ECONOMIC FEASIBILITY OF USING CASSAVA ROOT AFFECTED BY *CASSAVA BROWN STREAK DISEASE* IN POULTRY FEEDS IN MWANZA

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DISERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

Cassava brown streak disease is a destructive disease that causes loss of cassava root in terms of production volume and quality. The disease was reported in Tanzania for the first time in1936. The disease causes root rotting, the rotting is observed during harvesting thus making the root not suitable for human consumption. The overall objective of the study was to assess economic feasibility of using cassava affected by cassava brown streak disease in poultry feeds. The specific objectives were to determine farmers awareness on the presence and effects of the disease, to determine optimal feed formulation with and without cassava inclusion, to compare the costs for feeds formulated with affected and clean root and assess the profit generated by feeds formulated using affected cassava. Data for this study were collected from Sengerema district and Mwanza city. Three diets were formulated for broilers where two diets were cassava based and one diet did not include cassava. The economic evaluation was based on the diets formulated by assessing the cost and profits generated. Descriptive statistics was done to assess farmer's awareness; linear programming (LP) model was used to identify optimal combination of ingredients in the feed formula and unit contribution margin to assess profitability. The costs were compared between cassava based feeds and feeds without cassava. The results from LP model show that the costs of diets formulated were statistically different at one percent level of significance ($P < 0.01$). Sensitivity analysis was done to assess viability of using cassava in broiler diets. The study suggest that key actors in cassava subsector and livestock sectors to create awareness of farmer and processors on the possibility of using *Cassava Brown Streak Disease* affected cassava on broiler feeds as new channel of cassava value addition.

DECLARATION

I, FEDY MHABUKA, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

03-11-2015

Fedy Mhabuka (MSc. Candidate) — Date

The above declaration is confirmed;

03-11-2015

Dr. Anna Andrew Temu (Supervisor) — Date

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DEDICATION

This work is dedicated to my late father Amosi Chelula Mhabuka and my late mother Melekia Salehe Ng'unga who laid the foundation of my education, courage and endless support.

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LIST OF ABBREVIATIONS AND ACRONYMS

ARI	Agricultural Research Institute
CAVA	Cassava value addition
CBSD	Cassava Brown Streak Disease
CMD	Cassava Mosaic Disease
DAICO	District Agricultural, Irrigation and Cooperative Officer
DED	District Executive Director
ESRF	Economic and Social Research Foundation
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
IFAD	International Fund for Agricultural Development
LP	Linear Programming
MDG's	Millennium Development Goals
MUVI	Muunganisho wa Ujasiriamali Vijijini
SPSS	Statistical Package for Social Sciences
TC	Total Costs
TR	Total Revenue
TVC	Total Variable Costs
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

Agriculture is one of the major economic activities carried out by majority living in rural Tanzania. Farmers face many challenges such as drought, diseases, markets and other institutional setting which affect performance of agricultural sector. Development of drought and disease resistant varieties are important to overcome drought and disease challenges. Also development of new market channels and improvement of policy set up will help speed up development of agriculture sector.

1.1 Background Information

The Tanzanian economy depends on agriculture, which accounts for almost one-quarter of (24.7%) country's GDP; it provides 20% of export earnings provides 95% of the food requirement and employs about 75% of the population (Kayandabila, 2013). Agriculture is one of the major economic activities in Tanzania employing larger population of the rural people especially women. It involves growing variety of food crops, cash crops and livestock keeping within the rural setting (URT, 2012).

1.1.1 Livestock sub sector

Livestock production is one of the major agricultural activities carried out in Tanzania. The sub sector contributes to national food supply, converts rangelands resources into products suitable for human consumption and is a source of cash incomes and an inflation–free store of value. It provides about 30% of the agricultural GDP. Out of the sub sector's contribution to GDP, about 40% originates from beef production, 30% from milk production and another 30% from poultry and small stock production (URT, 2012). Majority of farmers in rural areas keep poultry at back yard under free range system. Only few farmers are engaging in commercial poultry farming under good management practices mainly in urban and peri urban. Poultry farmers face many challenges such as quality of feed, high costs of feeds and diseases especially for commercial poultry farmer who keep their animals in door (Hamra, 2010).

1.1.2 Cassava sub sector

Cassava (*Manihot esculenta Crantz*) is the major food crop produced in many tropical regions of the developing world. It provides energy to consumers due to the large amount of carbohydrates in its roots and the third most important food source in the tropics after rice and maize especially for developing countries in Africa (Girma *et al.,* 2013). Cassava is one of the crops grown mainly for human food but it can also be used in preparation of animal feeds for poultry, pigs, sheep and cattle. Cassava is an increasingly important crop in Tanzania it is the second most important food crop after maize in terms of production volume and per capita consumption (Nweke, 2003). Cassava is supporting the livelihood of 37% of farmers in rural areas. The majority of the poorest farmers (59%) are reported to grow cassava for food. Cassava is widely grown in all farming systems in Tanzania due to its adaptability to various soils and agro-ecological conditions (Bennett *et al.,* 2012). Cassava is an important food security and income generation crop for resource poor households in many countries of sub-Saharan Africa including Tanzania. Cassava is also considered to be important crop for climate change adaptation. Cassava roots can be processed into several products for human consumption, industrial raw material and for animal feed industries. Cassava leaves are used as vegetable in limited amount around the production area. The wider use of cassava products offers huge economic benefits to farmers who have markets for their produce and offer opportunities to transporters and processors. Consequently, it creates jobs and improves livelihoods in the rural areas and other stakeholders along the cassava value chain.

Cassava has several other advantages over rice, maize and other grains as food in areas where there is degraded resource base, uncertain rainfall and weak market infrastructures. Historically cassava played an important famine prevention role in many parts of Africa where maize is the preferred food staple and is a recurrent problem (Onyemauwa, 2010). In sub-Saharan Africa, cassava is grown chiefly as human food, but it is also an important animal feed and has several other industrial uses. Cassava has high potential of carbohydrate production per hectare which is about 40% higher than that of rice and 25% more than maize. Therefore cassava plays a major role in meeting carbohydrate demand for human food and livestock feeds (Tonukari, 2004).

1.2 Problem Statement

Despite its importance as famine reserve cassava production in recent years has been affected by *Cassava Brown Streak Disease* (CBSD). CBSD disease was first identified by the Germans in 1894 and the British in 1932. In Tanzania CBSD was first reported in 1936. The disease was observed in several countries of Eastern and Southern Africa in 1950's (McSween *et al.,* 2006). CBSD is a destructive disease that causes loss of cassava root (tuber) in terms of production volume and quality. It can render susceptible varieties unusable if cassava roots are left in the ground for over nine months when it is affected. CBSD was initially confined to coastal, low altitude areas in East Africa, but since the mid-2000s the disease has spread rapidly, affecting Tanzania, Uganda, Kenya, Rwanda and Burundi. The disease has already infected around 80% of crops in Uganda and around 20% of crops in Rwanda and Burundi (Ntawuruhunga and Legg, 2007). CBSD is now occurring in areas that were believed to be unsuitable for the disease such as high altitude areas away from the Indian coastal belt of Kenya, Tanzania and Mozambique. Cassava Brown Streak Disease causes substantial root yield loss of up to 100% particularly in worst affected areas (Ntawuruhunga and Legg, 2007). The threat of CBSD to food security and income of cassava farmers has not been eliminated (McSween *et al.*, 2006).

The rotting observed in the root during harvesting affects the quality of cassava and make cassava root not suitable for human consumption and other cassava end-users such as those using cassava as raw material in food industries like biscuits for human consumption. CBSD affected cassava is used to feed animals at small scale around the areas where cassava is grown but most of the affected cassava is thrown as wastes. Animals like pigs and sheep are fed with cassava affected with CBSD.

Studies conducted in Africa showed that cassava in its different forms has large potential of being used as animal feed (Oppong, 2013; Oladokun and Johnson, 2012; Ironkwe and Ukanwoko, 2012; Bennet *et al.*, 2012; Anaecto and Adighibe, 2011). In many countries livestock production is largely constrained by lack of good quality feed, the availability of alternative source of feed like cassava is important (Oppong, 2013). The studies were done to develop various feed formulation using cassava root as a substitute of maize grain. These studies used cassava which was also suitable for human consumption. CBSD affected cassava is left or thrown away as wastes hence creating losses to farmers with few exceptions where affected cassava is used to feed pigs and sheep. Ntawuruhunga and Legg (2007) suggested that farmers can use disease free planting materials to control the speed of disease spread, but in some cassava plants the signs of disease cannot be detected in the stems and leaves so difficult to identify disease free planting material from their farms. McSween *et al.* (2006) suggested that farmers can compensate for the diseases losses by increasing the plant density of cassava. However CBSD is borne in the planting material from one generation to next. Therefore the possibility of reducing the losses to farmers is very limited because even if plant population is increased as suggested by McSween still losses occur. Damaged cassava is rarely traded in the market. Therefore farmer's chances of losses. are high since the damage is realized during harvesting of the crop. At the time they realize the damage there is a lot of resource being invested that cannot be recovered.

Studies conducted have pointed out that there is a possibility of replacing maize grain by cassava root (Oppong, 2013; Oladokun and Johnson, 2012; Ironkwe and Ukanwoko, 2012; Anaecto and Adighibe, 2011). These studies were done using cassava which is also suitable for human consumption and other industrial uses. Previous studies did not recommend the use of cassava affected by CBSD as animal feed ingredient. The current study in collaboration with animal scientist aimed at assessing the potential uses of cassava affected by CBSD as animal feed ingredient as a strategy of minimizing losses to farmers, manage wastes and improve the livelihood of farmers in the rural areas engaging in cassava production. The results from animal scientist study showed that it is possible to include CBSD affected cassava in broiler feeds but it is not known how its use is likely to influence production costs for animal feed producers.

1.3 Justification of the Study

In Africa, the struggle to provide farmers with varieties resistant to pests and, in particular, viral diseases is an overwhelming challenge (Kueneman *et al.*, 2010). Studies have been conducted to find out techniques of eliminating the disease but no solution to the problem has been identified (Ntawuruhunga and Legg, 2007; McSween *et al.*, 2006). Efforts to find out control measures or cure the disease are still going on by different researchers trying to find out resistant varieties and means of curing or controlling the disease. While efforts are going on farmers still lose their crop due to presence of CBSD in their farms because no means of treatment has been identified so far. The situation made this study important since the control measures of the disease have not succeeded to eliminate the problem for many years (Omongo *et al.*, 2007). Ntawuruhunga and Legg (2007) pointed out that it was no longer possible to eradicate CBSD in Uganda therefore the neighbouring countries and regions should adopt eradication approach to limit the spread of the disease. Efforts are still on process and farmers still get losses due to presence of the disease.

The analysis of the effects caused by CBSD to farmers, intermediate users and end users of cassava affected by CBSD was important to identify the losses farmers get due to presence of the disease. Therefore the current study conducted an assessment on the economic viability of using affected cassava root as a substitute of maize grain in poultry feed. The study made an assessment of the viability of using CBSD affected cassava in poultry feed as a strategy of reducing farmer losses, managing wastes and rescue the endangered rural farmer's livelihood important. It aimed at preventing complete loss of income and an increase in food insecurity for smallholder farmers faced with significant production losses due to presence CBSD. It was important to identify farmer's awareness, the value of losses to small scale farmers and the benefits farmers get. The current study conducted an assessment on the economic viability of using affected cassava root as a substitute of maize grain in poultry feed.

1.4 Study Objectives

1.4.1 Overall objective of the study

The overall objective of this study is to assess the economic feasibility of using CBSD affected cassava root in poultry feed formulation.

1.4.2 Specific objectives

Specifically the study intended to;

i. Determine whether farmers are aware of the presence and effects of CBSD.
ii. Determine optimal feed formulation with and without cassava inclusion
iii. Compare the costs for feeds formulated with affected and clean root.
iv. Identify the profit generated by feeds formulated using CBSD affected cassava.

1.4.3 Hypotheses

i. Farmers are not aware of the effects caused by CBSD.
ii. There are no differences in optimal values in feed formulated with and without cassava inclusion.
iii. There are no differences in costs of feed formulation using CBSD affected cassava and clean cassava.
iv. Using CBSD affected cassava in poultry feed is not profitable.

1.5 Organization of the Dissertation

Chapter Two gives the information from various literature reviewed. Chapter Three explains the methods and techniques that were used in data collection, sources of data, type of data collected and techniques that were used in data analysis. It describes the study area, sampling procedures used and states the main instruments used in data analysis and means of testing hypothesis. Chapter Four presents results of analysis and discussion of the study findings. It includes socio economic characteristics of sample cassava growers, discussion of findings related to cassava production, cassava marketing, post harvest handling, animal feed formulation using cassava and profitability analysis of animal feed formulating enterprise. Chapter Five presents conclusion and recommendation to different cassava key players.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Agriculture Sector in Tanzania

Agricultural development has long been recognized as playing an important role in fostering development in the rest of the economy through a series of linkages between it and other sectors (Kayandabila, 2013). Agriculture also generally plays a predominant role in influencing the size and structure of the rural non-farm economy, by supplying raw materials for agro-processing, providing a market for agricultural inputs and consumer goods and services, releasing labour into other sectors of the economy and supplying and reducing the price of food to the non-farm economy (URT, 2012). It occupies a very important place in the lives of Tanzanians as well the national economy. It provides full time employment to over 70 per cent of the population as well as the bulk of the food. It is estimated that the country is fully self-sufficiency in food and, in good years, a net exporter of cereals (URT, 2008). Agricultural growth has varied across food crops and livestock. Within food crops cassava is ranked the fourth after maize, paddy and beans to contribute to GDP (URT, 2008).

2.2 World Cassava Production

Over the past ten year world cassava production has been increasing year after year (FAO, 2013b). Almost 70% of world cassava production is concentrated in five countries namely Nigeria, Brazil, Thailand, Indonesia and Democratic Republic of Congo (FAO, 2013a). Cassava yields vary with cultivars, season of planting, soil types and fertility and management practices. The increase in cassava production in the world was mainly due to increase in area under cassava production. The size of land under cassava worldwide in 2004 was 18.5 million hectares increased to 20.7million hectares in 2013 (Figure 1).

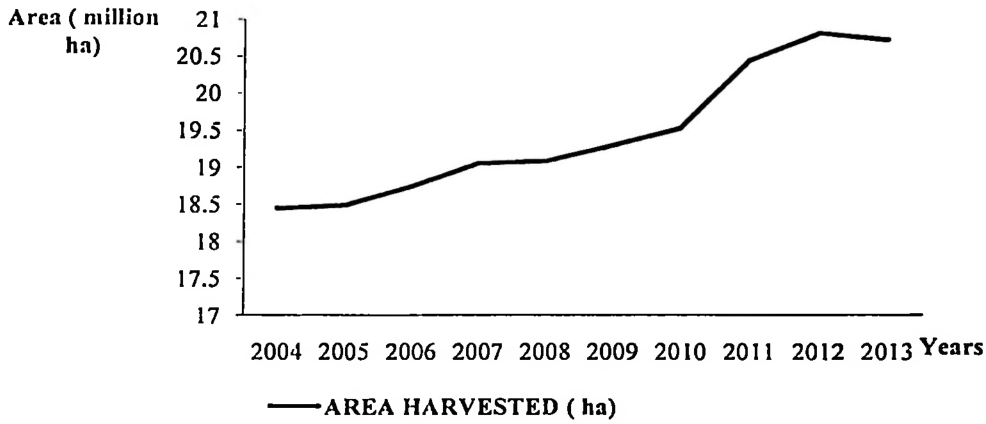

Figure 1: World's area under cassava production from 2004 to 2013 (000'000ha)

Source: FAO. 2013b

The production was 204.1 million tonnes in 2004 and increased to 276.7 million tonnes in 2013 (FAO, 2013b) (Figure 2). The increase in cassava production worldwide was also attributed by improvement in management practices as it was evidenced by the increase in yield per hectare. In 2004 the yield per hectare was 11.1 tonnes increased to 13.5 tonnes per hectare in 2013 (Table 1).

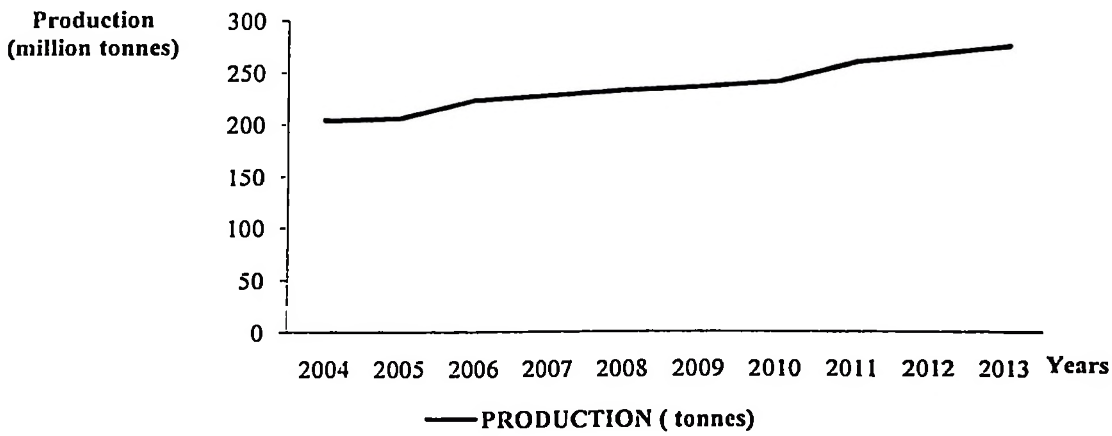

Figure 2: World cassava production from 2004 to 2013 (000 000)

Source: FAO, 2013b.

2.3 Africa Cassava Production

Cassava root production in Africa is mainly produced in tropical regions for various uses as human food, animal feed and industrial raw material. Tivana (2012) pointed out that in sub Sahara Africa it is mainly produced as human food crop and large portions are used by farmers themselves as a subsistence crop. Cassava production in Africa in the past ten years (2004 to 2013) has shown a growing trend. In 2004 the production was 110.1 million tonnes it increased to 157.9 million tonnes in 2013 (Figure 3).

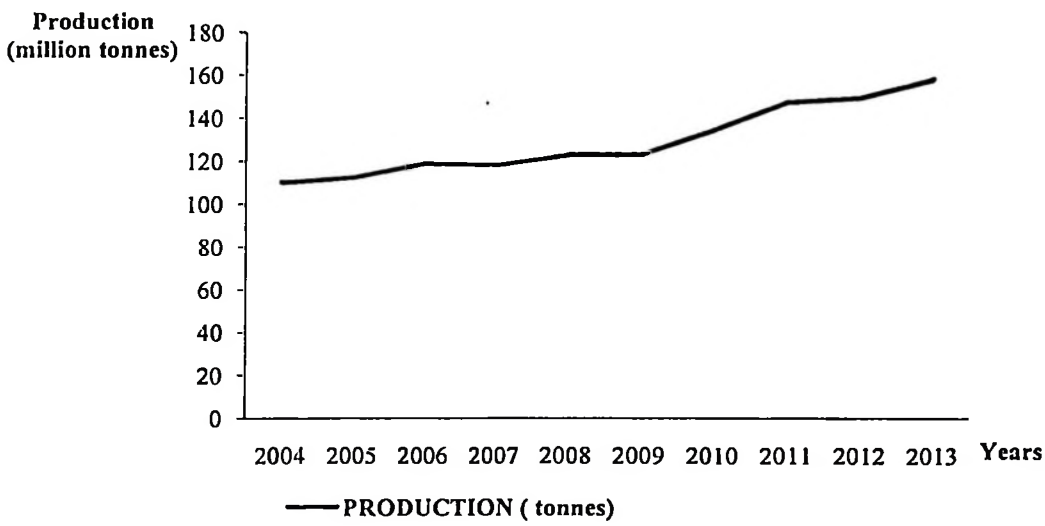

Figure 3: Africa cassava production from 2004 to 2013 (000 000)

Source: FAO. 2013b.

The increase was due to increase in the size of land under cassava production and improvement in management practices. The size of land under cassava production in 2004 was 12.2 million hectares and increased to 14.2 million hectares in 2013 (FAO, 2013a) (Figure 4). Africa in the same period had the lowest yield below the world's average yield (Tivana, 2012) (Table 1).

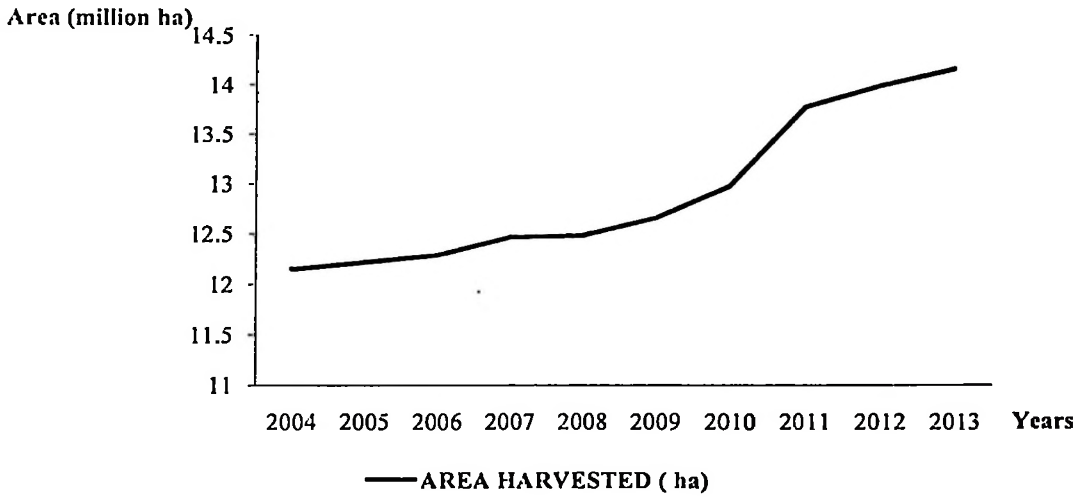

Figure 4: Africa area under cassava production from 2004 to 2013 (000.000)

Source: FAO. 2013b.

The world's and Africa's yield per hectare showed an increasing trend from 2004 to 2013, but Africa had lower yield per hectare as compared to the world's yield per hectare in the same period of time (Table 1).

Table 1: Cassava yield tonnes per hectare

Year	World cassava Yield tonnes/ha	Africa cassava Yield tonnes/ha
2004	11.06	9.06
2005	11.14	9.22
2006	11.90	9.68
2007	11.95	9.49
2008	12.22	9.84
2009	12.29	9.71
2010	12.43	10.34
2010	12.79	10.69
2012	12.93	10.67
2013	13.35	11.14

Source: FAO 2013b.

2.4 Cassava Production in Tanzania

In Tanzania, cassava is grown in most parts of the country. However, chief growing areas include areas along the coastal strip of Indian Ocean, along the lakes Victoria, Tanganyika and Nyasa and along Ruvuma valley. In recent years, cassava is also grown in other parts of the country as a result of Government efforts to stimulate local self-sufficiency in food supply (Theodory *et al.*, 2014; Mkamilo and Jeremiah, 2005). Cassava is one of the important food crops grown in Tanzania providing energy from its root and protein, minerals and vitamins from its leaves (URT, 2008). It is providing energy to consumers due to the large amount of carbohydrates in its roots and the third most important food source in the tropics after rice and maize especially for developing countries in Africa, Asia and Latin America.

The advantages of cassava over other staple food crops are tolerance to drought, capacity to provide yields in different agro ecologies and seasons where other crops would fail, low requirements for external inputs, flexibility in planting and harvesting (Girma, *et al.*, 2013). Cassava has become an important crop currently due to its adaptability to different climatic condition as the world is facing climate change. Cassava's adaptation across environments is broad, although it does not grow rapidly under cool conditions and it is not frost tolerant. Cassava can grow under harsh conditions of as low as 500 mm of annual rainfall or where rainfall is as high as 5 000 mm (Kueneman *et al.*, 2010). The ideal growth temperature range is 24°C to 30°C but it can tolerate temperatures ranging from 16°C to 38°C. Cassava can grow in the semi-arid tropics with an annual rainfall less than 800 mm, but the ideal rainfall is 1 000 to 1 500 mm per year (Tivana, 2012). Tanzania is ranked the sixth producer of cassava in Africa after Nigeria, Democratic Republic of Congo, Ghana, Angola and Mozambique. In the year 2013 the annual cassava production in Tanzania was estimated to 5.4 million tonnes with an average yield of 5.68 tonnes per hectare (FAO, 2013b).

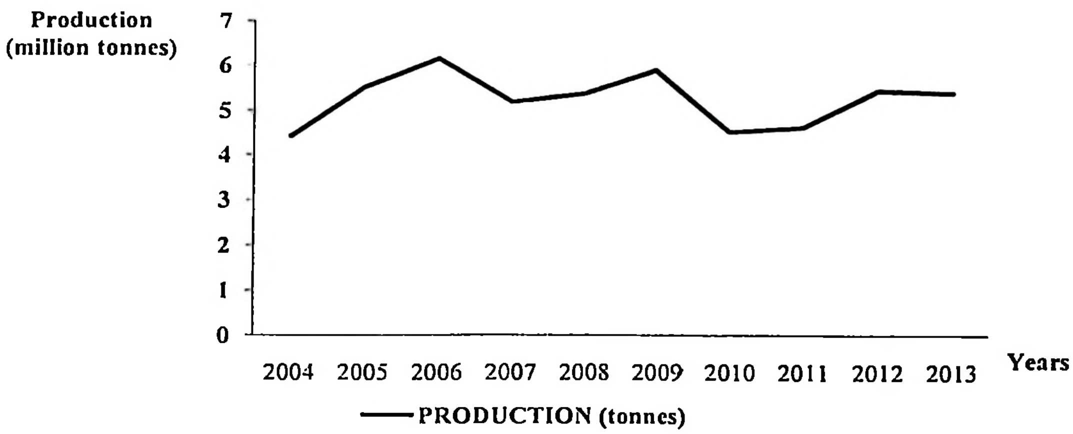

Figure 5: Tanzania cassava production from 2004 to 2013 (000 000)

Source: FAO, 2013b. FAOSTAT

Although Africa and world's cassava production has an increasing trends in the past ten years, Tanzania's cassava production have been fluctuating year after year in the past ten years (Figure 5). The fluctuation may be was caused by the fluctuation in the size of land under cassava in the same period (Figure 6).

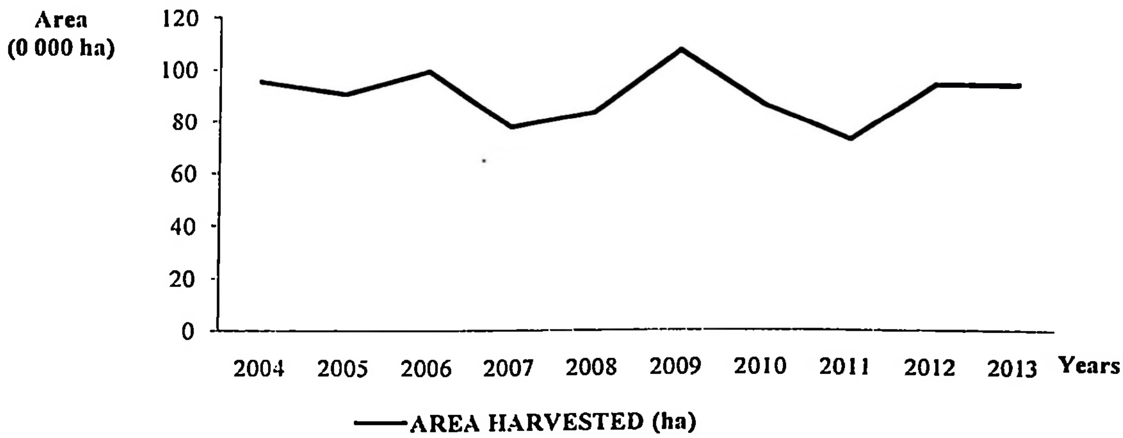

Figure 6: Tanzania area under cassava production from 2004 to 2013 (0 000)

Source: FAO, 2013b.

2.5 Cassava Utilization

Cassava is a major root crop grown for cash, food, feed and raw material for agro-allied firms for the production of starch, alcohol, pharmaceuticals and confectioneries (Ajan and Onwumbuya, 2013). The leaves and roots are edible; they are good sources of ethanol and rich in minerals, vitamins, starch and protein (Akpan *et al.*, 2013). Therefore cassava have several uses as human food, industrial raw material and animal feed ingredient.

2.5.1 Human food

Cassava roots are cultivated as staple food crop, cassava is efficient in producing cheap food energy for human (Apata and Babalola, 2012). Both cassava roots and leaves are suitable for human consumption. Roots are important sources of carbohydrates while leaves are rich in protein and minerals (Tiyana, 2012). In sub Sahara Africa including Tanzania cassava is mostly used for human consumption. Most government promotes the crop as a means of fighting against hunger when other crops fail. In recent years the crop is promoted as a means of climate change adaptation.

2.5.2 Animal feeds

The second most important utilization of cassava worldwide is animal feed. Roots and leaves are used for feeding animals like pig, sheep, goat and poultry. Bitter varieties are the preferred ones for this scope because have high starch content (FAO, 2013a). The roots of cassava plant can be used as on farm feed or as an ingredient in commercial animal feed. Sundried chips are milled into powders that are mixed with protein sources to make a nutritious animal feed. Cassava can replace the use of maize in preparation of animal feeds for dairy cattle, beef cattle, pork and poultry by using cassava chips known as *Makopa* (Mkamilo and Jeremiah, 2005).

Cassava, in its different forms, has been used as animal feed in many parts of the world. Cassava foliage (leaves and stem), peels and particularly the root; fresh, dried or in silage form; alone or mixed with other feed is used in feeding different species of animals (Apata and Babalole, 2012). In East Africa, the animal feed industry is turning to cassava as raw material as maize and wheat become expensive (FAO, 2013). Dried cassava roots are processed into pellets, chips and meal, mainly for poultry and pig industries (Oppong, 2013). The roots and leaves are valuable sources of nutrients for livestock (Apata and Babalole, 2012).

2.5.3 Cassava value addition

About thirty percent of cassava produced is consumed while raw the rest is either cooked into a variety of products which are used for food preparation at home, urban consumers and industrial processors. Cassava can be processed into various products for human consumption, animal feeds and industrial raw materials (Bennet *et al.*, 2012). Cassava is the second largest source of starch after maize (FAO, 2013a). Therefore it is important industrial raw material for starch production. Another important new area of cassava utilization is using it as feedstock for production of bio fuel especially in Asia (FAO, 2013a).

2.5.4 Poultry feeds

In poultry production, the birds ration has a different proportion of nutrient combinations which exactly depends on the types and age of the poultry birds (Osuntoki *et al.*, 2013). As a result of this variation in demand of nutrients animal scientist come up with different poultry feeds (mash) like chick mash, growers mash, layers mash, and broiler starter and broiler finisher. Poultry diets are made from a mixture of several feed stuffs such as cereal grains, soybean meal, and animal by products meal, fats, vitamins and mineral premixes (Oladokun and Johnson, 2012).

These feedstuff are expected to supply essential nutrients such as energy, proteins, vitamins and minerals. Energy and protein feedstuffs have been the major hindrances to efficient poultry production in most of countries (Tang *et al.*, 2012). Energy in poultry feed can be supplied by using maize grain and cassava root. Maize grain is mostly used in many parts of Africa as the source of energy in poultry feed (Oladokun and Johnson, 2012).

Feed for poultry varies according to age. However, the ingredients in all feeds used consist of corn for energy, soya for protein and other mixtures (Hamra, 2010). Seasonal fluctuations in the supply of conventional feed ingredients requires alternative energy source to ensure optimum performance of the birds. Anaecto and Adighibe, (2011) pointed out that cassava can be used as an alternative source of energy for poultry Bennet *et al.*, (2012) reported that among the uses of cassava as human food and industrial raw material still there is an opportunity of using cassava in livestock feeds including poultry in Tanzania.

Cassava products have been promoted as animal feed for more than two decades now, but the amount used is very limited due to unsuitable quality of cassava products available. Anti nutritional factors associated with cassava make feeding to non ruminant like poultry to be low (Tang *et al.*, 2012). Apata and Babalole (2012) pointed out that cassava have several nutritional features that leads to serious limitations for their practical use in poultry feeding as compared with cereal grains. They reported that starch is the major component of cassava with low level of protein. It is succulent material with low content of dry matter (25% to 32%) hence make preservation, transport costs and general handling difficult. It contains toxic cyanogenic glycosides which require processing to reduce to acceptable level. Dustiness of the dry root flour causes irritation of the respiratory tract unless feed is pelletized. Root and tuber by products have high crude fibre (12.1% to 16.0%). Processing is required to degrade the fibre for improved utilization by non ruminants.

2.5.5 Costs of poultry feeds

The greatest cost proportional cost in livestock production is expended of feeding especially for non ruminants. In poultry, feed ingredients represent 65 to 70% of the total costs in intensive system of production (Apata and Babalole, 2012). Olugbemi *et al.* (2010) pointed out that feed cost accounts for up to 80% of the total cost of poultry production and is a very important component in determining the extent of poultry survival and profitability.

Poultry and other livestock feeding are expensive as it takes 60 to 75% of the total cost of production. This is so because of high cost of maize which constitutes 40 to 50% of ingredients in feed ration formulation for poultry (Anaeto and Adighibe, 2011). Feed costs have a major impact on the profitability of poultry farm operations. The high cost of feed is related to the energy and protein contents of the diet. In an unbalanced diet, with an excess protein, feed would cost more, thus increasing production costs. With low protein diets, chickens would take more time to grow, and could be at a higher risk of catching diseases and high cost of feeding for long time. Chickens have different feed requirements depending on their type, age, and sex. Rations formulated to meet nutrient requirements produce faster growing, and healthier chickens, and thus better products and more profits (Hamra, 2010). To avoid the effect of wrong nutrient combination on poultry bird the animal scientists have come up with different form of poultry feeds among them are chick's mash, grower's mash, layer's mash, broiler's starter and broiler's finishers (Osuntoki *et al.,* 2013).

Major problem that affects the poultry industry in the tropics is the increasing prices of feed ingredients especially maize which are mostly used (Anaeto and Adighibe, 2011; Ironkwe and Ukanwoko, 2012). There is high competition of maize for human food and livestock feed. During the off season the prices of maize grain is high hence make the cost for livestock feed to be high. The costs of animal feeds are high because maize constitutes larger proportions of poultry feed ingredients. Abubakar and Ohiaege (2011) pointed out that maize is one of the most popular and commonly used ingredients in the diets of poultry. The cost of this ingredient has increased drastically due to competition between man and his livestock, problems associated with weather fluctuation, and local currency devaluation.

Many studies have been done to develop different feed ration where maize grain is replaced by cassava root. Anaeto and Adighibe (2011) pointed out that although the cost per kilogram declines as the level of cassava root meal replaces maize at the ration between 75% and 100%, at these ratios the production of eggs and weight of egg was reported to decline for layers. This study concluded that there was a realized profit in broilers fed with maize based feed, maize being replaced up to 50% by cassava.

2.6 Cassava Marketing

Cassava marketing systems are not well established in many parts of Tanzania. Cassava is sold to consumers mostly living near the production area; the supply chains are shorter especially for raw cassava due to its nature of bulkiness and high perishability. Msabaha,

(1990) pointed out that limited transport and storage facilities make access to market a problem. Both local and external markets for cassava are available; however, due to the bulk nature of the crop, farmers are obliged to sell their cassava at nearby markets mainly at reduced prices Sewando *et al.* (2011) pointed out that cassava production in Tanzania is characterized by low yields and low marketable surplus. Small scale farmers fail to access urban markets due to low volume of produce, supply fluctuations and lack of quality cassava products which can meet specified standards.

2.7 Cassava Production Challenges

The major challenges that face cassava farmers in Tanzania are diseases and shortage of improved planting material. Diseases like Cassava mosaic disease (CMD) and cassava brown streak disease (CBSD) threaten the production of cassava, a crop especially important to smallholder farmers in Tanzania. The two diseases are the most severe and wide spread in sub Saharan Africa (Ephraim *et al.*, 2015). Ntawuruhunga and Legg (2007) reported that CBSD is the second most important constraint affecting cassava production in Eastern Africa after cassava mosaic disease (CMD). CBSD causes severe root rotting and most parts unusable if the effects are above 75% (Figure 7). Kitabu (2013) and Kiishweko (2013) reported that in 2005, CBSD caused estimated crop losses in Tanzania of between 35 and 70 million USD per year calculated at a price of 100 USD per metric tonnes of fresh cassava. This loss of fresh root if converted using minimum average prices of high quality cassava flour in Dar es Salaam would make the loss of at least 70 to 140 million USD at wholesale, and 175 to 350 million USD at retail. A survey done by Muhanna and Mtunda (2002) in Tanga, Tanzania reported crop losses up to 74% due to Cassava Brown Streak Disease as was quoted by Mkamilo and Jerremiah (2005).

Score	Root Symptom Description	Pictorial
1	No symptoms on storage roots	
2	less than 5% of storage root tissue is necrotic	
3	5-10% of storage root tissue is necrotic	
4	10-50% of storage root tissue is necrotic	
5	More than 75% of storage root tissue is necrotic	

Figure 7: CBSD Root Severity Scoring Scale

Source: ARI – Ukiriguru (2014)

The other challenges that face farmers and researchers as cassava stake holders is how to quantify the losses attributed by CBSD. Hillocks *et al* (2001) suggested various methods to calculate the losses. The methods or approaches suggested were direct yield loss method, loss of marketable yield method, loss of useable yield and loss of yield as a consequence of early harvesting. Among the methods suggested the loss of useable yield seems to be more practical though it is time consuming.

2.8 Theoretical and Analytical Techniques Review

2.8.1 Theoretical review

The study is based on theory of the firm. The theory was traditionally one of branch of microeconomics which studied the supply of goods by profit maximizing agents. In this case, the theory production costs played a crucial role. The theory assumes that rational firm owners attempt to maximize some organizational objective, subject to resource constraints, input prices and market structure in which the firm operates (Webster, 2003).

Wilkinson (2005) reported that, the theory of the firm as an aspect of managerial economics to work efficiently you have to consider the relationship with other theories such as demand theory, cost theory and competition theory. Where demand theory is related with consumer theory and cost theory relates with production theory. This theory tries to explain how individuals who constitute firms are motivated and interact.

Theories of the firm not only try to answer why businesses are organized in firms but how the relationships within the firm as well as between the firm and society at large look like. The relationship outside the firm extends to those who can sell raw material to the firm and those who can buy firms product and other services such as transport which can influence the performance of the firm.

However much of a commodity a business firm produces, it endeavours to produce it as cheaply as possible. Taking the quality of the product and the prices of the productive factors as given, which is the usual situation, the firm's task is to determine the cheapest combination of factors of production that can produce the desired output. This task is best understood in terms of what is called the production function, *i.e.*, an expression of relationship between the quantities of factors employed and the amount of product obtained. It states the amount of product that can be obtained from each and every combination of factors. The production process is faced by constraints. Therefore the study uses theories of costs to find out how to minimize costs of production. To implement this linear programming (LP) model was adopted so as to identify the least cost feed which will meet nutritional requirement as per bird category. The costs of all inputs which include all ingredients were included in the cost function of feed formulation.

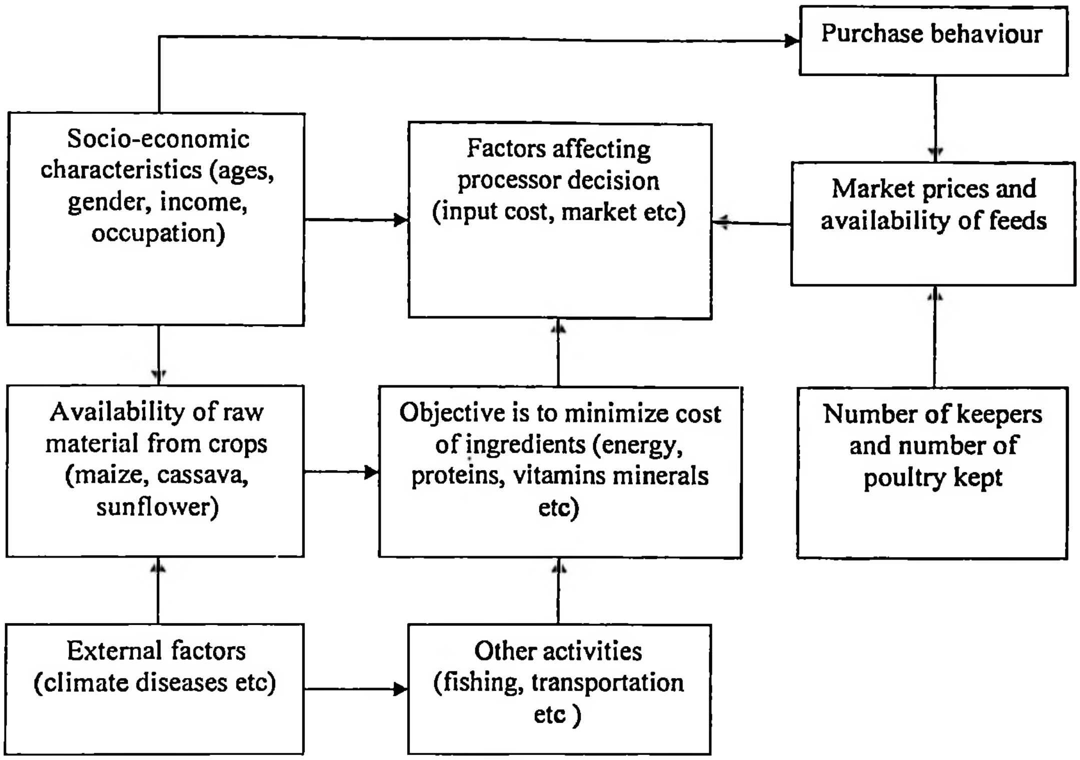

Figure 8: The conceptual Frame work

2.8.2 Analytical techniques review

Studies have been conducted to formulate livestock feeds using various feedstuffs locally available. Researchers use various techniques to identify animal feed which meets all necessary nutritional requirements at a reasonable cost. Researchers have been trying to assess the effects of substituting feed ingredients in animal feed on growth performance and profitability of livestock enterprises. Various techniques are used to assess the viability of ingredient substitution in animal feeds. These include linear programming, sensitivity analysis, partial budget and cost–benefit analysis.

2.8.2.1 Linear programming model

Linear programming (LP) is a method of determining the least-cost combination of ingredients using a series of mathematical equations. There are many possible solutions to each series of equations, but when the factor of cost is applied, there can only be one least cost combination. The obligation to meet infinite needs with restricted resources is one of the biggest challenges encountered in the market today (Ozsan *et al.*, 2010). Therefore LP model can be used to overcome challenges occurring due to scarcity of resources as was pointed out by Ozsan *et al.* (2010). Linear programming (LP) is a powerful analytical tool that can be used to determine an optimal solution that satisfies the constraints and requirements of the current situation (Better, 1988). Osuntoki *et al.* (2013) pointed out that LP models indicates the right combination of the various decision variables which can be best employed to achieve the objectives taking full account of the practical limitations within which the problem must be solved. LP has been used in the evaluation and optimization of raw material resources and capital, under certain restricting circumstances to get the most benefit (Han *et al.*, 2011). Hassan (2005) used a linear programming model to determine the optimum cropping pattern as a prerequisite to efficient utilization of available resources of land, water, and capital for Pakistan's agriculture. Bretas (1991), reported a general linear programming model which was developed to determine an income-maximizing set of management activities for a cash-crop farm subject to groundwater quality standards for pesticide contamination. Al-Deseil (2009), used LP model to analyze feed formulation problem for broiler ration in Jarash where the objective was to obtain the optimum feed formulation with least cost but satisfying necessary nutritional requirements. Therefore using theory of the firm and theory of cost with the objective function of minimizing costs of feed production and meet the minimum nutritional requirement LP model was adopted as the suitable model to identify least cost feed formulation with affected cassava as one of the ingredient.

2.8.2.2 Sensitivity analysis

Sensitivity analysis is a part of mathematical programming solutions and is used in making nutritional and economic decisions for a given feed formulation problem (Roush *et al.,* 2009). Oladokun and Johnson, (2012) used sensitivity analysis to ascertain the effects and economic implication of changes in price in the market has on feed prices. The study used the identified least cost feed formulated using LP model to assess the effects of changes in prices of ingredients to the price of feed and the profit of poultry farms in Nigeria. The study reported that an optimal solution provides best choice of decision variables for one fixing of the input parameters. Therefore sensitivity analysis tried to show what happens when the parameter changes. Alagic *et al.* (2006), used sensitivity analysis to address changes of clinical coliform mastitis, vaccine efficacy, daily milk yield per cow and differences between replacement heifer and culled cow salvage prices. Hamra (2010), used sensitivity analysis to examine profitability under high cost circumstances, as well as forecasts of likely future movements in costs and revenues.

2.8.2.3 Profitability analysis

According to Harward and Upton (1991), "profitability is the 'the ability of a given investment to earn a return from its use". Therefore profitability is the ability of a business to earn a profit. A profit is what is left of the revenue a business generates after it pays all expenses directly related to the generation of the revenue, such as producing a product, and other expenses related to the conduct of the business activities. Profitability means ability to make profit from all the business activities of an organization, company, firm, or an enterprise. It shows how efficiently the management can make profit by using all the resources available.

Hossain *et al.* (2013) pointed out that profitability of poultry business depend on the availability of quality feed ingredients at reasonable price. Therefore it is important to identify least cost feed to generate enough profit in poultry business. Tang *et al.* (2012) pointed out that high costs of poultry feed originates from energy and protein feedstuffs. Different researchers use different approach to analyze profitability of various enterprises.

Turinawe *et al.* (2011) used partial budget analysis to assess the profitability of between different forage production technologies in Uganda. The study observed significant difference in profitability between farmers using improved forage technologies and those using traditional technologies. Farmers using improved technologies had higher profit. Alagic *et al.* (2006) used partial budgeting approach to assess the effects of changes in the costs of vaccine and labour required for vaccination to profit dairy farmers. Wanyama *et al.* (2004) used partial budgets to analyze insecticide use and the potential for Bt Maize varieties in the control of stalk borer in Kenya. The study analyzed the economic impact of Bt varieties which were tolerant to stalk borer and the types of insecticides used by farmers. Gillespie *et al.* (2008) used partial budgets to investigate the role of labor and profitability in choosing a grazing strategy for beef production in the U.S. Gulf Coast region. Carlson (2007) used partial budgeting to evaluate the costs and benefits in a field rice study by comparing the weed control, yield and revenue with alternative herbicide programs.

Achoja (2009) used gross profit margin and net profit to determine the profitability of the poultry and resource use efficiency in egg and broiler enterprise. Net profit provide the clues to the company's or firm's pricing policies, cost structure and production efficiency. Sadiq *et al.* (2013), used farm budgeting technique to investigate the profitability of small scale maize production in Nigeria. The study identified the costs and returns per hectare and finally the gross margin was calculated as an indicator of farm profitability.

2.9 Summary of Literature Reviewed

It was reported that cassava production is one of the important crop grown in tropics where other crops would fail due to significant climatic condition variations. Cassava yields vary significantly between countries due to differences in types of cultivars used, season of planting, management practices and soil type and fertility. Its importance has been increasing year after year as was evidenced by the increase in size of land under cassava and volume of cassava worldwide. It was also reported that cassava is important source of energy to human being and livestock. It is rich in carbohydrate but low level of protein as compared to maize. Cassava has a huge potential of being used as food for human, animal feeds and industrial raw materials for products like starch production, biscuits and feedstock for biofuel production. It was also reported that energy in poultry can be supplied by combining maize grain and cassava root in certain proportions. Cassava root was reported to have low level of protein and in some cases it contains toxic cyanide. Different studies have used different approaches to study the possibility of including cassava in poultry feed and its implication on costs of feed and profitability to feed processors. The techniques used were such as linear programming, sensitivity analysis, profitability analysis, partial budgeting and cost benefit analysis. This study used linear programming model, sensitivity analysis and profitability analysis to assess economic feasibility of using affected cassava in poultry feeds.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location

The study was conducted in Sengerema District Council where cassava is grown and Mwanza City where Misenani Agro vet is located. The company is dealing with managing hatchery of broiler and layers chicks, veterinary services and animal feed processing. Sengerema District is one of seven districts in the Mwanza Region of Tanzania. It is bordered by Ukerewe district to the north, Ilemela and Nyamagana districts to the east, Geita Region to the south and west and Misungwi district to the southeast. The District is found between 2° and 3° latitudes south of the equator and between 31° 45' and 32° 45' longitudes East of Greenwich meridian. The total geographical surface area of Sengerema District is 8 817 km^2. Out of this, 5 482km^2 (62.8%) is covered by water of Lake Victoria while the remaining 3 335 km^2 (37.8%) is covered by dry land where settlement and other economic activities are carried out. The district is located at an altitude between 900 and 1 300 meters above mean sea level. The district has a total of five divisions and 34 administrative wards (DED Sengerema).

3.1.2 Climate

Sengerema District has a bimodal rainfall pattern which consists of short and long rainfalls. The short rains starts in October and reaches its peak in December and ends in January. The long rains start in February and end in May. The annual rainfall of the District ranges from 800mm to 1 200mm. The District mean temperature is between 21°C and 23°C with August being the hottest month. There are two main agro ecological zones, namely, the Northern and Southern zones. The Southern zone receives a reliable amount of rainfall between 900 and 1 200mm per annum. The Northern zone receives unreliable rainfall normally less than 1 000mm per annum (DED Sengerema). The zone is a major area for livestock keeping and growing of drought resistant crops, like cassava, cotton and sweet potatoes. Cassava is grown in the two agro ecological zones (all wards) of Sengerema district.

3.1.3 Population

Sengerema District had a population of 663 034 which was composed of 330 018 (49.9%) male and 333 016 (50.2%) female with annual growth rate of 3.6% in 2012 (URT, 2013). Sengerema accounts for 23.9% of the total population of Mwanza region. The district has an average of six people per household. To date, Sengerema District has an estimated population of 737 251 where 367 151 are males and 370 100 are females. The District has 34 administrative wards distributed into two agro ecological zones. The wards vary considerably in terms of size and population characteristics for example the average household size varies from 4.9 to 7.4 persons per household for Maisome ward having the lowest and Kagunga being the highest. The sex ratio also varies considerably where Maisome had the highest sex ratio (112) and Ibisabageni having the lowest sex ratio (89) (URT, 2013). Sengerema District is predominantly inhabited by the Sukuma and Zinza tribes as well as Kerewe tribe in the islands.

3.1.4 Economic activities

The major economic activities carried out in Sengerema are agriculture, fishery, livestock keeping, mining and small business enterprises with agriculture being the main pillar of the District economy. The contribution of agriculture to the District GDP is estimated at 70% and provides employment to more than 75 percent of the labour force (ESRF, 2014). The main food crops produced in Sengerema District are cassava, maize, beans and groundnuts. Banana was popular but has dropped due to persistent outbreak of Bacterial Wilt disease which has affected most of Kagera Region and part of Mwanza Regions where banana is grown.

Another important economic activity in Sengerema District is fishery as about 62% of the surface area of the district is covered by water of Lake Victoria. Fishing is mainly done along the shores of Lake Victoria and its surrounding islands. Catches of fish are used domestically for consumption but also sold in markets outside Sengerema District including fish processing industries based in Mwanza.

Sengerema District continues to rely on livestock production and ownership to fulfill their social and economic obligation. The District has a total area of 68 963 ha suitable for pasture development. The main stocks being kept are cattle, goat, sheep, pig and chicken. Cattle keeping are mainly for milk production but also for commercial purposes, for ploughing and other social cultural obligation such as pride price.

3.2 Research Design

The study employed a cross sectional research design. The design allows data to be collected at a single point in time (Bailey, 1998; Wilkinson, 2005). The method was chosen because is able to meet the purpose of the study to find the prevalence of the outcome of interest, for the population or subgroups within the population at a given time. It allows assessment of what has been happening over time on factors affecting the subject of study and their outcome at a given time. Cross-sectional studies can be thought of as providing a snapshot of the frequency of an event or other related variables in a population at a given point in time. Therefore the method was adopted to study the entities who were individual farmers producing cassava and processor of animal feed for poultry using cassava as one of the ingredient in the feed formulation. The entities were subjected to answer question of interest to represent the entire population of the study area.

3.3 Sampling Technique

Multistage sampling technique was employed by this study to obtain the representative sample. At the first stage Mwanza region was selected purposively because it is one of the regions producing cassava in Tanzania and sponsor requirement. In the second stage Sengerema district was selected randomly out of seven districts of Mwanza region. At third stage two wards of Nyamazugo and Kasungamile were randomly selected out of 34 wards in Sengerema district (Figure 8). From each ward three villages were selected randomly to make a total of six villages and lastly 20 farmers were selected from each village to make a total sample of 120 farmers. Two sampled farmers were not interviewed because they had family problems during the day of interview. Therefore the total number of respondents interviewed was 118 (Table 2).

Table 2: Sample profile

Ward	Village name	Number of respondents	Focus group discussion Number of participants
Nyamazugo	Nyamazugo	20	
	Kijuka	20	8 Farmers
	Nyamizeze	20	
Kasungamile	Kasungamile	18	
	Nyamililo	20	10 Farmers
	Nyantakubwa	20	
Total		118	

3.4 Data Collection

Data collection process used structured questionnaire (Appendix 2 and 3) was designed to capture primary data from respondents. Administered questionnaires comprised both close and open ended questions to capture qualitative and quantitative data for analysis to accomplish the objectives of the study. The questionnaire was administered by the researcher and one enumerator to each farmer using Swahili language. Farmers were interviewed by means of personal interview method. Individual farmers were interviewed in their homes or village offices after initial appointments through the Extension officer who introduced the researcher to all farmers to be interviewed. The objectives of the study were explained to each respondent which made them willing to participate. Majority of farmers showed positive response to questions asked. Two respondents were missing in Kasungamile village because the randomly selected respondents had one of their relatives who passed away at the date when the interview was to be done.

Two focus group discussions were carried out one in each ward (Table 2). Focus group discussions were used to gather great in-depth of knowledge and additional information from knowledgeable and informed people on the subject matter under study in the study area. The price of affected cassava was obtained from few farmers who reported that they managed to sell cassava affected by CBSD.

3.5 Data Analysis

The collected data were edited, coded and summarized before analysis. Qualitative and quantitative analysis was carried out to achieve specific objectives. The analysis used descriptive and inferential statistics by using Lingo 15.0, Microsoft excel and Statistical Package for Social Sciences (SPSS) computer software. Descriptive statistical tools (percentages and frequencies) were used to summarize the information gathered on socio economic characteristics of respondents. In order to verify farmer's response and awareness on presence of CBSD in the study area. T test (t-test) was used to see if the cost of feed formulated without cassava, with clean cassava and affected cassava were

3.6 Analytical Model

3.6.1 Farmers awareness on presence and effects of CBSD

Descriptive statistics was used to analyze socio economic characteristics of selected cassava farmers in the study area. The farmer's awareness was measured using cross tabulation between farmers response if they have been experiencing cassava diseases and farmers experience in cassava production which was depicted by the number of years a farmer has been engaging in cassava farming. The results were tested using Chi-Square tests to see if they were significant.

3.6.2 Least cost feed formulation

The linear programming technique was adopted for analyzing objective two because of its advantage that it helps to make the best possible use of available productive resources and highlighting bottle necks of some resources remaining idle in the firm or factory. Linear programming is one of the mathematical techniques used in solving a variety of problems related to management with special characteristic of solving maximising benefits or minimising costs in firms. The Linear programming was adopted under the assumption that the constraints and objective functions are linear equations representing straight lines. Factors such as uncertainty, weather conditions and supply variations were not taken into consideration in the model because feed formulation depends much on the quality and quantity of ingredients in formula if they meet nutritional requirement for the bird category.

The feed formulation model seeks the optimum combination of available feed ingredients that will satisfy the nutritional requirements of the animal at the least cost possible. The model has to satisfy a set of constraints on nutritional levels, availability restrictions, special ingredients to be included, budget or fund constraints. The mathematical model which is applicable to each type of ration using the available ingredients is constructed as follows;

$$Minimize\ Z = \sum_{j=1}^{8} C_{ij}X_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Subject to

$$\sum_{j=1}^{8} X_j \leq N \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$b_iL\sum_{j=1}^{8} \leq \sum_{j=1}^{8} a_{ij}X_j \leq b_iU\sum_{j=1}^{1} X_j \ldots\ \forall_j = 1,2 \ldots 8 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$L_k \leq X_k \leq U_k, \forall_k \in Su \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$X_k \leq b_k \sum_{j=1}^{8} X_j, \forall_k \in Su \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$X_j \geq 0, \forall_j = 1,2 \ldots\ldots 8 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where:

Z = Total cost of feed ingredient used in the feed formulation to produce one kilogram.

C_j = Unit cost of feed ingredient *j*.

X_j = Quantity of feed *j* ingredient in the feed mix (decision variable) which includes quantity of maize (X_1), cassava (X_2), soya cake (X_3), sunflower cake (X_4), maize bran (X_5), fish meal (X_6), salt (X_7) and premix (X_8),

a_{ij} = Amount (in fraction of X_j) of nutrient *i* available in ingredient *j*.

b_{ij} = Dietary requirement of nutrient *i* for a bird category.

i = Index identifying feed nutrient component.

j = Index identifying feed component.

k = Index identifying restricted ingredients

U = Index identifying set of restricted ingredients.

X_k = Quantity of restricted ingredient.

N = Total quantity (kg) of feed to be produced

Minimum and maximum dietary requirements used in the LP model are shown in Table 3.

Table 3: Values of minimum and maximum dietary requirements of nutrients

	Requirement	
	Lower limit	Upper limit
Protein %	18	20
Metabolizable energy (kcl/kg)	3000	3200
Carbohydrates % (X1 + X2)	<=	48.2
Maize % (X1)	24.1	48.2
Cassava % (X2)	<=	24.1
Soy cake % (X3)	20.0	30.0
Sunflower cake % (X4)	10.0	27.0
Maize bran % (X5)	3.0	18.0
Fish meal % (X6)	18.0	33.0
Salt % (X7)	0.3	Fixed
Premix % (X8)	0.3	Fixed

3.6.3 Comparison of costs for feeds formulated with affected cassava and clean roots

The prices for various ingredients which were used in least cost feed formulation were obtained using questionnaires administered to farmers and animal feed processor in Sengerema and Mwanza respectively (Appendix 8 & 9). The price of affected cassava was obtained from few farmers who reported that they managed to sell at low prices between Tsh 35 to 50 per kilogram. In the LP model the price of affected cassava used was Tsh 150 per kilogram. This was the average price of the maximum price of affected cassava which was Tsh 50 and the price of clean cassava which was Tsh 250 per kilogram. The comparison of costs of feeds formulated using LP model in objective two was done by comparing the costs of feeds made from clean cassava and that of the affected cassava. The hypothesis was tested using t – tests to see if they were significantly different.

3.6.4 Profitability analysis

Profit generated by one kilogram of poultry feed processed by the processor was specified as

$$\prod = TR - TVC$$

Where $\prod$ = Unit contribution, TR = Total Revenue generated by one kilogram of broiler feed (TR = Price of one kilogram), TVC = Total variable cost of producing one kilogram of broilers feed

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio Economic Characteristics of Respondents

4.1.1 Sex of respondents

Table 4, shows that majority 68.6% of the respondents interviewed were male and the remaining 31.4% were female. This implies that most of the families are male headed households.

4.1.2 Age of respondents.

It was observed that 55.9% of cassava farmer had an age between 41 and 60 years, 31.4% had an age between 18 and 40 years and the remaining 12.7% their age was above 60 years. Therefore this implies that 87.3% of cassava growers in the study area were aged between 18 to 60 years. This indicates that cassava farming activities are carried out by active working age group. Also the results show that people with age between 40 and 60 years participate most in cassava production as compared to people with age below 40 years (Table 4).

4.1.3 Education level of respondent

The education level shows that 75.4% of the sampled cassava farmers had attained primary education, 12.7% had attained secondary education, 11.0% didn't attend any formal education and 0.8% attained post secondary education. Therefore 88.9% of farmers were literate that they can read and write and learn how to adopt new technologies in cassava production, marketing and processing. Also education level helps farmers to be able to identify signs of CBSD in their farms (Table 4).

Table 4: Social economic characteristics of respondents (N = 118)

Category	Frequency	Percent
Sex of respondent		
Male	81	68.6
Female	37	31.4
Age group		
18 – 40	37	31.4
41 – 60	66	55.9
60 <	15	12.7
Education level		
Never gone to school	13	11.0
Primary education	89	75.4
Secondary education	15	12.7
Tertiary education	1	0.8
Marital status		
Married	104	88.1
Widow or widower	6	5.1
Divorced	1	0.8
Not married	7	5.9
Total	118	100.0

4.1.4 Marital status

The study findings indicate that 88.1% of sampled cassava farmers in the study area were married. Also results indicated that 5.9% of cassava farmers were not married, widowed and divorced accounted for 5.1% and 0.8% respectively (Table 4).

Table 5 Ward average family size

Ward	Mean	Minimum	Maximum	Frequency
Kasungamile	7.69	2	14	58
Nyamazugo	8.78	1	22	60
Average for two wards	8.25	1	22	118

4.1.5 Family size of the respondent

It was found that the average family size in the study area was 8.3 persons per household, where the household with large number of household members was 22 persons per household and the lowest was one person. The average household size of 8.3 members was high than the district average of six members per household as was pointed out by

2012 population census report (URT, 2013). According to ,population census report (URT, 2013), the household size was 6.1 and 6.7 for Nyamazugo and Kasungamile wards respectively but the survey average was higher for the two wards which was 8.8 and 7.7 for Nyamazugo and Kasungamile wards respectively (Table 5). Higher average household size is attributed by population growth overtime. URT (2013), reported that district population was 663 034 in 2012 with annual growth rate of 3.6% therefore in 2015 the population is estimated to be 737 251. About 74.6% of the household surveyed had an average household size of ten members per household (Table 6). Also it shows that 20.3% had a family size with members between 11 to 15 per household and 5.1% had members above 15 per house hold. Nyamazugo ward had the highest average household size than Kasungamile ward (Table 5). Large household size was mainly attributed by polygamous, extended family relationship and orphans.

4.1.6 Farmers experience in cassava production

It was observed that majority about 32.2% of farmers interviewed had an experience in cassava production for a period between one and ten years. Other groups were 31.4% with experience between 11 to 20 years, 20.3% between 21 to 30 years, 8.5% between 31 to 40 years and 7.6% their experience was 41 years or above (Table 6).

Table 6: Distribution of respondents according to family size and experience in cassava production

Category	Frequency	Percent
Family size group		
1 – 5	25	21.2
6 – 10	63	53.4
11 – 15	24	20.3
15 <	6	5.1
Experience in cassava production		
1- 10	38	32.2
11 - 20	37	31.4
21 -30	24	20.3
31 – 40	10	8.5
41 <	9	7.6
Total	118	100.0

4.2 Cassava Production

The findings indicate that majority 81.4% of farmers in the study area uses local planting material in their farms. The local planting material used takes long time of two to three years to mature. Only 18.6% of farmers use improved planting material most of which was obtained from Ukiriguru research station. The names of improved varieties used were *Mkombozi*, *Kyaka* and *Berinde* (Table 7). For farmers using improved varieties the reasons for their preference pointed out was early maturity, high yielding, and resistance to diseases. The distribution by reason of preference was 31.8% high yielding, 9.1% resistant to diseases and 59.1% early maturity between six to nine months (Table 7). Their reasons for preference of these varieties are in line with what was reported by ARI-Ukiriguru officials that *Mkombozi*, *Berinde* and *Kyaka* are high yielding and have high tolerance to CMD and CBSD.

Despite of these better characteristics of improved varieties farmers still use local varieties because of shortage of improved planting material and high cost of obtaining planting material from multiplication centers.

Table 7: Distribution of respondents according to variety of cassava grown, reasons for preferences and village

	Frequency	Percent
Variety grown		
Local variety	96	81.4
Mkombozi	21	17.8
Kyaka, Berinde	1	0.8
Reasons for preference		
Resistant to disease	2	9.1
Early maturity	13	59.1
High yielding	7	31.8
Village		
Kasungamile	3	13.6
Kijuka	17	77.3
Nyantakubwa	2	9.1
Total	22	100.0

Farmers using improved planting material were found in three villages of Kijuka (77.3%) in Nyamazugo ward, Kasungamile (13.6%) and Nyantakubwa (9.1%) in Kasungamile ward (Table 7). Farmers in Kijuka village use motorized processing machine to process cassava into quality cassava flour. The processing machine is owned by a group of farmers in the village called *MKOMBOZI* Group who were brought together and coordinated by *Muunganisho wa Ujasiriamali Vijijini* (MUVI) Tanzania.

4.2.1 Other food crops grown in the study area

The findings in the study area indicate that 98.3% of farmers reported to grow cassava as food and cash crop. Few farmers 1.7% reported that have abandoned cassava production because of frequent attack from diseases which affected the harvests from their fields. Apart from cassava production 59.3%, 24.6% and 16.1% reported to grow maize, paddy and sweet potato respectively for food and cash. Maize is given higher priority by many farmers in the study area during long rain season and cassava and sweet potato are mainly planted during short rain season (Table 8).

Table 8: Distribution of respondents according to food crops grown (N = 118)

Crops grown	Frequency	Percent
Potato	19	16.1
Paddy	29	24.6
Maize	70	59.3
Total	118	100.0

4.2.2 Land ownership and utilization

The findings from the study area show that farmers own small plots of land which is available for production of various crops. It was observed that farmers own an average of 6.56 acres per household. There was a huge disparity in the size of land owned among farmers the largest land size owned per household was 40 acres and the lowest was 1.5acres with a range of 38.5 acres. About 45.64% of land owned was under cassava production in the year 2013/14 season with the average of 2.99 acres per household. The maximum acreage cultivated by one individual household was 20 acres. The other part of land 54.36% was used for production of other crops such as maize, paddy, potato, beans, groundnuts, cotton and pasture (Table 9).

It was also observed that majority (71.3%) had land less than three acre which was under cassava production in the year 2013/14 season. Few farmers grew cassava with land size between 3.1 and 5.0 acres, 13% had land under cassava production ranging from 5.1 to 10 acre and 0.9% had land under cassava above 10 acres (Table 9).

Table 9: Land ownership and utilization

	Land owned	Land under cassava
Mean	6.5636	2.9958
Range	38.50	20.00
Minimum	1.50	0.00
Maximum	40.00	20.00
Land under cassava production	Frequency	Percent
Farm size (acres)	23	20.0
0.1 -1.0	59	51.3
1.1 - 3.0	17	14.8
3.1 - 5.0	15	13.0
5.1 – 10	1	0.9
>10.1	3	2.5
Total	115	100.0

4.2.3 Financing cassava production

It was observed that 93.2% of cassava farmers in the study area financed cassava production activities from own personal saving. Donor projects contribution was 4.2% and 2.5 % reported that they were supported by friends to finance cassava production (Table 10). This includes farmers using improved and local planting material.

Table 10: Distribution of respondents according to sources of financing cassava farming

	Frequency	Percent
Source of funds		
Personal saving	110	93.2
Friends	3	2.5
Donors	5	4.2
Source of funds for improved cuttings		
Personal saving	18	81.8
Donors	4	18.2
Total	22	100.0

For farmers using improved planting material 81.8% financed farming activities from their own personal saving and 18.2% were supported by MUVI Tanzania in Kijuka village, Nyamazugo ward (Table 10).

4.2.4 Diseases affecting cassava in the study area

It was reported by 99.2% that they have been experiencing various diseases in cassava farms (Table 11). The most common signs reported were dark brown streaks and spots on stems, scratch-like wounds on stems, shoot tip death, cassava stem drying, and discoloration in the storage roots, root rot, twisted and misshapen leaves, and dead spots on leaf scars, yellowish patches in leaves, and presence of white flies. These signs indicate that the fields were affected by CBSD and CMD.

Table 11: Distribution of respondents according to diseases affecting cassava

	Frequency	Percent
Experiencing diseases		
YES	117	99.2
NO	1	0.8
Disease experienced		
CBSD	75	63.6
CBSD & CMD	28	23.7
CBSD, CMD & Whiteflies	6	5.1
CBSD & Whiteflies	9	7.6
Total	118	100.0

Table 11, indicates that 63.6% of farmers have been experiencing shoot and stem drying, root rot and yellow patches in leaves which indicates that the fields were affected by CBSD. In addition to signs of CBSD 23.7% reported to experience twisted and misshapen leaves in cassava fields. The results indicates that the fields were affected by both CBSD and CMD. Presence of CBSD, CMD and whiteflies was reported by 5.1% that affected the field jointly and 7.6% reported to experience CBSD symptoms and presence of whiteflies in their farms.

4.2.5 Farmers awareness on the presence and effects of CBSD in the study area

Cross tabulation was done between years of growing cassava and presence of cassava disease and between "YES" and "NO" responses on the presence of disease in the study area. The results indicated that farmers are aware on the presence of the diseases in their farms as was reported by 99.2% (Table 11). The results are significant (P value of 0.010) and χ^2 Value of 58.496) (Table 12).

Table 12: Chi-Square Tests

Cross tabulation	χ^2 Value	P Value
Presence of cassava disease in the area * Years of growing cassava (experience)	58.496	0.010***
Presence of disease: Yes response * No response	118.00	0.008***

*** Significant at 1% significance level

Plate 1, indicates parts of cassava plant affected by CBSD as was captured during data collection. The red arrows in the left hand side of the figure, indicates parts of cassava root affected by CBSD leading to root rotting and dark spots. Rotting and spots make the root or tuber not suitable for human consumption. The red arrows in right hand side indicate parts of cassava leaves affected by CBSD. This was captured during survey indicating the presence of disease in the study area.

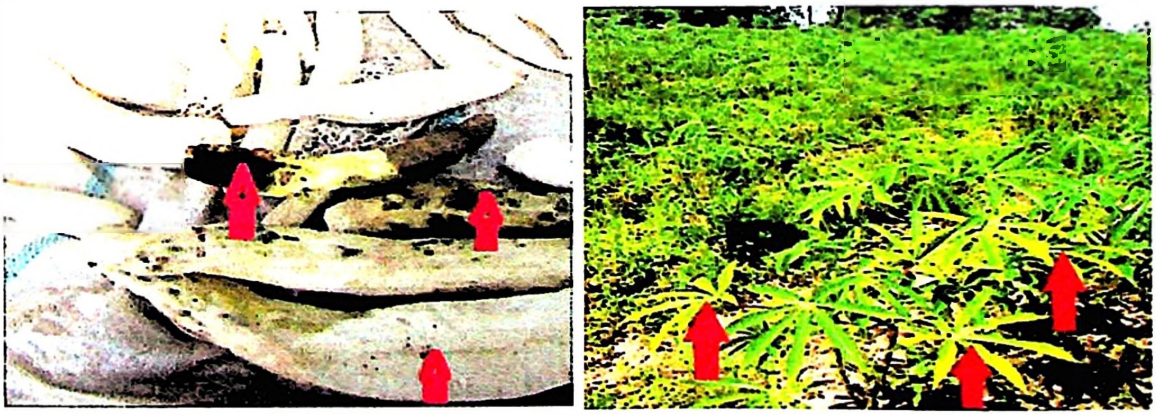

Plate 1: Parts of cassava affected by diseases

4.2.6 Constraints to cassava production

Major constraints in cassava production which were pointed out by cassava farmers were presence of diseases like CBSD and CMD which affects the yield and discourages farmers to engage in cassava farming (Table 11). Lack of storage technology and facility to store planting material after harvest to the next planting season. The problem make farmers to avoid using improved variety which matures early and they fail to keep the planting material to the next planting season. Farmers also pointed out that they face transport problem to transport planting material to the field and cassava back home after harvests. Lack of modern machine for cassava processing was reported in five villages out of six visited that they don't have processing machine. They use traditional technologies (methods) to prepare cassava for consumption, storage and sale. *Makopa* and *Udaga* are prepared using traditional technologies. Large portion of their cassava is sold or stored in form of processed *Makopa* or *Udaga*. It was also reported that farmers lack reliable source of improved planting material resistant to diseases. Local planting material are widely used whereby 81.4% of farmers in the study area reported to use local planting material which takes long time to mature hence make them susceptible to CBSD infestation as they are left in the field more than nine months (Table 7).

4.3 Cassava Marketing and Post Harvest Handling

4.3.1 Cassava marketing

It was observed that 83.9% of farmers in the study area sell their cassava in form of *Makopa* or *Udaga* and flour to village consumers or urban traders. Other farmers 16.1% produce cassava for family use they don't sell to any group due to low level of production as a result of smaller size of land they own or large family size. Out of 83.9% of cassava products sold 48.3% were sold to urban traders and 35.6% was sold to village consumers within the village (Table 13).

It was also observed that 74.6% of farmers sold their cassava in form of *Makopa* or *Udaga* to village consumers and urban traders. Only 9.3% of cassava was sold in form of high quality flour processed using modem technology this was observed in Kijuka village, Nyamazugo ward. The processed flour was packed in packages of five kilograms; most of their flour was sold to urban traders from Sengerema, Geita and Mwanza (Table 13). Only 3.4% reported to sell cassava products to specific users that is food vendors in urban areas. About 88.1% sell cassava products to different buyers without taking into consideration the uses of cassava products. So they don't have customers with specific uses like biscuits and animal feed processors (Table 13). It was reported by 83.9% of farmers who sell cassava products that the payment was on cash basis at delivery. The mode of payment was on cash no farmer reported to sell on credit or receive payments in advance before supplying the products. The remaining 16.1% do not sell cassava products; they produce for home consumption (Table 13).

Table 13: Distribution of respondents according to cassava selling

	Frequency	Percent
Do you sell cassava		
YES	99	83.9
NO	19	16.1
Consumer/buyer		
Consumed at home	19	16.1
Village consumers	42	35.6
Urban traders	57	48.3
Form of cassava sold		
Do not sell cassava	19	16.1
Makopa/Udaga	88	74.6
Flour	11	9.3
Do you sell to specific user		
None response	10	8.5
YES	4	3.4
NO	104	88.1
Mode of payment		
Do not sell cassava products	19	16.1
Payment on delivery in cash	99	83.9
Total	118	100

It was observed that large amount of cassava sold in the year 2013 and 2014 was from farmers using who used improved varieties in their farms. About 117 320 kilograms (54.1%) of cassava was sold by farmers who used improved variety like *Mkombozi, Berinde* and *Kyaka* in their farms. For farmers using local variety managed to sell a total of 99 630 kilograms (45.9%) in the same period out of 216 950 kilograms sold in 2013 and 2014. The average for farmers using improved variety was 2 620.9 and 2 711.8 kilograms for 2013 and 2014 respectively this was higher than the average sold by farmers using local variety which was 345 and 692.8 kilograms for 2013 and 2014 respectively (Table 14). Although farmers using improved planting material were few in number but they had larger proportions (54.1%) of cassava sold in 2013 and 2014. This may be is attributed by high yielding and resistance to diseases of the new varieties used.

Table 14: Distribution of cassava selling by type of planting material used

Types of planting material used	Year	N	Total cassava sold (Kg)	Mean cassava sold (Kg)	Percent
	2012/13	22	57660.00	2620.9091	
Improved variety	2013/14	22	59660.00	2711.8182	
	2012 to 2014	22	117 320	5 332.7	54.08
	2012/13	96	33120.00	345.0000	
Local variety	2013/14	96	66510.00	692.8125	
	2012 to 2014 .	96	99 630	1 037.8	45.92
Total cassava sold	2012 to 2014	118	216 950	1 838.6	100

4.3.2 Price determination

The prices of cassava products in the study area were determined using various approaches the most important one was through negotiations between buyers and sellers which was reported by 74.6%. Others 4.2% reported that the prevailing market price was used to decide the selling price, 3.4% reported that the buyer determined the price and 1.7% the prices were determined by producers themselves (Table 15). It indicates that farmers who are group members participate in the negotiation to fix the prices of their products. In Kijuka village, Nyamazugo ward farmer's process high quality cassava flour using the machine owned by *MKOMBOZI* group they discuss and agree on prices as a group. They set low prices for that buying cassava flour in bulk and transport it to urban consumers. The price charged for buyers buying cassava flour in bulk Tsh 800 per kilogram while for those buying in small quantity was Tsh 1 000 per kilogram of processed flour.

Table 15: Distribution of respondents according to power of price determination

How price is determined	Frequency	Percent
None sellers	19	16.1
By producer	2	1.7
By buyer	4	3.4
Negotiable	88	74.6
Competitive market price	5	4.2
Total	118	100.0

4.3.3 Post harvest handling

Post harvest activities are carried out by farmers before selling cassava products to consumers. The main post harvest activities carried out by many farmers were sorting to separate roots affected by various diseases such as CBSD and CMD. The roots which are highly affected by diseases are sorted out in the field and thrown or left in the field. Those roots which were in good condition were transported to their homes or to the processing machine. Peeling was done at home to prepare cassava for *Makopa* or *Udaga*. During peeling exercise sorting is also done by removing parts affected by diseases which were not detected in the initial sorting. The peeled cassava is soaked in water or fermented and washing before drying in the sun to get *Makopa* or *Udaga*. *Makopa* or *Udaga* are either stored for future use or sold to different buyers of cassava product. Farmers in Kijuka village where they have a motorized machine for processing cassava flour they also engage in packing into bags of five kilograms and transport the flour to customers located in Sengerema, Geita and Mwanza. During sorting and peeling 99.2% of farmers reported that they managed to identify roots with streaks and rotting which is the sign of presence of CBSD in their fields (Table 16).

Cassava affected with diseases was regarded as low grade cassava which was not suitable for human consumption. About 93.2% of farmers reported that it is difficult to sell low grade cassava because is not suitable for human consumption so none of the consumers of cassava products demand for it. Only 6.8% of farmers managed to sell affected cassava at very low prices between Tsh 35 and 50 per kilogram. The buyers of low grade cassava were farmers who use it to make local brew. Local brewers use cassava which is not severely damaged by diseases (Table 16).

For farmers who did not manage to sell low grade cassava 88.1% reported that they threw it in the fields and spread them as manure in their farms, 3.4% decided to burn it, 1.7% used to feed poultry and 0.8% reported to throw in the cattle shade to feed cattle (Table 16). For those spreading the remnants of affected cassava in their fields increases the incidence of diseases to expand in the area.

Table 16: Distribution of farmers managed to identify and sell CBSD affected cassava

CBSD identified	Frequency	Percent
YES	117	99.2
NO	1	0.8
Affected cassava sold		
YES	8	6.8
NO	110	93.2
Uses of low grade cassava		
Burning	4	3.4
Feed poultry	2	1.7
Given to cattle	1	0.8
Local brew	7	5.9
Thrown	104	88.1
Total	118	100.0

4.4 Cassava in Poultry Feeds

4.4.1 Cassava inclusion in poultry feeds

Cassava was included in broiler feeds to replace maize in the diets. Ten experimental diets were formulated by the animal scientist for feeding broilers, out of ten one diets did not include cassava it was used as a control diet by the animal scientist experiments. The remaining nine diets included cassava at 12.05%, 24.1% and 36.15% of the total feed formulated. Cassava based poultry feeds formulated replaced maize at 25%, 50% and 75% to supply energy. Cassava used in feed formulation was divided into three classes according to level of damage caused by CBSD, where class I cassava had no signs of diseases in the root, class II the damage was up to 5% and class III the damage was between 5 to 10% of the storage root as shown in root severity scoring scale (Figure 7). Class IV and V were not included in the study due to its severity. From each class, three diets were formulated by animal scientist at 12.05%, 24.1% and 36.15% to make a total of 48.2% of carbohydrate of the feed formulated. The ten diets were formulated without taking into consideration of costs of ingredients in the formulation. This study used LP model to formulate least cost feed which will meet nutritional requirement.

4.4.2 Least cost feed formulated

The least cost feed was formulated using LP model in Lingo 15.0 x 64 computer software. The costs of ingredients were put into consideration to obtain least cost feed using the LP model. There were three models where in model one there was no cassava inclusion in the model. Model two cassava class I was included in the model and model three included cassava class II and III together. The difference between class I and other classes was on the percentage of crude protein in cassava and level of damage. The level of crude protein used was 3.09% and 2.98% for clean cassava (class I) and affected cassava (class II & III) respectively as was calculated by animal scientist during preparation of experimental diets as was explained in section 4.4.1. The cost of feed without cassava inclusion was Tsh 692.96 per kilogram of feed formulated. The cost of feed formulated with cassava inclusion was Tsh 691.84 and 667.84 per kilogram for clean and affected cassava respectively (Table 16). The source of variation in costs of feeds with cassava was due to differences in the price of clean and affected cassava used which was Tsh 250 and 150 respectively. The level of cassava inclusion from the LP model results was 0.24 (24%) in one kilogram of feed formulated. This is equivalent to 49.9% of the energy source in the feed. The optimal inclusion of cassava from the LP model of 24% of the total feeds formulated implies that maize can be replaced by cassava at 49.9% in the diet. This is in line with what was reported by Ngiki *et al.* (2014) that cassava root meal can be included up to 50% and 60% in broilers and layers feed rations to replace maize respectively. There was differences in ingredients between cassava based feeds with clean cassava (class I) and affected cassava (class II & III) (Table 17).

Table 17: Ingredients estimates from LP model

Variables	No cassava	Variable estimates from LP model With Cassava	
		Class I (clean)	Class II & III (affected)
Maize (X1)	0.45289	0.24100	0.24100
Cassava (X2)	0.00000	0.24000	0.24000
Soy cake (X3)	0.15000	0.20000	0.20000
Sunflower cake (X4)	0.10000	0.10000	0.10000
Maize bran (X5)	0.11115	0.03300	0.03300
Fish meal (X6)	0.18000	0.18000	0.18000
Salt (X7)	0.00300	0.00300	0.00300
Premix (X8)	0.00300	0.00300	0.00300
Minimum cost	692.9619	691.84	667.84

The costs of feeds per kilogram were higher in feeds without cassava (Tsh 692.96) than the feeds with cassava (Tsh 691.84 and 667.84) for clean and affected cassava respectively. The costs were compared with the feeds formulated with affected cassava. The differences were statistically significant at 5% significant level (Table 18) ($P < 0.05$).

There was a small variation in costs between feeds without cassava and cassava based feeds due to increase in soy cake to compensate for protein declined as a result of cassava inclusion. Cassava has little amount of protein as compared to maize, therefore as the amount of cassava increases there is a need to add other sources of protein to meet the minimum requirement of protein. The level of soy cake from the LP model without cassava was 15% while with cassava inclusion increased to 20% to compensate for protein lost due decrease in maize in the feed and increase of cassava in the feed (Table 17).

Table 18: Test statistics

	t	df	P value	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
With cassava	56.653	1	0.011**	679.84000	527.3655	832.3145
No cassava	54.168	1	0.012**	680.40095	520.7989	840.0030

** Significant at 5% significant level (P < 0.05

4.4.3 Economics of replacing maize by cassava in broiler diets

Results from feed formulated using linear programming model revealed that the costs of producing one kilogram of broiler feed was Tsh 692.96, 691.84 and 667.84 for feeds without cassava, clean cassava and affected cassava respectively. The level of cassava inclusion reduced the costs of feed formulated. The results indicated that the inclusion of cassava can be done up to 24% of total feeds which is equivalent to 49.9% of carbohydrate sources. This implies that the remaining 50.1% of carbohydrate will be supplied by maize and other sources of energy in the feed formulation. In all ration formulated the one with zero percent cassava had the highest cost (Tsh 692.96) per kilogram. The results are in line with what was reported by Anaeto and Adighibe (2011) that the cost of feed declined as the level of Cassava Root Meal (CRM) increased.

At the price above Tsh 300 it is not economical to include cassava in the feed formulation because the cost of feed formulated per kilogram was increasing as the price of cassava increased (Table 19). Feed formulation was found to be feasible when the price of dried cassava is either less or equal to 66.7% of maize price. Therefore, if the average market price of dried cassava will be Tsh 300 per kilogram then cassava inclusion in broiler feed will be feasible assuming that the current price of maize will remain at Tsh 450.

Table 19: Costs of broiler feeds (1kg) at different price levels of Cassava (LP Model)

Price per kg	No cassava	With cassava
150	692.9619	667.84
200	692.9619	679.84
250	692.9619	691.84
300	692.9619	703.84
350	692.9619	715.05
400	692.9619	725.06
450	692.9619	735.08

The prices of maize are allowed to vary from Tsh 250 and above without affecting the optimal values of variable ingredients in the feed formulated. The prices of cassava are allowed to vary in a range of Tsh zero to 330 in the formulation without affecting the optimal values of feed formulated (Appendix 7). These allowable variations in the prices will increase or decrease the objective coefficient without changing the optimal values for the variables.

Table 20: Feasibility of using cassava in broiler feeds at different levels of cassava prices

Price	Class I	Class II & III
150	+	+
200	+	+
250	+	+
300	+	+
350	-	-

+ = The costs of feed is low and substitution is viable (feasible).

- = The costs of feed are high substitution is not viable (not feasible).

4.5 Profitability of Using CBSD Affected Cassava in Poultry Feed

Contribution margin was used to assess the possibility of generating profit from cassava based broiler feeds. It was noted that all cassava based broiler diets had positive contribution margin at all cassava price levels less than Tsh 300. This implies that the costs of feed formulation were high in feeds without cassava than those with cassava. Therefore feeds with cassava inclusion generate more profits than those without cassava due low costs of blending the feed. The differences are statistically different at 95% confidence interval. At the current price of broiler feed (Tsh 710.00 per kg) all diets had positive contribution margin.

In the feed formulation developed through LP model the contribution margin for feeds formulated without cassava was positive but lower than the feeds with cassava when the price of cassava is Tsh 300 or below per kilogram (Table 21). For diets formulated with cassava inclusion at 49.9% contribution margin was positive up to a point when the price of cassava is Tsh 300 per kilogram. At the price of Tsh 350 and above the contribution margin becomes negative.

Table 21 Unit contribution margin of broiler feed at different price levels of cassava

Item	Price of cassava per kilogram	Costs per Kg of feed produced (Tsh/Kg)	Unit contribution margin(Tsh/Kg)
No cassava		692.96	17.04
	150	667.84	42.16
Class I	200	679.84	30.16
	250	691.84	18.16
	300	703.84	6.16
	350	715.05	-5.05
	150	667.84	42.16
Class	200	679.84	30.16
II & III	250	691.84	18.16
	300	703.84	6.16
	350	714.99	-4.99

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study assessed the awareness of farmers on the presence of Cassava Brown Streak Diseases (CBSD) in Sengerema and economic viability of using affected cassava in poultry feeds. Basing on the findings many farmers (99.2%) were aware of the presence of CBSD in the district the results were significant at 1% significant level ($p< 0.01$) (Table 12). Farmers have been experiencing the diseases in their fields this made some farmers (1.7%) to stop production of cassava due to losses they get as a result of CBSD.

It was observed that many farmers lack knowledge how to identify, control and eliminate or minimize the effects of the disease in their fields. Also it was found that majority (81.4%) of farmer's plant local varieties which takes long time to mature hence increases the incidence of being affected by CBSD as cassava is left in the field for long time. Its implication is that farmers keep on planting affected cuttings in their fields and increase the disease incidence in the area leading to low production of cassava. The declines in production affect food security in the area and discourage expansion of land under cassava production.

Ukiriguru Research Station has developed improved varieties which matures early, resistant to diseases and high yielding but farmers are not using them because the planting material are not available to them. For farmers who have started using improved varieties reported that the yields were high and cassava matures early. Time of harvesting do not take place at the same time with planting period so make farmers face challenges of keeping planting material until the next planting season. Farmers who have started planting improved varieties face the challenge of failure to store the cuttings to the next planting season after harvest as they mature early between six to nine months. So farmers prefer local planting material which take long time to maturity and give them an opportunity of getting planting materials for the next planting season. Local varieties planting material are locally available in their farms and mostly used. But can lead to increase in the disease incidence in the area.

Management of wastes or affected cassava is not good since the remnants are thrown in the field as was reported by majority (88.1%) of farmer hence promote the spread of the disease. Affected remnants carry the virus of the diseases to the next planting season and continue attacking the crop and accelerate disease spread.

Experiments were carried out by animal scientist who formulated cassava based broilers feeds. The feeds formulated didn't take into consideration the effects of costs during substitution. Ten experimental diets were formulated one diet didn't include cassava completely and nine diets included cassava at 25, 50 and 75% for each class of cassava. Therefore each class had three diets one at each level of replacement. Class one cassava was the one which was not affected by diseases, class two the effects of diseases are between zero and five percent and class three the damage is between five to ten percent.

Basing on the LP model results it was noted that the optimal inclusion of affected cassava class II (5% damage) and class III (5-10% damage) is 24% in one kilogram of feed formulated. Inclusion of 24% is equivalent to 49.9% replacement of maize as the energy source in the feed. Protein declines due to inclusion of cassava therefore it is important to compensate by adding other sources of protein such as soy bean, sunflower cake and fish meal to supply the required level of protein in the feed. Other sources of protein are more expensive than the maize which was replaced by cassava. Also it was noted that using cassava is economically viable if the price of cassava is either less or equal to 66.7% of maize price.

The use of CBSD affected cassava in poultry feeds can reduce the wastes and losses caused by the disease to farmers. Also it provides another channel of rejected cassava as a raw material to animal feed processor.

5.2 Recommendations

Recommendations and suggestions to key actors in cassava subsector were developed regarding to the opportunities and weakness identified during this study.

i. **Training:** Training to farmers on farming practices which helps to reduce the rate of diseases spread. The training should mainly focus on diseases identification in the field, selection of proper planting material, land preparation and hygienic practices at farmer's level. Farmers also should be trained to manage farms with affected plants to avoid further spread of CBSD in the area. Post harvest management of cassava such as processing, drying and storage technologies are important to make farmers able to prepare cassava as raw material in animal feeds so as to create market for cassava which is affected with CBSD. Also farmers and other stakeholders should be trained to identify clean planting material.

ii. **Planting material:** Basing on the results that many farmers plant local variety in their farms it will be advantageous to increase the supply of improved planting material in order to make it available to many farmers. Also proper distribution of planting material is important to be under the control of expert to make sure that only none infected planting material are distributed to famers. Increase planting material multiplication in the lake zone can help to eliminate the problem of shortage of cuttings and it will help to solve the problem of farmer's failure to store cuttings for the next planting season.

iii. **Extension services:** Strengthening of extension services to create awareness of famers on management practices and importance of using improved varieties in their farms. Extension services should provide information on the uses of cassava in animal feeds, diseases control and selection of better improved varieties. It should also go together with identification of more animal feed processors and sensitize them on the advantages of using cassava in animal feed formulation. Extension workers should help farmer to create market linkages for cassava products and by products. Also extension service is required to train farmers on how to prepare cassava as raw material for animal feed processing.

iv. **Policy recommendation:** Using class I, II and III of cassava in poultry feeds is a profitable venture, expanding and scaling-up similar enterprises to other parts of the country would accelerate the process of transforming the cassava subsector and livestock sector poultry in particular which is consistent with the millennium development goal (MDG's). However, policies to improve the limiting factors for example the lack of access to processing technology, lack of improved and clean planting material are of paramount importance. Policies to govern distribution and control of quality of clean planting material should be put in place to improve cassava subsector. Also efforts are required to inform animal feed processor the possibility of including affected cassava as one of ingredient in poultry feeds as a strategy to promote market for affected cassava.

v. **Further study:** The area covered by this study is smaller than the ideal size anticipated. This is because of collection of data was limited to Mwanza region. However, the results provide some important conclusions which may be important for further evaluation of uses of CBSD affected cassava in poultry feeds in other parts of the country. Therefore it is proposed that further detailed studies with wider coverage should be done.

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APPENDICES

Appendix 1: Model 1 Lingo output

Results without Cassava inclusion

```
  Global optimal solution found.
  Objective value:                              692.9619
  Infeasibilities:                              0.000000
  Total solver iterations:                             3
  Elapsed runtime seconds:                          0.22

  Model Class:                                        LP
  Total variables:                  5
  Nonlinear variables:              0
  Integer variables:                0
  Total constraints:               15
  Nonlinear constraints:            0
  Total nonzeros:                  39
  Nonlinear nonzeros:               0
```

Variable	Value	Reduced Cost
X1	0.4528492	0.000000
X3	0.1500000	0.000000
X4	0.1000000	0.000000
X5	0.1111508	0.000000
X6	0.1800000	0.000000
X7	0.3000000E-02	0.000000
X8	0.3000000E-02	0.000000

Row	Slack or Surplus	Dual Price
1	692.9619	-1.000000
2	0.000000	-909.5238
3	0.000000	4761.905
4	0.2000000E-01	0.000000
5	166.7674	0.000000
6	33.23258	0.000000
7	0.2815079E-01	0.000000
8	0.2118492	0.000000
9	0.1500000	0.000000
10	0.000000	-2093.810
11	0.1700000	0.000000
12	0.000000	-763.3333
13	0.1884921E-01	0.000000
14	0.1500000	0.000000
15	0.000000	-1857.619
16	0.000000	409.5238
17	0.000000	-4090.476

Appendix 2: Model 1 Lingo 15.0 syntax used
Model used in LP

```
Model used in LP

Objective function:

Min = 450*x1 + 1200*x3 + 400*x4 + 330*x5 + 1200*x6 + 500*x7 +
5000*x8;

Subject to:
x1 + x3 + x4 + x5 + x6 + x7 + x8 = 1; Production constraint
0.0965*x1 + 0.3787*x3 + 0.2673*x4 + 0.1217*x5 + 0.3291*x6 <=
0.20; Protein constraint upper limit
0.0965*x1 + 0.3787*x3 + 0.2673*x4 + 0.1217*x5 + 0.3291*x6 >=
0.18; Protein constraint lower limit
3657.65*x1 + 3308.92*x3 + 1659.47*x4 + 3464.46*x5 + 1830.59*x6 <=
3200; Metabolizable energy upper limit
3657.65*x1 + 3308.92*x3 + 1659.47*x4 + 3464.46*x5 + 1830.59*x6 >=
3000; Metabolizable energy upper limit
x1 <= 0.481; Maize
x3 >= 0.15; Soy cake
x4 >= 0.10; Sunflower cake
x5 <= 0.18; Maize bran
x6 <= 0.33; Fish meal upper limit
x6 >= 0.18; Fish meal lower limit
x7 = 0.003; Salt
x8 = 0.003; Premix
x1,x3,x4,x5,x6,x7,x8 >= 0; Non negativity condition
```

Appendix 3: Model 2 Lingo output

With Cassava class I (Clean cassava)

```
Global optimal solution found.
  Objective value:                                 691.8400
  Infeasibilities:                                 0.000000
  Total solver iterations:                                3
  Elapsed runtime seconds:                             0.18

  Model Class:                                           LP

  Total variables:                     6
  Nonlinear variables:                 0
  Integer variables:                   0

  Total constraints:                  15
  Nonlinear constraints:               0

  Total nonzeros:                     46
  Nonlinear nonzeros:                  0
```

Variable	Value	Reduced Cost
X1	0.2410000	0.000000
X2	0.2400000	0.000000
X3	0.2000000	0.000000
X4	0.1000000	0.000000
X5	0.3300000E-01	0.000000
X6	0.1800000	0.000000
X7	0.3000000E-02	0.000000
X8	0.3000000E-02	0.000000

Row	Slack or Surplus	Dual Price
1	691.8400	-1.000000
2	0.000000	-330.0000
3	0.000000	80.00000
4	0.3603400E-02	0.000000
5	0.1639660E-01	0.000000
6	183.9764	0.000000
7	16.02363	0.000000
8	0.2400000	0.000000
9	0.000000	-200.0000
10	0.1000000E-02	0.000000
11	0.000000	-870.0000
12	0.000000	-70.00000
13	0.1470000	0.000000
14	0.1500000	0.000000
15	0.000000	-870.0000
16	0.000000	-170.0000
17	0.000000	-4670.000

Appendix 4: Model 2 Lingo 15.0 syntax used

```
Cassava class I.

Objective function:
Min = 450*x1 + 250*x2 + 1200*x3 + 400*x4 + 330*x5 + 1200*x6 +
500*x7 + 5000*x8;

Subject to:
x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 = 1; Production constraint
x1 + x2 <= 0.481; Energy constraint
0.0965*x1 + 0.0309*x2 + 0.3787*x3 + 0.2673*x4 + 0.1217*x5 +
0.3291*x6 <= 0.20; Protein constraint upper limit
0.0965*x1 + 0.0309*x2 + 0.3787*x3 + 0.2673*x4 + 0.1217*x5 +
0.3291*x6 >= 0.18; Protein constraint lower limit
3657.65*x1 + 3595.69 *x2 + 3308.92*x3 + 1659.47*x4 + 3464.46*x5 +
1830.59*x6 <= 3200; Metabolizable energy upper limit
3657.65*x1 + 3595.69 *x2 + 3308.92*x3 + 1659.47*x4 + 3464.46*x5 +
1830.59*x6 >= 3000; Metabolizable energy lower limit
x1 <= 0.481; Maize upper limit
x1 >= 0.241; Maize lower limit
x2 <= 0.241; Cassava
x3 >= 0.20; Soy cake
x4 >= 0.10; Sunflower cake
x5 <= 0.18; Maize bran
x6 <= 0.33; Fish meal upper limit
x6 >= 0.18; Fish meal lower limit
x7 = 0.003; Salt
x8 = 0.003; Premix
x1,x2,x3,x4,x5,x6,x7,x8 >= 0; Non negativity condition
```

Appendix 5: Model 3 Lingo results

Cassava Class II & III

```
Global optimal solution found.
  Objective value:                              667.8400
  Infeasibilities:                              0.000000
  Total solver iterations:                             3
  Elapsed runtime seconds:                          0.19

  Model Class:                                        LP

  Total variables:                   6
  Nonlinear variables:               0
  Integer variables:                 0

  Total constraints:                15
  Nonlinear constraints:             0

  Total nonzeros:                   46
  Nonlinear nonzeros:                0
```

Variable	Value	Reduced Cost
X1	0.2410000	0.000000
X2	0.2400000	0.000000
X3	0.2000000	0.000000
X4	0.1000000	0.000000
X5	0.3300000E-01	0.000000
X6	0.1800000	0.000000
X7	0.3000000E-02	0.000000
X8	0.3000000E-02	0.000000

Row	Slack or Surplus	Dual Price
1	667.8400	-1.000000
2	0.000000	-330.0000
3	0.000000	180.0000
4	0.3867400E-02	0.000000
5	0.1613260E-01	0.000000
6	183.9764	0.000000
7	16.02363	0.000000
8	0.2400000	0.000000
9	0.000000	-300.0000
10	0.1000000E-02	0.000000
11	0.000000	-870.0000
12	0.000000	-70.00000
13	0.1470000	0.000000
14	0.1500000	0.000000
15	0.000000	-870.0000
16	0.000000	-170.0000
17	0.000000	-4670.000

Appendix 6: Model 3 Lingo 15.0 syntax used

Objective function:

Min = 450*x1 + 150*x2 + 1200*x3 + 400*x4 + 330*x5 + 1200*x6 + 500*x7 + 5000*x8;

Subject to:

x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 = 1; production constraint

x1 + x2 <= 0.481; Energy constraint

0.0965*x1 + 0.0298*x2 + 0.3787*x3 + 0.2673*x4 + 0.1217*x5 + 0.3291*x6 <= 0.20; Protein constraint upper limit

0.0965*x1 + 0.0298*x2 + 0.3787*x3 + 0.2673*x4 + 0.1217*x5 + 0.3291*x6 >= 0.18; Protein constraint lower limit

3657.65*x1 + 3595.69 *x2 + 3308.92*x3 + 1659.47*x4 + 3464.46*x5 + 1830.59*x6 <= 3200; Metabolizable energy upper limit

3657.65*x1 + 3595.69 *x2 + 3308.92*x3 + 1659.47*x4 + 3464.46*x5 + 1830.59*x6 >= 3000; Metabolizable energy lower limit

x1 <= 0.481; Maize upper limit

x1 >= 0.241; Maize lower limit

x2 <= 0.241; Cassava

x3 >= 0.20; Soy cake

x4 >= 0.10; Sunflower cake

x5 <= 0.18; Maize bran

x6 <= 0.33; Fish meal upper limit

x6 >= 0.18; Fish meal lower limit

x7 = 0.003; Salt

x8 = 0.003; Premix

x1,x2,x4,x5,x6,x7,x8 >= 0; Non negativity condition

Appendix 7: Ranges in which the basis is unchanged:

Objective Coefficient Ranges:

Variable	Current Coefficient	Allowable Increase	Allowable Decrease
X1	450.0000	INFINITY	200.0000
X2	250.0000	80.00000	INFINITY
X3	1200.000	INFINITY	870.0000
X4	400.0000	INFINITY	70.00000
X5	330.0000	70.00000	80.00000
X6	1200.000	INFINITY	870.0000

Righthand Side Ranges:

Row	Current RHS	Allowable Increase	Allowable Decrease
2	0.9940000	0.2960887E-01	0.4625145E-02
3	0.4810000	0.1000000E-02	0.3968502E-01
4	0.2000000	INFINITY	0.3603400E-02
5	0.1800000	0.1639660E-01	INFINITY
6	3200.000	INFINITY	183.9764
7	3000.000	16.02363	INFINITY
8	0.4810000	INFINITY	0.2400000
9	0.2410000	0.5492988E-01	0.1000000E-02
10	0.2410000	INFINITY	0.1000000E-02
11	0.2000000	0.1402101E-01	0.6380000E-01
12	0.1000000	0.8877407E-02	0.1000000
13	0.1800000	INFINITY	0.1470000
14	0.3300000	INFINITY	0.1500000
15	0.1800000	0.9807163E-02	0.7905786E-01

Appendix 8: Questionnaire for cassava growers

ECONOMIC FEASIBILITY STUDY OF CASSAVA ROOT AFFECTED BY *CASSAVA BROWN STREAK DISEASE* IN POULTRY FEEDS IN TANZANIA

Questionnaire number __________

Name of enumerator__________

Date ________________

District _________________________. Ward _________________________

Village __________________________

Name of respondent _________________________. Age ______________.

Sex of respondent _________________ Marital status______________________

Level of education

a) Never gone to school

b) Primary education

c) Secondary education

d) Certificate/diploma

e) University

Total number of family member................

Male under 18................ Female under 18 .... Total female...........

Male over 18................... Female over 18 .... Total male.............

A. CASSAVA PRODUCTION

1. Do you grow cassava (*If NO go to question 7*)

a) Yes

b) No

2. If Yes for how long you have been growing cassava ______________ years

3. How many acres of land do you own ______________

4. How many were under cassava production in the last season______________

5. How did you get the land for planting cassava

   a) Inherited

   b) Rent /Lease

   c) Purchase

   d) Pledge

   c) Others (specify)

6. What was the source of funds to finance cassava farming activities (*tick the appropriate*)

   a) Personal savings

   b) Friends

   c) Donors

   d) Loan from bank

   e) Traders

   f) Processors

   g) Farmer organization/Cooperatives

   h) Others (specify)

7. What other crops do you grow for food (*list in the order of importance*)

   a)______________________________

   b)______________________________

   c)______________________________

   d)______________________________

   e)______________________________

8. In cassava production do you use improved seed (i) Yes (ii) No

9. If yes what varieties did you grow in the last two season

   a) ______________________________

   b) ______________________________

   c) ______________________________

   d) ______________________________

10. Why did you prefer such varieties

    a) Sweet

    b) Resistant to diseases

    c) Mature early

    d) Good market

    e) High yield

    f) Others specify_____________________________

11. Have you ever experienced any disease affecting cassava in your field. (i) Yes (ii) No

12. If YES which disease affected the crop in your field the season 2013/2014

    a) __________________________________

    b) __________________________________

    c) __________________________________

B. CASSAVA MARKETING AND POST HARVEST HANDLING

13. Do you sell your cassava (i) Yes (ii) No

14. In what form do you sell your cassava (e.g. fresh, dried, flour etc)

    ____

15. What is the unit of measurement during selling

 a) Kiroba ....(Equivalent to ______________kg)

 b) Tenga .... (Equivalent to ______________kg)

 c) Others (specify)

16. What portion of cassava harvested did you sell in the last two seasons

Season	Amount harvested	Amount consumed at home	Amount sold	Amount rejected
2013/2014				
2012/2013				

State if it is in Viroba or Tenga and its equivalent in Kg.............

17. What was the reason for rejecting cassava roots for boiling, roasting, flour making

 a) ....

 b) ....

 c) ....

18. Do you sell cassava to specific users

 a) YES

 b) NO

19. To whom did you sell your cassava

 a) Village consumers

 b) Urban traders

 c) Processors for human food

 d) Processors for animal feed

 e) Exporters

 f) Others (specify)..

20. How was prices offered by clients determined

 a) By producer

b) By buyer

c) Negotiable

d) Competitive market price

e) Others (specify) ....

21. What mode of payment did they use

a) Pay in advance

b) Pay on delivery in cash

c) Pay on credit

22. What postharvest activities do you carry out from harvesting to selling (*eg drying, sorting, transporting etc*)

....

....

23. After harvesting did you manage to identify cassava affected by CBSD from your farm.

a) Yes

b) No

24. If YES in 23 above did you manage to sell affected cassava (low grade cassava)

a) Yes

b) No

25. If YES in question 24, what was the selling price ________________

26. If NO in question 24, what did you do with the affected cassava (low grade cassava).

a) ....

b) ....

27. If someone is ready to buy affected cassava at what price are you willing to sell................

28. What challenges did you face as a cassava producer

....

....

29. What is your suggestions to overcome such challenges in 28 above.

....

....

....

Thank you for your cooperation

Appendix 9: Questionnaire for poultry feed processor

ECONOMIC FEASIBILITY STUDY OF CASSAVA ROOT AFFECTED BY *CASSAVA BROWN STREAK DISEASE* IN POULTRY FEEDS IN TANZANIA

Date ____________________________

District __________________________. Ward __________________________

Name of company/enterprise________________________________

2. When did the company/enterprise commence its activities.......................
3. What are the operations carried out by the company

   a)...

   b)...

   c)...

4. What materials are used in processing poultry feeds

   ....

   ....

   Do the enterprise use cassava as one of the ingredient in poultry feeds

   (i) Yes

   (ii) No

5. If no is there any possibility (potential) of using cassava in poultry feeds

   a) Yes

   b) No

6. If YES where do you think will be the source of cassava as raw material (districts where cassava comes from)

   ....

   ....

   ....

7. Where do you purchase cassava from as raw material for your operation (who are your suppliers)

   a) Farmers

   b) Processors

   c) Traders

   d) Middlemen

   e) Others (specify)

8. In which form do you purchase it

   a) Fresh cassava

   b) Semi processed

   c) Dried cassava

   d) Others (specify)

9. Do you purchase graded cassava (Do you purchase cassava in grades)

   a) Yes

   b) No

10. If YES what are the criteria used for grading it.

    a) ....

    b) ....

    c) ....

11. What characteristics do you prefer so that you are willing to pay for product value (Arrange by priority)

    a) ....

    b) ....

c) ....

d) ....

e) ....

12. What price did you pay for the best grades.............................(shillings /kg)

13. What price did you pay for the lowest grades ....(shillings /kg)

14. How prices were determined for these grades

a) By producer (supplier)

b) By buyer (feed processor)

c) Negotiable

d) Competitive market price

e) Others specify

15. What types of poultry feeds do the enterprise formulate (*tick the appropriate*)

a) Chick mash

b) Growers

c) Layers

d) Broiler starter

e) Broiler finisher

f) others

16. Do you formulate other animal feeds apart from poultry feeds using cassava?

a) YES

b) NO

17. What other animal feeds to formulate

a) ....

b) ....

c) ....

18. What are the important nutritional requirements for poultry feed you use/meet at this company

....

....

19. What is minimum or maximum amount required in each feed formulated

	Nutrient	Requirement on feed staff (Resistirction)				
		Chick mash	Growers	Layers mash	Broiler starter	Broiler finisher
b1	Weight (kg)					
b2	Crude protein (kg)					
b3	Fat (kg)					
b4	Crude fiber (kg)					
b5	Calcium (kg)					
b6	Methionine (kg)					
b7	Lysine (kg)					
b8	Metabolizable energy (kcal Kg^{-1})					
b9	Salt (kg)					
b10	Vitamins/minerals					
b11	Others					

20. Please provide details of cassava used in 2014 for each month

Month	Amount used in kg	Price paid if not graded	Price paid for each grade/kg if graded				
			1	2	3	4	5
January							
February							
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							
Total amount							

21. Please provide information about the ingredients used in poultry feed formulated without cassava in every 1000kg (1 tonne) in 2014

Ingredient	Amount used in each feed type				
	Chick mash	Growers	Layers	Broiler starter	Broiler finisher
Maize					
Soya bean					
Cotton/sunflower cake					
Maize bran					
Rice bran					
Bone meal					
Fish meal					
Salt					
Lysine					
Methionine					
Premix					
Limestone					

22. Please provide information about the ingredients used in poultry feed formulated with non affected cassava as one of the ingredient in every 1000kg (1 tone) in 2014

Ingredient	Amount used in each feed type				
	Chick mash	Growers	Layers	Broiler starter	Broiler finish
Maize					
Cassava					
Soya bean					
Cotton/sunflower cake					
Maize bran					
Rice bran					
Bone meal					
Fish meal					
Salt					
Lysine					
Methionine					
Premix					
Limestone					

23. Please provide information about the ingredients used in poultry feed formulated with cassava affected by CBSD as one of the ingredient in every 1000kg (1 ton) in 2014

Ingredient	Amount used in each feed type				
	Chick mash	Growers	Layers	Broiler starter	Broiler finish
Maize					
Cassava with CBSD					
Soya bean					
Cotton/sunflower cake					
Maize bran					
Rice bran					
Bone meal					
Fish meal					
Salt					
Lysine					
Methionine					
Premix					
Limestone					

24. Provide the cost for each ingredient used in poultry feed formulation

Item	Price/kg	Amount per ton (1000kg)	Total cost per ton (1000kg)
Maize			
Cassava without CBSD			
Cassava with CBSD			
Soya bean			
Cotton/sunflower cake			
Maize bran			
Rice bran			
Bone meal			
Fish meal			
Salt			
Lysine			
Methionine			
Premix			
Limestone			
Labour			
Electricity			
Stationery			
Other costs			

25. Provide information about sales of poultry feed formulated in 2014

Type of feed	Sales of poultry feeds 2014					
	Without cassava		With cassava not affected by CBSD		With cassava affected by CBSD	
	Quantity	price	Quantity	price	Quantity	price
Chick mash						
Growers mash						
Layers mash						
Broiler starter						
Broiler finisher						
Pig meals						
Cattle meals						
Others						

26. What are the challenges of feed formulation using CBSD affected cassava.

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What is your suggestions to overcome such challenges in 19 above.

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Thank you for your cooperation