5 Experience level

The minimum number of years of experience of the participants was three (3) years with the maximum years being forty-four (44) years. The maize farmers indicated that farming has been part of their whole lives as their parents and guardians who were already in the occupation introduced them to it.

4.1.6 Number of children and other dependents

All the maize farmers interviewed indicated during the study they had at least one (1) child. The participant with six (6) children had the highest number. In addition to their children, some of the maize farmers were responsible for the wellbeing and provision for other dependents within their households. These additional dependents were of varying age groups, mostly children and elderly individuals who are too frail to be involved in any labour-intensive activities to earn income for their daily needs. Furthermore, the dependents were either related to the maize farmer in different capacities such as through biological relations or just mere acquaintances.

The number of children and other dependents are so important in maize production as these individuals may be depended on for labour throughout the maize supply chain. Children and other dependents in the household assist farmers in undertaking several arduous duties which may have required paid additional labour. A maize farmer that has a bigger household means there is more family-labour which is critical especially during harvesting, transportation and threshing and cleaning stages of the maize supply chain. Having a bigger household with children and other dependents present more incentive to produce and store more grains for consumption.

Table 4. 2: Overview of themes used

Research Questions	Themes
1. What factors contribute to grain loss in NAMA?	Timing of harvest Apathy and misuse of agrochemicals Inadequate storage options Hoarding of grains
2. What are the socio-economic effects of grain losses on the inhabitants of NAMA?	Waste of limited resources Income of individuals within the maize supply chain Food security
3. What are the constraints in addressing grain losses in NAMA?	Financial constraints

Source: Author's construct

4.2 Reasons why maize losses are recorded

The main aim of this sub-section is to analyse the respective responses from participants on the main reasons grain loss are recorded in maize production in the Nsawam Adoagyiri municipality. These losses are recorded throughout the maize supply chain especially at pre- harvest handling, post-harvest processing and various storage practices among maize producersin the municipality. Three major themes emerged out of the various responses gathered from the participants on the field.

4.2.1 Timing of harvest

Maize farmers employ a lot of methods in their pre-harvest handling and management of maize production in their farms. These methods involve leaving the maize crop on the field to fully mature and dry in order to increase market prices and have the right moisture content to safely store the grains in the available storage options. Furthermore, these methods may influence the period of harvesting. Harvesting is the initial and critical step in maize production which determines the overall crop quality of maize.

During the interaction with maize farmers, it emerged that, harvesting in the municipality is entirely done manually with physical labour with cutlasses when the maize is fresh and removed with bare hands when the maize is dried. According to Darfour & Rosentrater (2016), the timing of harvesting is a determining factor dictating grain loss during the harvesting stage of maize production. In the Nsawam Adoagyiri municipality, grain loss occurs before or during the harvesting periods as crops are not adequately matured and has a high moisture content. Maize is harvested early with high moisture content due to the preferences of consumers who patronize boiled maize. The following excerpts show the reasons maize farmers harvest their crops early.

"We harvest the fresh maize with high moisture content at dawn around 3am as it is highly preferred by aggregators as well as food vendors who boil and sell to consumers. In case we are unable to sell, we are forced to dry them on the shed which is susceptible to insect attacks as the moisture levels are high" (A2, Maize farmer).

Also, farmers may delay in harvesting their maize crops in order to leave it on the field to adequately dry. This makes it convenient for the farmers to reduce the risk of the maize grain developing mould and attacks from pest. This also reduces the task involved in dehusking and shelling of the maize grains from the cobs. As harvesting is also labour-intensive, maize farmers may be forced to delay the period of harvesting as a result of limited supply of labour.Maize farmers who do not have a large family size may be forced to hire labourers to undertake the task of harvesting the maize crops. On the supply of labour, this was the response from some of the maize farmers.

"I depend hugely on external labour as I am a young man with only one little child. If I do not get labour on time to harvest the maize crops, I am forced to leave them on the field for a longer period which exposes them to attacks from birds, insects and at times theft. At times getting labour to help on the farm becomes difficult as the youth choose to be involved in other businesses like motorcycle taxi (Okada) (A8, Maize farmer)*".*

Another stated: *"All my children are matured and have moved to other places within the country. Due to my old age, I am forced to harvest the maize crops alone with my wife. In case any of us is not physically fit, we are forced to delay harvesting. I once abandoned my matured maize on the farm as I struggled to get labourers to harvest and carry them to my home"* (A9,Maize farmer).

The manual labour required for harvesting in developing countries means that, during harvesting peaks alongside other existing factors such as inclination to other occupation, there may be shortages in the supply of labour.

The white maize variety, which is mostly harvested fresh, has a high moisture content. It is the maize variety boiled and sold by food vendors. The maize farmers reiterated; "this variety cannot be stored for a longer period on the shed if we are unable to sell it fresh to the aggregators". On the other hand, leaving the matured maize on the farm with the aim of drying and reducing the moisture result in grain loss due to attacks from birds and other pests.

4.2.2 Apathy and misuse of agrochemicals

From the data obtained through the interaction with the participants, another major cause of grain loss in maize production within the municipality is the apathy towards the use of agrochemicals which is known to effectively reduce grain loss significantly. KII with agricultural extension officers revealed that; misuse of agrochemicals results in its ineffectiveness driving the apathy towards its application to grains. There was a divided opinion on the use of agrochemicals in protecting grains among the maize farmers. Some maize farmers explained, they are anxious to apply chemicals to grains as it may pose health risks. The misuse of chemicals in agriculture in SSA is a major setback to its effectiveness. Below is the response from the key informant interview participant.

"Some farmers continue to misuse chemicals on their respective farms and homes. I recall a situation where one farmer intended to kill off weeds growing in his farm ended up destroying the maize crops due to wrong application. A mixture of pirimiphos-methyl (Actellic) and permethrin, commercially sold as Actellic Super is an effective chemical if used right can help limit grain loss in maize production. Unfortunately, most farmers are not conversant with its usage and effectiveness" (Extension officer).

Other responses from maize farmers on the usage of chemicals in maize production is outlined below.

"I try to sell the grains immediately after dehusking and shelling to prevent losses. The surplus is stored in a room but not for a longer period. I do not add any chemical as I believe it has health consequences. Chemicals that are added to a sack of grain to kill insects may also have some effect on our health" (A8, Maize farmer).

"After dehusking and shelling I usually sell it immediately. If there is any surplus, I make sure they are adequately dried and stored in a sack. I add some chemicals which is in the form of tablets by wrapping them in cotton wool and keeping it in the sack which allows the grains to be kept for over 6 months without any damages" (A10, Maize farmer).

Per the responses from the maize farmers, the use of chemicals is an effective way to controlling pest and insect attacks on maize grains. However, adequate training and knowledge of its usage is required to achieve positive result of limiting grain loss. The extension officers further cautioned;

"the incorrect dosage and application can pose a health hazard and also result in high storage losses".

4.2.3 Inadequate storage options

During the interactions with the maize farmers and extension officers, questions were asked about the available storage options in the municipality and its efficiency to maintain grains in good quality for a longer period of time. The maize farmers gave varying reasons why they continue to make use of the traditional storage options which expose grains to significant losses. Below are excerpts from some of their responses;

"We build a shed to keep the harvested grain without removing the husk for four months. We light fire under the shed to speed up the drying process. However, maize stored on the shed is exposed to theft and rodent attacks" (A7, Maize farmer).

"I try to sell the grains immediately after dehusking and shelling to prevent losses. The white maize variety easily losses quality if kept in the sack for more than a month. Since I do not add any chemicals to the grains in the sack, I cannot keep it for a longer period to get higher prices"(A8, Maize farmer)

"We have advised the maize farmers to construct cribs as an alternative to the traditional storage options currently available to them. Also, hermetic bags were introduced, and farmers were trained on its usage and effectiveness in preventing grain loss. However, adaptation to its usage has been poor and slow" (Extension officer).

Storage is important to maize farmers as it makes it possible for grains to be stored for a longer period in a good state to ensure food security as well as for future favourable prices. Harvested maize is spread on the open floor or kept in oxygen and moisture permeable bags which are unable to prevent grain loss. The available traditional storage option does not give maize farmers the capacity to sufficiently store the grains as there are continuous threats from insects, pests and thieves.

From observations on the field, none of the farmers used modern or any form of advanced storage facilities in storing the maize grains for effective protection against losses. For instance,the hermetic bag which is one of the recommended modern storage options known to considerable limit grain loss. None of the farmers interviewed used this storage option to store grains after harvest. The maize farmers widely cited financial constraint and lack of knowledge as the main reasons for not considering the modern storage facilities.

4.2.4 Hoarding of grains for favourable prices

It emerged from the study that, maize farmers within the municipality mostly have ready market for harvested maize throughout the year. However, one major challenge to maize farmers is the prices at which they are willing to sell their produce for. From the interviews and observation on the field, maize farmers are driven to either store or sell their grains based on the existing market prices.

One of the maize farmers elaborated how prices influence their decision to either sell or store their maize grains.

"We are forced to sell immediately after harvest due to financial constraints. However, as we all plant and harvest around the same period, prices are mostly low due to increased supply in the market. In order to get good prices, we delay the harvesting to allow the grains to be adequately dried. We then store the grains as long as we could till demand goes up before we sell it" (A4, Maize farmer).

Another farmer reiterated that they are forced to store maize that are not immediately sold after harvest;

"We grow the white maize in the major season and the yellow maize in the lean season. Harvesting the white maize fresh can generate substantial returns as it is mostly boiled and consumed. If we are unable to sell the white maize fresh, it is left on the farm to dry. Unfortunately, the white maize

cannot be stored for a longer period to generate high prices in the available storage facilities" (A22, Maize farmer).

From the responses it emerged that, maize farmers heavily depend on storage facilities in order to generate favourable prices for their yield. However, the available traditional storage facility is not adequate to sustain the harvested grains for longer periods.

4.3 The effect of grain loss

There are varying figures associated with reported grain loss across SSA countries. The magnitude of the effect of grain loss are contestable as estimating the amount of grain loss remains a challenge. Nevertheless, from the interaction with the participants, various impacts of grain loss in the Nsawam Adoagyiri municipality emerged. Grain loss in maize production has both environmental and economic effect on households within the municipality. The most prominent impacts are outlined below.

4.3.1 Waste of limited resources

Maize production requires the use of some limited but important resources by farmers. These resources include water and land which is critically required for the maize production that ensures the constant supply for both rural and urban consumption. Maize farmers invest significant time and effort in order to secure these limited resources with the aim of generating income to provide basic needs for their families. Noticeably, virtually all the maize farmers interviewed are not the original owners of the lands used for farming. There are land tenure systems in place that apportion how much yield both farmers and owners receive after harvest.Additionally, lands previously used for agricultural activities are being sold off to estate developers for the construction of residential housing units.

These arrangements are also dependent on the type of crop(s) cultivated on a land. In maize farming within the municipality, the yield after harvest is divided into three (3) folds where one (1) is given to the owner and the farmer takes the remaining two (2). All the work and inputs required for the tilling and cultivation of crops on the land is the responsibility of the farmer. The farmers are required to produce agriculture inputs such as insecticides, fertilizers,farm tools and transportation as well as labour involved in different stages of maize production.Therefore, grain loss reduces the amount of yield available to farmers for household consumption and sale at the market for income. The remarks made by some maize farmers are as follows:

"Since I started farming, I have never owned the land I work on. We have an arrangement with the owners where a portion of the total yield regardless of how much is lost is shared accordingly. Grain loss significantly reduces the total amount of grains we get as well as our income. The land tenure system is a major problem for us!" (A11, Maize farmer).

"The land tenure system does not favour the farmers. A significant portion of the farmer's share is used to procure farming inputs such as insecticides, weedicides and fertilizers. If these inputs are not used on the farm our yield reduces drastically which goes against us" (A15, Maize farmer).

From the preceding responses, maize farmers considerably invest to secure limited resources to ensure maximum yield on their farms. Grain loss leads to wastage of resources and also results in smallholder farmers becoming net buyers for the same crops they grow.

4.3.2 Income of individuals within the maize supply chain

Maize farming is one of the major agricultural activities in the Nsawam Adoagyiri municipality. It gives individuals the opportunity to generate income for their basic needs and wellbeing. Maize farmers and other players within the maize supply chain explained how grain loss affects their income levels.

"My main source of income is from maize farming. Any grain loss recorded affects the income I get from the maize farming. At times, out of 10 bags of maize harvested, 4 bags can be lost. This situation reduces the number of bags of maize available for me to sell and also save for future consumption" (A15, Maize farmer).

Another stated; *"If we are unable to sell the fresh white maize to the aggregators, we struggle to store them for longer periods. They turn into a powdery form when kept on the sheds for too long. In this state, we can neither consume nor sell it to the aggregators. Even when we feed it to the household livestock, it changes their faecal droppings and makes them sick"* (A11, Maizefarmer).

Other individuals within the maize supply chain explained how grain loss affects their income.

"I check for the quality of the maize grains before purchasing it from the farmers. I usually reject any discolourised and insect-infested grains which reduces the overall income of the maize farmer" (Aggregator).

Grain loss may occur all along the maize supply chain from the field to the market, which reduces real income for all producers. This especially affects the poor in rural areas, as such a high percentage of their daily economic activity is devoted to maize production. Inefficiencies in the maize supply results in the poor quality and safety of grains which reduces the income producers especially farmers generate.

4.3.3 Food security

During the in-depth interviews with respondents and field observation, another impact of grain loss associated with maize production is food security. A significant volume of grains is lost in developing countries after harvesting, exacerbating hunger and resulting in the wastage of expensive inputs and resources. Inadequate postharvest handling and management threaten food security and the overall livelihoods of rural poor who depend on maize farming as a source of food and income. Grain loss in maize production also impede the supply and quality of grains to the rapidly increasing urban consumers and potential export markets for foreign exchange.

In the Nsawam Adoagyiri municipality, grain loss threatens subsistence farmers who largely depend on maize production for household consumption. While most maize farmers cultivate other crops such as cassava, pepper, green pepper, garden eggs, pineapple, pawpaw and plantain, maize is a staple crop which is still needed for the preparation of several delicacies.

A maize farmer described the effect grain loss has on his family with regards to food security;

"I only rely on the produce from my farm to survive since I do not have any additional job. At times when significant losses occur, it reduces the food available for my household consumption. Thus, I depend on the benevolence of my neighbours who provide me with some food" (A7, Maize farmer).

4.4 Constraints in addressing grain loss

4.4.1 Financial constraints

One major problem faced by farmers in SSA is financial constraints that restrict their ability to intensively invest in their farming activities. Farmers require financial assistance to obtain agricultural inputs needed to increase crop production and improve storage facilities to store surplus yield for future consumption and sale. It is widely known that the use of modern and improved storage technologies significantly reduces post-harvest losses (Kaminski & Christiaensen, 2014). Experts within the municipality hold the same view as modern storage and improved practices reduces grain loss. Below is the view of an extension officer on modern storage and the constraints farmers face procuring them.

"Farmers do not usually get any form of financial assistance from any formal financial institutions as they hardly possess the required documentation and collateral needed. This restricts their ability to get farm inputs such as fertilizers, insecticides, weedicides and most importantly investing in modern facilities to reduce food losses" (Extension officer).

To affirm the response from the extension officer, some maize farmers expounded on their financial situation especially with regards to assistance from formal financial institutions.

"We have arrangements with the aggregators who assist us financially in times of hardship. The aggregators provide us with money which is mainly used to purchase agricultural inputs and cater for our household needs. We have never had financial assistance from any formal financial institutions. They explained it was too risky to give us loans for our farming activities" (A2, Maize

farmer).

"I do not get any form of financial assistance from any formal financial institution. I get support from my customers who give me money in difficult times, and I supply them with maize after harvest to repay the debt. Due to the documentation processes involved and the kind of work I do, I feel I will not get any assistance from the banks" (A8, Maize farmer).

From interactions with the maize farmers, it emerged none had ever received any form of financial assistance from formal financial institutions since they started farming. The maize farmers largely relied on the benevolence of family and friends and other times aggregators who provide financial assistance in exchange for harvested yield. Though maize farmers get such informal financial assistance, they are purposely used for household needs and at times for agricultural inputs such as fertilizers, pesticides and improved seeds. Maize farmers inability to access loans from formal financial institutions limit their ability to heavily invest in modern storage technologies proven to reduce grain loss.

4.5 Analysis of findings

This section aims at discussing the findings with regards to the respective research questions.

4.5.1 Assessing the major causes of losses from maize production in the Nsawam Adoagyiri Municipality

Maize undergoes various stages that includes; harvesting, drying, cleaning, storage, processing, transportation and markets before it finally gets to the consumer. During the movement within the supply chain, grains are lost as a result of several factors such as; activities of insects, pests and rodents, improper handling and inadequate storage facilities not capable of sustaining and protecting grains. Grain loss happens throughout the stages of the maize supply chain. In the Nsawam Adoagyiri municipality, the predominant agricultural activity in the municipality is crop farming. Crops are cultivated within the municipality throughout the year. Maize is a staple food used for a range of dishes within the municipality. Cultivation of maize is also an avenue for individuals to generate income for their wellbeing and needs.

Within the municipality, maize farmers plant twice within the year with the first planting season in April and the second in October. Grain loss in maize production occurs throughout the supply chain within the municipality. Within the municipality, maize harvesting is usually done manually with cutlass and at times with bare hands. White maize is usually harvested fresh when the color of the outer husk is still green. Aggregators distribute to other vendors who boil and sell to consumers. One reason the white maize is harvested fresh is due to its poor ability to be stored for longer periods in the available traditional storage facilities. Delaying in harvesting can make the maize grains susceptible to attacks from birds, pests and rodents.

The threshing process in maize production involves detaching the grains from the cobs. This is done when the maize is sufficiently dried after being left on the farm after maturity or kept on a shed. Threshing within the municipality is also done manually where the dried maize cobs without the outer husk is kept in a sack and stroked severally with sticks. The grains are then carefully removed from the cobs. During the threshing process, occurrences such as spillage, incomplete separation of the grain from chaffs, grain breakage, are some of the main causes of grain loss. After the threshing process, grains are cleaned by separating grains from broken grains and other foreign materials such as dried weeds, stones and sand. Winnowing is one of the main methods used during cleaning. The winnowing process accounts for about 4% of the total grains lost within the supply chain (Kumar & Kalita, 2017).

The moisture-content level required for grains to be kept for a longer period is at 13%. Grains which are not adequately dried can result in mould growth, pest and insect infestation and increase losses during storage. Maize farmers within the municipality mostly leave the maize crops on the farm after maturity to start the drying process. Even though this practice exposes the grains to birds, rodents and insect attacks, maize farmers have limited drying options. The grains are separated from the cobs through threshing and spread on plastic sheet to naturally (sun) dry them. This method of natural drying is cheap but requires constant supervision as grains left unattended may be eaten by birds and household livestock such as goats, sheep and pigs. Grains may also get contaminated with sand, stones, faecal droppings of animals. Unexpected rains can revert the whole drying process if dried grains are not constantly monitored.

Other drying methods includes arranging the harvested maize with the outer husk intact on a shed. Fire is lit or cooking is done beneath the shed to intensify the drying process. One limitation faced by maize farmers who resort to this method includes rodent attacks as well as theft.

Storage plays an important role in the maize supply chain as it allows for grains to be kept for a long period of time. All the maize farmers interviewed stated that, they only make use of traditional storage facilities within the municipality. Maize farmers lack the financial resources to fully invest in modern and improved storage facilities which are known to reduce grain loss.

Maize grains are usually stored on sheds which also serves as a facility for further drying. Maize stored on the shed are exposed to rodents, insects and theft which can cause losses. Other maize farmers kept the maize in aerated sacks which exposed the grains to insect infestation. The Agricultural Department within the municipality introduced modern storage options such as the hermetic bags but interest from the maize farmers has been poor. Sugri et al., (2021), similarly reported the low patronage of hermetic bags by farmers which significantly leads to grain losses. Also, maize farmers were advised to construct metal cribs which are known to be durable and helps reduce grain loss. Again, the initial cost involved in procuring such facilities is a major challenge for farmers. A study by Farnworth (2021) in Kenya, Malawi, Zambia and Zimbabwe also found that, the initial investment costs for metal silos present a major barrier to adoption by farmers.

Transportation within the municipality has improved drastically as road networks link various communities to their respective farms. This allowed maize farmers to use tricycles and at times small trucks to convey harvested maize from the farm to their homes. Grain loss are hardly recorded within the municipality as a result of transportation issues. Also, maize farmers usually have access to market throughout the year. Maize grains are stored for longer periods in order to get favourable prices. However, poor storage facilities mean maize farmers continue to record losses during this stage.

Lastly, respondents suggested several measures to help reduce grain loss in maize production within NAMA. Some of the measures required individual efforts while others required assistance from policymakers and other non-governmental organizations. Most respondents indicated improved storage facilities can help in reducing grain losses. Figure 4.1 below shows the key words commonly used by respondents.

Figure 4. 1: Measures required to help reduce grain loss

Source: Fieldwork

4.5.2 Identifying the socio-economic effects of maize losses on the inhabitants of Nsawam Adoagyiri Municipality

Grain loss present various environmental, social and economic effects on households, society and economy. Grain loss results in wastage of critical resources such as land and water in the environment. In the Nsawam Adoagyiri municipality, farmers are already facing difficulty with access to lands for farms as available lands are constantly being sold off to estate developers for residential purposes. Most maize farmers do not own the lands used for farming and instead enter into land tenure agreements with landowners within the municipality. These agreements are mostly unfavourable to farmers as they are responsible to till the land and provide the necessary agricultural input to cultivate crops. For instance, maize farmers are usually required to divide the final yield into three (3) where landowners are given one (1).

Nsawam Adoagyiri Municipality is endowed with a number of water bodies. These water bodies are in the form of rivers, dams and dugouts. The municipality is drained mainly by River Densu and its tributaries such as Ntua, Pompon, Ahumfra and Dobro. Regardless, maize farmers mainly depend on rainfall for irrigation on their respective farms. During dry seasons, some maize farmers acquire farmlands close to these water bodies in order to access water for irrigation purposes. Thus, these resources are wasted if significant grain loss are recorded by maize harvest. It is estimated 173 billion cubic meters of water is used to produce food that are lost or wasted whiles 198 million hectares of cropland is used to grow food that is lost or wasted annually (Lipinski et al., 2013).

Economically, grain loss presents wasted investments as it reduces the incomes of actors within the maize supply chain. Maize farmers are faced with financial constraints as many encounter difficulties in securing loans from formal financial institutions. This renders farmers with few options to access financial assistance to invest in their respective farms. Maize farmers usually depend on aggregators who provide financial assistance in exchange for harvested maize.

In addition, maize farmers purchase various agricultural inputs such as fertilizers, weedicides and pesticides in order to ensure a bumper harvest for increased returns. Agricultural activities such as maize farming requires substantial labour. Maize farmers with larger family sizes depend on their children and other dependents for free labour. At times, additional labour is hired to support activities on the farm. This additional labour is paid for with part of the overall yield. Maize farmers bear all the cost and expect to generate adequate income from selling their grains to aggregators and at the market. Grain loss recorded especially after harvest significantly reduces the income of maize farmers and other actors within the maize supply chain.

Lastly, both subsistence and commercial farmers found in rural areas depend on their respective farms for most of their food supply. Grain loss recorded in maize production does not only threaten the income of maize farmers but also their food security. Supply of maize to the growing urban population can reduce as a result of grain loss.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The final chapter presents the summary of the key findings, to answer the research questions and objectives. The first section describes the summary of the final findings. The second section also describes the conclusions that are drawn from the key findings of the study. The third and final section makes some recommendations in addressing grain loss.

5.1 Summary of key findings

This study set out to examine the effect of grain loss on socio-economic wellbeing with evidence from maize production in the Nsawam Adoagyiri municipality. The main objectives of the study are to assess the major causes of losses from maize production as well as identify the socio-economic effects of losses on the inhabitants of Nsawam Adoagyiri municipality. The study was conducted in the NAMA as agriculture is the major economic activity in terms of employment and income generation. Various individuals within the maize supply chain were interviewed to understand the processes involved in maize production within the municipality and the factors resulting in losses. Maize farmers are one of the main actors in the maize supply chain explained the challenges faced that limit their ability to fully address grain loss in the initial stages of production.

The study established that, losses in grain production are experienced worldwide. However, these losses are prevalent in SSA and has socio-economic effects on various households and society. Throughout the maize supply chain, significant losses are made during harvesting, threshing and cleaning, drying, storage, transportation and at the respective market centres. In developing countries, pre-harvest and post-harvest losses are recorded, which threaten food security and result in expensive agricultural inputs and resources such as fertilizer, weedicides,irrigation water, land and labour being wasted.

During postharvest management in maize production, there are both quantity and quality grain loss. Qualitative losses can result in reduction in market and nutritional value which may also pose a serious health hazard if contaminated grains are consumed. Quantitative losses also reduce the grains available for maize farmers for household consumption and also to sell in order to generate income. The study found that, several factors influence losses in maize production within the municipality. One major cause of losses in maize production is the timing on which farmers harvest their crops after maturity. Harvesting timing is a crucial factor that dictate losses during harvesting of maize. Farmers harvest fresh maize early to sell to vendors who boil and sell to consumers. In case the maize farmers are unable to sell the fresh maize, the high moisture content makes it susceptible to mould growth and insect infestation.

Late harvest also exposes the maize crops to rodents and bird attacks. Also, apathy and misuse of agrochemicals is one of the main causes of losses. Agrochemicals such as pirimiphos-methyl (Actellic) and permethrin, commercially sold as Actellic Super which is known to effectively reduce grain loss significantly are misused by some farmers. This situation has dire consequences as these chemicals can be poisonous if applied wrongly. This has created an apathy towards its application on grains. Furthermore, the traditional storage facilities available to maize farmers also limit the period of time grains can be safely stored, and also expose them to insects, rodents and pest attacks.

The study also found that, there are socio-economic impacts of grain loss in the municipality especially on maize farmers. Limited resources such as land and irrigation water are used to produce grains that are lost. Losses also reduces the expected returns in income for maize farmers and other actors in the supply chain. In addition, losses exacerbate poverty and food security of households.

From the study, it was understood that maize farmers usually hoard grains in storage facilities when prices in the market are unfavourable. Maize farmers also continue to struggle to get access to loans from formal financial institutions which constrains their ability to invest in their farming activities such as procuring modern storage facilities.

5.2 Conclusion

From the above discussions, various conclusions can be reached. First, losses in maize production are prevalent throughout the municipality. The study revealed that, losses are recorded throughout the maize supply chain during harvest, threshing and cleaning, drying,

storage and lastly at market centres. At times, pre-harvest losses are also recorded as delayed harvesting of matured maize crops are exposed to attacks from birds and insects.

The agricultural system within the municipality is mostly manual-based which is labour- intensive and requires so much time. Maize farmers generally depend on their family for labour. It also emerged that farmers do not cultivate only one particular crop and as such maize farmers interviewed also grow other crops such as garden eggs, okro, pepper, green pepper, plantain, cassava and oranges. Different varieties of maize are planted by maize farmers. The white maize variety which includes *Obatanpa* is usually planted during the raining season in May and harvested fresh with its husk still green in colour. This type of maize is mostly boiled and sold to consumers. The yellow variety which includes *Pioneer (or Pannar)* is planted in October and mostly left to dry on the field after maturity.

From the study, losses in maize production within the municipality is caused by several factors within the supply chain. The timing of harvest is one of the major causes of losses in maize production within the municipality. Matured maize that are harvested too early contain high moisture content and are susceptible to mould growth and insect infestation. Maize farmers explained that, fresh maize with the green husk is preferred by vendors who boil and sell to consumers. The yellow maize is mostly left on the field to adequately dry which exposes them to birds and insect attacks.

The use of agrochemicals is widely known to help reduce losses in grain production especially during storage. However, the study established that, the constant misuse of agrochemicals significantly reduces their effectiveness. The wrong usage of these chemicals can also be dangerous to the health of consumers. There was also a section of maize farmers who were totally against the usage of agrochemicals during storage and thereby recorded significant losses. However, these maize farmers used various agrochemicals on their respective farms but were against the direct application of other chemicals to the grains. The traditional storage facilities available to maize farmers do not have the capacity to fully protect grains from losses. Thus, losses are constantly recorded during the storage stage.

The study also revealed that, losses have both environmental and economic impacts. Limited resources such as land and other agricultural investments are used to produce maize that are not consumed or are lost. The expected income of actors within the supply chain are also reduced due to losses recorded. As maize is the major source of food for most Ghanaians, continuous losses reduce the food available which threatens the food security of respective households especially in rural areas.

Lastly, the study revealed that, maize farmers are faced with financial constraints as they struggle to secure loans from formal financial institutions within the municipality. Thus, maize farmers struggle to invest in modern storage facilities that are capable of reducing losses and prolonging the period grains can be stored. Maize is sometimes stored for longer periods in order to gain favourable prices from the market.

5.3 Recommendations

To begin, the storage facilities available to maize farmers must be improved to handle grains for longer periods as well as preventing insects and pest infestation. The study established that, maize farmers depend on traditional storage options such as sheds, sacks and bare floor. Maize farmers must be supported to form local cooperatives to secure loans from financial institutions as a group which reduces paperwork and collateral burden on individual farmers. This will help farmers procure improved and modernized storage facilities such as the hermetic bags and metal cribs in order to reduce losses during storage. These improved and modernized storage can help maize farmers keep surplus maize for longer periods to allow future sales for favourable prices.

Training of maize farmers on the use of agrochemicals especially during storage stage can help to significantly reduce losses. This will also reduce apathy towards its usage and encourage more maize farmers to use agrochemicals in addressing losses.

Lastly, the government must embark on initiatives and policies aimed at addressing various problems affecting maize farmers especially postharvest losses. Such initiatives and policies will help sensitize various stakeholders in the agricultural industries about the main causes of losses in maize production and ways it can be addressed. This will build capacity, ensuring sharing of information and best practices with the aim of reducing losses throughout the maize supply chain.

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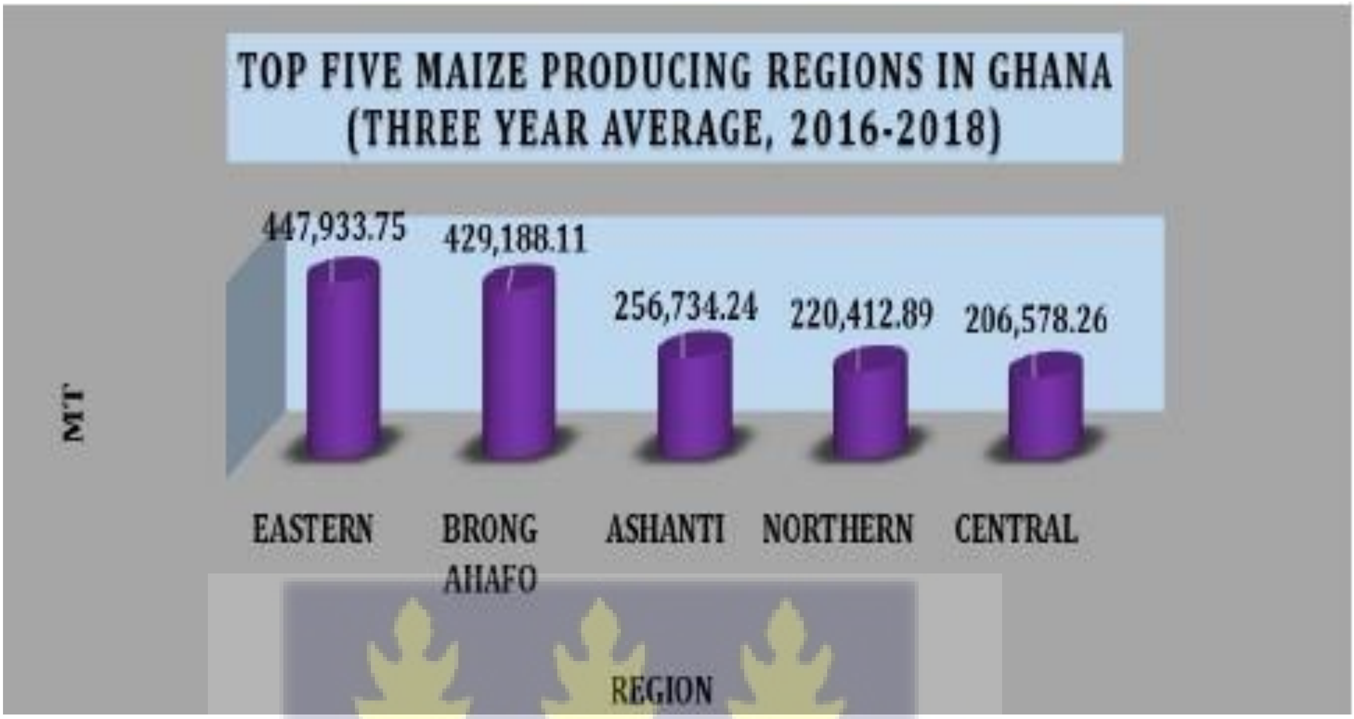
APPENDICES

Appendix 1: Top five maize producing regions in Ghana



Source: MOFA, 2019

Appendix 2: Production Levels of Crops

CROPS	YIELD OF CROPS (METRIC TONS/ HA) AND AREA CULTIVATED (HA)							
	2014		2015		2016		2017	
	Yield (mt/ha)	Area (Ha)	Yield (mt/ha)	Area (Ha)	Yield (mt/ha)	Area (Ha)	Yield (mt/ha)	Area (Ha)
Maize	1.6	7,820.5	2.0	7,231.1	2.2	5,789.9	3,960	5,609.9
Pineapple	59	540.8	64	10,837.1	62	3,734.9	N/A	3,674.9
Cassava	30	7,782.5	33	7,351.5	35	5,769.7	4,975	5,569.7
Cocoyam	N/A	N/A	N/A	N/A	N/A	N/A	186	N/A
Yam	15	215.5	19	249.3	19	108.2	138	100.2
Plantain	3	540.8	4	N/A	4	321.1	1,017	300.1
Oil palm	15	485.9	15	380.3	15	67.6	N/A	67.6
Pawpaw	30	105.6	30	63.4	30	118.3	N/A	118.3
Vegetables	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source: Mid-Term Development Plan, NAMA, 2014

Appendix 3: Interview Guide for maize farmers

UNIVERSITY OF GHANA, LEGON

INSTITUTE OF STATISTICS, SOCIAL AND ECONOMIC RESEARCH

MA IN DEVELOPMENT STUDIES

Introduction

The purpose of this interview guide is to seek for primary data for the conduct of an academic study on the "**Effect of Grain Loss on Socio-Economic Wellbeing: Evidence from Maize Production in The Nsawam Adoagyiri Municipal**". The information being sought is solely for academic purposes and the identity and responses of all participants shall be kept confidential. Your support and co-operation are very much anticipated.

MAIZE FARMERS

Community……………………… Name of interviewee…………….………………………

Date of administration …………………....... Time………………………

Background

1. Age range
2. Marital status
3. Number of children
4. Number of dependents
5. Level of education
6. How long have you been in farming?
7. Apart from maize do you cultivate any other crops?
8. What other economic activities do you engage in aside farming?

Maize supply chain

1. What is the size of your maize farm?
2. What variety of maize do you cultivate?

I. What are the desirable features of this variety? (e.g., drought tolerant, high yielding, short gestation period etc.)

3. Describe some of the methods you employ in protecting your grains before harvest time. (Attacks from birds, rodents, insects etc . .)

4. When do you harvest and what factors do you consider in that decision? (Pre-drying, labor, market etc.)
5. What method do you use in harvesting your crops? (Mechanical or manual method)
6. What was your total output in the last cropping season? (Major season output and minor season output)
7. Describe the method involved in threshing and cleaning the maize grains after harvesting. Do you hire external labour to undertake this activity or rely on family assistance? If you rely on family assistance who usually undertakes this activity?
8. What are the available storage options you can afford for protecting and storing your grains? Approximately how long can these available options preserve the grains?
9. Describe how the grains are dried? How do you determine if the grains are adequately dried before storing?
10. How do you transport the grains from the farm to the market or house?
11. In what medium do you keep the grains during transportation?
12. Do you have access to new information regarding maize cultivation and processing?
13. What market arrangements do you use to sell your maize after harvest? How long after harvest do you sell your maize?
14. What percentage or proportion of your income is from maize farming (i.e., 1 to 10)?
15. How much grains do you lose after harvest (quantity and value)?
16. Do you have access to credit facilities to invest in your maize cultivation?

    If not, where do you get financial assistance to manage your farm?

17. What measures do you think must be implemented to limit grain losses in maize cultivation within the municipality?

Appendix 4: Key informant interview (KII) with agricultural extension department

UNIVERSITY OF GHANA, LEGON

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MA IN DEVELOPMENT STUDIES

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EXTENSION OFFICERS

1. What is your position and role?
2. What are the main varieties of maize cultivated in the municipality?
   i. Is there any reason farmers opt to cultivate a particular variety?
   ii. Do farmers have ready market after harvest?
3. What are the main causes of grain losses in the municipality?
   i. In your opinion, how does this affect farmers' income?
4. Are there any storage facilities available to farmers in this municipality (i.e., warehouses, silos etc.)?
   i. Realistically, how long can you store maize with the current storage options within the municipality?
   ii. Can these storage facilities maintain the quality of grains?
5. What storage technologies have been introduced or promoted by the department for use by maize farmers? (Hermetic bags, metal silos etc.)
6. Does the department disseminate information concerning improved practices in maize cultivation?
   i. What are the medium used?
   ii. Which chemicals are used by farmers in protecting their crops on the farmland?

7. Which chemicals are used by farmers in protecting their crops after harvesting especially during storage?

   i. Are the farmers adequately trained in the use of such chemicals?

8. Do maize farmers have access to credit facilities or any form of financial assistance?
9. What measures do you think must be implemented to limit losses in maize production within the municipality?