ECONOMICS OF SMALL - SCALE PADDY AND SUGARCANE PRODUCTION IN KILOMBERO DISTRICT, TANZANIA

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ABSTRACT

Paddy and sugarcane are important food and commercial crops in Tanzania. Paddy and sugarcane have similar ecological requirements. In areas where both are produced the two crops compete for resources. Therefore better decisions have to be made on land allocation so that farm profitability can be maximized. Unfortunately the knowledge on appropriate land allocation for paddy and sugarcane enterprises is limited in the literature. Thus the present study was conducted in Kilombero district to determine profitability of paddy and sugarcane produced by smallholder farmers and the profit maximizing combination of the two crops. Specifically the study aimed at comparing the returns to land for paddy and sugarcane enterprises, determining the most profitable combination for paddy and sugarcane enterprises and identifying constraints in paddy and sugarcane production and marketing. Primary data were collected through a cross-sectional survey by using structured questionnaires. A total of 138 smallholder farmers who produce both paddy and sugarcane were randomly selected and interviewed. Smallholder farmers in the study area were found to use acreage as their unit of land. By using gross margin analysis sugarcane was found to have high return to land per acreage than paddy. Hence sugarcane is more profitable than paddy. But it was found that Kilombero Sugar Company which is the only market for sugarcane in Kilombero district has low processing capacity. The company cannot buy all sugarcane produced by smallholder farmers per year. By using linear programming model the study found that, for a smallholder farmer to maximize farm profitability per year it is better to cultivate 4 acres of paddy and 2.5 acres of sugarcane. Many other constraints were identified but the study concludes that the market limit for sugarcane is the major constraint for smallholder farmers to maximize their farm profits. The study recommends more investment in sugarcane processing.

DECLARATION

I, **MIRIAM TITUS CHANZI**, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor being currently submitted for a degree award in any other institution.

_____ _____

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Dr. Damas Philip Date

(Supervisor)

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DEDICATION

To my husband Charles and children Moureen and Ivan

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LIST OF ABBREVIATIONS

AAG	Action Aid Ghana
ACT	Agricultural Council of Tanzania
ADF	African Development Foundation
BACAS	Bureau for Agricultural Consultancy and Advisory Services
CFACP	Commission for Agricultural Costs and Prices
E	East
EAAPP	Eastern African Agricultural Productivity Program
ESRF	Economic and Social Research Foundation
EUCORD	European Cooperative for Rural Development
FAO	Food and Agricultural Organization
FTF	Feed the Future
ha	hectare
IFAD	International Fund for Agricultural Development
IRRI	International Rice Research Institute
kg	kilogram
km^2	kilometre square
LSU AgCenter	Loisiana State University Agricultural Centre
MAFAP	Monitoring African Food and Agricultural Policies
MAFC	Ministry of Agriculture Food Security and Cooperatives
MIT	Ministry of Industry and Trade
mm	millimetre
MNRT	Ministry of Natural Resources and Tourism
MRCO	Morogoro Regional Commissioners Office
N	North

OIDA	Ontario International Development Agency
PASS	Private Agricultural Sector Support
PELUM	Participatory Ecological Land Use Management
RI	Rabobank International
RIU	Research into Use
RLDC	Rural Livelihood Development Company
RRCoE	Regional Rice Centre of Excellence
S	South
SMEs	Small and Medium Enterprises
SSA	The Swaziland Sugar Association
t	tonne
TASGA	Tanzania Sugarcane Growers Association
UNCTAD	United Nation Conference on Trade and Development
URT	United Republic of Tanzania
VCISIs	Value Chain Institutions and Support Institutions

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tanzania has about 95.5 million ha of land, out of which 44 million ha is suitable for agriculture (Tomitaka, 2012). Food crops production dominates the agricultural economy, occupying 5.1 million ha of cultivated area annually (URT, 2011). Tanzania's agriculture is dominated by smallholder farmers who have between 0.9 ha and 3 ha of land (Towo and Kimaro, 2013).

In Tanzania, agriculture continues to be the mainstay of economy, contributing close to 26 % of GDP and employing 75 % of the labour force, with women contributing more than 75 % of the agricultural labour (FTF, 2011). According to 2012 Population and Housing Census results, approximately 70% of the total population in Tanzania lives in rural areas, where they derive their livelihood from agricultural activities (URT, 2013). Therefore, improvement in agriculture is important in improving Tanzanian's livelihoods.

Paddy and sugarcane are important food and commercial crops in many countries. Paddy (Rice) domestication started in Yangtze Valley of China 8200–13 500 years ago (IRRI, 2011). Nowadays paddy is produced in many countries around the world. Most of paddy (rice) produced in the world comes from China, India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, Pakistan, Philippines, Korea and Japan. Asian farmers account for 87% of the world's total paddy production (FAO, 2013). Sugarcane was first domesticated as a crop in New Guinea around 6000 BC. New Guinean farmers and other early cultivators of sugarcane chewed the plant for its sweet juice (Daniels *et al.,* 2004). The main product of sugarcane is sucrose, which accumulates in the stalk internodes. Sucrose,

in its common name called table sugar is extracted and purified in specialized mill factories (Ophardt, 2003). Sucrose is used as raw material in human food industries or is fermented to produce ethanol (Mino, 2010). According to FAO estimates of 2013, Brazil was the largest producer of sugarcane in the world. The next five major producers, in decreasing amounts of production were India, China, Thailand, Pakistan and Mexico (FAO, 2013). The world demand for sugar is the primary driver of sugarcane agriculture. Cane sugar accounts for 80% of sugar produced in the world. Most of the rest (20%) is made from sugar beets (ADF, 2005).

In Tanzania paddy and sugarcane are among the major sources of employment, income and food security for majority of farming households especially in areas where they are produced (Tarimo and Takamura, 2001; RLDC, 2009). Paddy is mainly produced in the regions of Shinyanga, Morogoro, Mbeya, Mwanza and Rukwa. It is also not uncommon crop in Kilimanjaro, Manyara, Arusha, Dodoma, Iringa and Tanga regions (URT, 2011). Paddy production in Tanzania is dominated by smallholder farmers who practice rain-fed agriculture. Only 20% of farmers produce under irrigation (MAFC, 2009).

Sugarcane is primarily grown in four estates, namely Kilombero Sugar Company (KSC) and Mtibwa Sugar Estate (MSE) which are located in Morogoro region, Tanganyika Plantation Company (TPC) which is found in Kilimanjaro region and Kagera Sugar Estate (KSE) which is located in Kagera region. Apart from sugarcane grown by Estates, sugarcane is also produced by smallholder farmers who are residing near the estates (BACAS, 2004). For example; it is estimated that 40-50% of sugarcane in Kilombero district is produced by smallholder farmers (Kamuzora, 2011). Majority of smallholder sugarcane farmers are members of out-growers associations. Examples of out-growers associations in Tanzania are Mtibwa Out-growers Association (MOA), Ruhembe Cane

Growers Association (RCGA), Kilombero Cane Growers Association (KCGA), and Kagera Sugarcane Growers Association (KSGA) (Matango, 2006).

The production of paddy and sugarcane in Tanzania is not high enough to meet the demand. For example, rice supplied by the local production is varying from a self sufficiency level of over 80% in good years to about 67% in bad years. The rest has been supplied by the imports (RLDC, 2009). For the case of sugarcane, the country is estimated to consume 520 000 tonnes of sugar including 120 000 tonnes refined sugar used for industrial purposes. However, the annual raw sugar production is 300 000 tonnes. Therefore there is a deficit of 220 000 tonnes which is supplied by the imports (RI, 2013). Moreover, the consumption of rice and sugar in Tanzania is increasing as a result of population increase. This shows an increase in market opportunities for both crops.

However, like in other crops smallholder paddy and sugarcane farmers face a lot of challenges such as low access to fertile land, low access to improved farm inputs (such as seeds, fertilizers and agrochemicals), insect pests and diseases, low access to credit facilities and low access to market (MAFC, 2001; Afari-sefa, 2012). These challenges are among the barriers for success in production and marketing of both crops. As a result smallholder paddy and sugarcane farmers end up getting low farm incomes.

Kilombero district is among the districts of Morogoro region in Tanzania. Its climate is suitable for both paddy and sugarcane production. Majority of smallholder farmers near Kilombero Sugar Company produce paddy and sugarcane as their main sources of income and food security (Musamba *et al.,* 2011). Despite the suitability of the land and climate for paddy and sugarcane production, yields are still below the potential (Siima *et al*., 2012). Also farmers are faced with the problem of market limit for sugarcane since

Kilombero Sugar Company is the only market for sugarcane in the district (Siima *et al*., 2012; Bombo, 2013). Due to the fact that paddy and sugarcane are their most important crops, farmers have to properly utilize their limited resources; land, labour and capital in production of both crops to make sure that they get high returns from their resources and no wastage of resources.

Paddy and Sugarcane have similar ecological requirements. They all grow better in the tropical areas, both crops require ample supply of water and they are all labour intensive crops (EUCORD, 2012; PASS, 2013). Therefore in areas where both paddy and sugarcane are produced, proper land allocation should be done for each crop in order to ensure that available resources are properly utilized. Proper utilization of resources will lead to yields improvement which will consequently lead to increase in farm income and hence increase in farm profits.

The knowledge on profitability of paddy and sugarcane and the most appropriate enterprises combination is important in helping farmers make better decisions in production of both crops. The present study, among other things, aimed at determining profitability of paddy and sugarcane and the most appropriate enterprises combination for a smallholder farmer to maximize overall farm profitability.

1.2 Problem Statement and Justification

Paddy and sugarcane are among the important food and commercial crops in Tanzania (Tarimo and Takamura, 2001; RLDC, 2009). In Kilombero District especially near Kilombero Sugar Company, paddy and sugarcane are the major crops produced by smallholder farmers for the purpose of earning income and for food security. Farmers are motivated to produce these crops because the climate of Kilombero district is suitable for

production of both crops. Moreover, the presence of Kilombero Sugar Company motivates smallholder farmers to produce sugarcane (Musamba *et al.,* 2011).

As highlighted by EUCORD (2012) and PASS (2013) paddy and sugarcane have similar ecological requirements. In areas where both are produced farmers have to make better decision on the amount of land to allocate to each of the two crops, with regard to resources availability and marketability of the crops. Inappropriate land allocation may lead to low farm productivity which consequently lead to low farm income. Also with inappropriate land allocation farmers may end up producing more crops than what their market can absorb and this is wastage of resources.

Despite the favourable condition for paddy and sugarcane production in Kilombero district, smallholder farmers are getting low productivity in both paddy and sugarcane. The potential production for paddy and sugarcane are 5t/ha and 80t/ha respectively (Uliwa and Ringo, 2007). But the actual production were found to be 3.5t/ha for paddy and 64t/ha for sugarcane (Siima *et al*., 2012).This low productivity is likely to be caused by among other factors, inappropriate enterprises combination. As a result farmers are ending up getting low farm income from both crops.

Despite low productivity, smallholder farmers in Kilombero district are producing more sugarcane than what their market can absorb. As explained earlier, Kilombero Sugar Company is the only market for sugarcane produced by smallholder farmers in Kilombero district. Due to its low processing capacity, the Company cannot buy all sugarcane produced by smallholder farmers per year. This causes some farmers to miss the opportunity of selling their sugarcane in some years (Siima *et al*. (2012). Therefore sugarcane income to some farmers in some years becomes zero. The knowledge on the

most appropriate enterprises combination for paddy and sugarcane is important in helping farmers make better decision for production of both crops and hence maximize their farm profitability. However, this knowledge is limited in the literatures.

In different areas where both paddy and sugarcane are produced including Kilombero district, many studies have been conducted. But most of the previous researchers were interested on other things apart from finding the appropriate enterprises combination for paddy and sugarcane. For example; the study by Togolay (2010) which was conducted in Mvomero district just determined the gross margins of paddy and sugarcane. Togolay (2010) did not determine the appropriate enterprises combination for paddy and sugarcane although smallholder farmers in his study area are the producers of both paddy and sugarcane. The same was done by Chongela (2008) in Kilosa District.

In Kilombero district (the study area), the study by Musamba *et al.* (2011) aimed at examining the costs and benefits associated with water in crops production (that is, economic value of water in crops production). Moreover the study by Benard *et al*. (2014) aimed at assessing the information needs of rice farmers in Tanzania.

Up to this moment there is no clear recent documentation on the appropriate (the most profitable) enterprises combination for paddy and sugarcane. That is why the present study among other things aimed at determining the most profitable enterprises combination for paddy and sugarcane produced by smallholder farmers in the study area. The findings from this study will be helpful to farmers themselves, the government of Tanzania and other stakeholders in the strategic plans for production of these two crops.

1.3 Objectives

1.3.1 Overall objective

The overall objective of the present study is to determine profitability of paddy and sugarcane produced by smallholder farmers and the profit maximizing combination of the two crops.

1.3.2 Specific objectives

Specific objectives are:-

(i) To compare the returns to land for paddy and sugarcane among smallholder farmers in the study area.

(ii) To determine the most profitable combination for paddy and sugarcane enterprises.

(iii) To identify constraints toward better performance in paddy and sugarcane production and marketing in the study area.

1.3.3 Research Hypothesis

The returns to land for paddy and sugarcane are not statistically different.

1.3.4 Research questions

(i) What is the optimal combination for paddy and sugarcane enterprises?

(ii) What are the constraints toward better performance in paddy and sugarcane production and marketing in the study area?

1.4 Organisation of the Dissertation

This dissertation is organized into five chapters. The first chapter presents the background information for the study, problem statement and justification, objectives of the study, a

research hypothesis for the first specific objective and two research questions for the second and the third specific objectives respectively. The second chapter reviews theoretical and empirical economic aspects of small-scale paddy and sugarcane production. More emphasis is on the issue of farm profit maximization in terms of enterprises combination. The third chapter presents the methodology used in the study. The fourth chapter presents the results and discussion of the study. The last chapter presents the conclusion and recommendations emanating from the findings of the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Key Concepts

2.1.1 Production

Production is the process of combining and coordinating materials and forces (inputs, factors, resources, or productive services) in the creation of some goods or services (output or product) (Beattie and Taylor, 1985). The terms input and output only have meaning in connection with a particular production process. Output from one production process can be an input to another production process, or it can be final consumer good (Bombo, 2013). In agriculture, especially in crops production, the basic resources or inputs or factors of production are land, labour and capital. With capital a farmer can buy other inputs such as fertilizer, agrochemical, additional land and additional labour.

2.1.2 Sugarcane production

Sugarcane (*Saccharum officinarum*) is a well-known perennial plant of the grass family and its production is confined to the warmer regions of the earth. Sugarcane grows in all tropical and subtropical countries (Panda, 2011). Sugarcane requires plentiful supply of water, for a continuous period of six to seven months each year, either from natural rainfall or through irrigation. The crop does not tolerate severe frosts. Therefore, most of the world's sugarcane is grown between 22°N and 22°S, and some up to 33°N and 33°S. Both plentiful sunshine and water supplies increase cane production (Galloway, 2005).

According to PASS (2013), sugarcane requires ample supply of water, 1200 -1500 mm per annum. In freely drained soils, a high precipitation can be tolerated. The duration of the rainy season is important in sugarcane growth. For example, at the Kilombero Sugarcane

Estates where annual rainfall could be as high as 1500 mm per annum, sugarcane is also irrigated because most of the rainfall is restricted to the period between March and May. Adequate moisture and temperature are the two most important ecological requirements that are essential for efficient growth and productivity of the sugarcane crop (PASS, 2013).

Chidoko and Chimwai (2011) argued that sugarcane is a labour intensive crop especially for weeding and harvesting and it is an important user of agro-chemicals like fertilizers and herbicides. According to Sundara (1998) the cost structure in sugarcane farming is such that human labour takes 45%, pesticides consume 4%, artificial and organic fertilizers take 14%, seeds take 14%, machine labour takes 17% and interests consume 4%. But the costs incurred depend upon the level of crop management by the farmers, their economic condition and credit availability. This argument implies that sugarcane is a labour intensive type of crop as almost half of the costs are spent on labour. Machine labour is ranked second while fertilizers and seeds are the third.

According to Chidoko and Chimwai (2011), inputs play a great role in the growth of sugarcane. They argued that inputs are required within 3-4 months of planting to get the best crop. For example; if fertilizers are not available on time it affects the growth rate and thus the return per piece of land. Therefore it is important to apply the required quantities of inputs as when they are needed. Lower input use will certainly save costs but reduce productivity. Furthermore, Sundara (1998) argued that the age of a ratoon has an inverse relationship with crop yield. If no new cane is planted that implies declining trend in productivity.

Humbert (1999) agreed that inputs are very important in achieving good yields. He identified seed, fertilization, irrigation, transport costs and ratoon management as the key

elements to be managed for efficient sugarcane production. The right varieties for the climate and soils need to be grown. Land has to be prepared taking into consideration the method of irrigation to be used and it should facilitate water movements.

2.1.2.1 Sugar extracted from Sugarcane

Sugar extracted from sugarcane is called sucrose, in its common name “table sugar” (Ophardt, 2003). Sucrose is a carbohydrate that occurs naturally in every fruit and vegetable. It is the major product of photosynthesis, the process by which plants transform the sun's energy into food. Sucrose occurs in greatest quantities in sugarcane and sugar beets from which it is separated for commercial use. In sugarcane sucrose is stored in the stalks while in sugar beets it is stored in roots (Ophardt, 2003). According to ADF (2005), sugarcane is the main source of all sugar produced in the world. It accounts for about 80% and most of the rest (20%) is made from sugar beets.

2.1.2.2 Sugarcane processing

Sugarcane processing requires two stages; sugar mill crushing and sugar refinery extraction. At the first stage sugarcane is processed into raw sugar at mills. Sometimes “mill white” sugar for local consumption is produced at this stage using sulphur dioxide to inhibit colour forming reactions during evaporation. This is done to stabilize the sugar juices. At the second stage the raw sugar is transferred to refineries to produce refined sugar. The final products of refining include powdered, granulated and brown sugar which contains some molasses. Other products of the processing include molasses, bagasse and filter cake (Steindl, 2005).

2.1.2.3 Importance of sugarcane

Many countries in the world which produce sugarcane have realized that although the production of sugar from sugarcane is the most paying proposition, it is better to produce many value added products by diversification and utilizing the by-products of the sugar industry instead of depending on just one product, sugar. The main by-products of the sugar industry which have greater economic value are bagasse, mollasses and filter cakes or press mud. Other by-products which are of less commercial value are sugarcane trash, sugarcane tops, wax, boiler or fly ash, factory and distillery effluents (Dotaniya and Datta, 2014).

According to Huntrods (2008), sugar from sugarcane (sucrose) is used as a sweetening agent for foods and in the manufacture of cakes, candies, preservatives, soft drinks, alcohol and numerous foods. Augstburger *et al.* (2000) explained that sugarcane is chewed in all of the producing countries because of its sweet cell juice. Moreover, sugarcane juice is mostly used to sweeten foodstuffs, but can also be consumed as fresh or fermented juice.

Furthermore, according to Huntrods (2008), molasses is used as animal feed but it can also be sold as syrup to flavour rum and other foods or as additive for ethyl alcohol. Bagasse is burned as fuel for the mills and it can be used as a feedstock for ethanol production. But ethanol can also be made directly from sugarcane. That is; instead of first converting sugarcane to sugar juice, ethanol can be produced by processing the entire plant. Prado *et al.* (2013) explained that filter cake is used as a complete or partial substitute for mineral fertilizers in sugarcane cultivation, in the cultivation of other crops, in composting, in vermin composting and as a substrate in the production of seedlings. Yadav and Solomon (2006) reported that, sugarcane has been grown in different countries since the middle of 19^{th} century, primarily for the production of sugar. It was only after the global energy

crisis of 1973 that scientists and technologists realized the value of sugarcane, its by-products and co-products. Today sugarcane is considered as one of the best converter of solar energy in to biomass and sugar. The biomass which contains fiber, lignin, pentosans and pith can be converted to value added products by application of suitable chemicals, biochemical and microbial technologies. Sugarcane is a versatile crop since is a rich source of food (sucrose, jaggery and syrups), fiber (cellulose), fodder (green leaves and tops of cane plant), fuel and chemicals (bagasse, molasses and alcohol) (Yadav and Solomon, 2006; Dotaniya and Datta, 2014). Azam and Khan (2010) argued that sugarcane is an important cash crop and an important source of income and employment for the agricultural communities which produces it. Moreover, sugar is one of the essential items of daily consumption.

2.1.3 Paddy production

Paddy is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). Paddy is normally grown as an annual crop, although in tropical areas it can survive as a perennial and can produce a ratoon crop for up to 30 years (IRRI, 2003). Paddy production is well-suited to countries and regions with low labour costs and high rainfall, as it is labour-intensive to cultivate and requires ample water. However, paddy can be grown practically anywhere, even on a steep hill or mountain area with the use of water-controlling terrace systems (EUCORD (2012). Although its parent species are native to Asia and certain parts of Africa, centuries of trade and exportation have made it common in many cultures worldwide (LSU, 2000).

2.1.3.1 Paddy to rice

Paddy is a rice seed. It consists of a husk (the inedible outer part) and the edible rice grain inside (Maclean *et al*., 2002). For paddy (a rice seed) to be used to grow a new rice crop

the husk is retained and the whole seed is planted. To get to the edible rice grain inside the seed the husk has to be removed. Underneath the husk is the rice grain covered with a layer of bran. When rice has its bran intact it is called 'brown' rice. Some brown rice grains may even be viable if planted because the 'germ' part of the grain, which is the part of the seed that germinates into a new plant, may not have been damaged when the husk was removed. If the bran is also removed, you get 'white' rice.

2.1.3.2 Importance of paddy (rice)

According to Das *et al.* (2014), rice is the major staple food for half of the world's population. Ologbon *et al.* (2012) reported that rice is a common staple food in Africa; a rich and cheap source of carbohydrate to both man and animals. According to Das *et al.* (2014), rice is the most important grain with regard to human nutrition and caloric intake. Rice is rich in carbohydrates and proteins and is used mainly for human food consumed in the form of whole grains. It provides more calories and protein than cassava, maize or sorghum/millet. Norman and Kebe (2005) reported that rice is usually cooked by boiling in water, steaming or frying, and is eaten with beans, gari, vegetables, fish and meat or with stews. It is also eaten in the form of parched rice, rice flour, rice flakes, puffed rice and rice pudding. Rice flour is used in confectionery, rice-cream, pudding and pastry.

Norman and Kebe (2005) further highlighted that urbanization is one of the major factors which influence the increase in rice consumption. Rice dishes are comparatively easy to prepare compared to other traditional cereals, such as sorghum, maize and millet, thereby reducing the work involved in food preparation. Rice, therefore, fits easily into urban lifestyles, which tend to be crowded with a multitude of time-consuming activities. Apart from the benefits obtained from consuming rice, rice husk as a by-product has its importance. According to IRRI (2009) rice husks can be used for different purposes. For

example they can be used as fuel, litter material in animal husbandry, organic fertilizer after decomposition, building material or as insulation material.

According to Kadiri *et al.* (2014), paddy cultivation is the principal activity and source of income for millions of households around the globe. Several countries of Asia and Africa are highly dependent on paddy (rice) as source of foreign exchange earnings and government revenue. Moreover, Awotide *et al.* (2011) argued that paddy production is a major source of employment, income generation and nutrition in many poor food-insecure countries in Sub-Sahara Africa. The numerous activities involved provide employment to millions of people who work either directly in paddy production or in related support services. Benard *et al.* (2014) reported that paddy is the second most important commercial and food crop in Tanzania after maize. It is among the major sources of employment, income and food security for Tanzania farming households.

2.1.4 Small-scale crops production

There is no universally accepted definition of scale of production either a small-scale or medium-scale or large-scale. Different countries use various measures of size depending on their level of development (MIT, 2002). Some criteria which are mostly used in defining the scale of crops production are such as size of landholding, the number of workers engaged, amount of capital invested, techniques or technologies used in production and quantity of sales (Calcopietro and Massawe, 1999; MIT, 2002; Mbilinyi *et al*., 2013). By using these criteria a simple definition of small-scale of production can be production which is done in a small piece of land, with few workers, small capital investment, uses low levels of technology and has low quantity of sales. But as stated earlier, the size of each criteria depend on the level of country's development.

In Tanzania, majority of small-scale farmers (smallholder farmers) are those who produce in the land area between 0.9 ha and 3 ha (Mbilinyi *et al*., 2013; Towo and Kimaro, 2013). But other characteristics are also considered. As stated by Murphy (2012), in many countries especially in Sub-Saharan Africa, Tanzania inclusive, small-scale producers are those who operate in a situation that they have low or no access to decent inputs such as good quality land, seeds, fertilizers and agrochemicals. They lack smart technologies including irrigation. They lack, or have low access to capital markets, credits and information about both growing conditions and markets. Therefore, the explanations given in this paragraph guided the identification of small-scale paddy and sugarcane production in the study area and hence the identification of small-scale farmers for the present study.

2.1.5 Marketing

Marketing is a management process which identifies, anticipates and supplies customer requirements efficiently and profitably. This implies that marketing is a process of getting the right product to the right people at the right price, the right time and the right place (MAFC, 2006). Gabagambi (2011) defined marketing as a performance of all the transactions and services associated with the flow of a good from the point of initial production to the final consumer. Agricultural marketing refers to the performance of all business activities involved in the flow of goods and services from the point of initial agricultural production to the ultimate consumer (Kohls and Uhls, 1990).

2.1.6 Constraints in small-scale paddy and sugarcane production

Virgin *et al.* (2007) reported that, African small-scale farmers who are to a large extent both poor and vulnerable, are under pressure to produce more and better quality food, but are facing severe difficulties to do so. These difficulties include lack of infrastructure, management and husbandry problems, the degradation of their natural resource base, weak

markets and other socio-economic constraints. The severe effects of HIV/AIDS and malaria negatively affect the availability of agricultural labour and the productivity of rural communities. Furthermore as the result of the effects of recently global climate change, to reach maturity, food crops and livestock must be able to resist multiple stress factors including drought, disease stress and low soil fertility.

Norman and Kebe (2005) reported that West and East African smallholder farmers have low productivity in their paddy fields due to several constraints, including high incidence of pests, weeds and diseases, drought and poor water control, poor seed management, poor soil fertility management, lack of access to credit, farm inputs, farm machinery and animal traction, and shortage of labour. Other constraints in paddy production are late planting, poor post-harvest handling, processing and marketing, poor extension services, inadequate rural infrastructures and ineffective farmers' organizations (AAG, 2004).

The Swaziland Sugar Association (SSA) technical farming services noted that most of the challenges facing smallholder sugarcane growers revolved around financial and social issues. The financial and social issues have resulted into untimely or no application of agricultural production inputs such as fertilizer and herbicides and, consequently, very low yields (SSA, 2008). UNCTAD (2000) highlighted that access to finance is the biggest constraint for small-scale growers joining the Swaziland sugar industry. It is very difficult to obtain a loan for farming on Swazi Nation Land, as there is no title deed for collateral. Swazi Nation Land is land owned by the King in trust of the Swazi Nation (UNCTAD, 2000; Sifundza and Ntuli, 2001).

Ronard (2007) argued that in South Africa a major problem for small-scale growers is access to loans for establishing and managing their cane fields, particularly when they plan

to irrigate. Most of them have land in the communal areas which they cannot use it as collateral for loan. In India CFACP (2005) suggested that the timely availability of credit at reasonable rate of interest to farmers is crucial because it helps them to purchase the required inputs like seed, insecticides and pay for other charges.

In many African countries land ownership to smallholder farmers is a problem. For example; as it was highlighted by UNCTAD (2000) and Sifundza and Ntuli (2001), smallholder farmers in Swaziland do not own land. The Swazi Nation Land is land owned by the King in trust of the Swazi Nation. According to Ronard (2007), in South Africa most of smallholder farmers have land in the communal areas. It is impossible for a single smallholder farmer to own land.

In Ghana land tenure system is a constraint to rice production because of its general effects on both access and security. The system tends to limit the size of holdings and investments towards land improvement, especially in the lowland rain fed ecology. There is general gender bias in favour of men in the allocation of land. The country has a large rain fed lowland ecology that is suitable for rice production but remains largely unexploited (Ministry of Food and Agriculture of the Republic of Ghana, 2009).

In Tanzania, currently there is a move to attract huge local and foreign direct investments in village lands in sectors such as agriculture, mining, tourism and biofuel production. This, in turn, alienates people's land through accumulation in the hands of big national and multinational companies, leaving small-scale producers landless (Chachage, 2010). In Kilombero district smallholder farmers are moved away and the land they used to cultivate is titled to large-scale farmers such as Kilombero Sugar Company Limited (KSCL), the large-scale producer of sugarcane and Kilombero Plantations Limited (KPL), the large-

scale producer of paddy (rice) (Chachage, 2010). Regnard (2006) reported that land scarcity is the most important constraint facing small-scale farmers in Tanzania.

The study by Siyao (2012) conducted in Kilombero district reported that lack of access to the current, relevant and appropriate agricultural information in the rural areas has led to the stagnation of growth of sugarcane produced by small-scale growers. The same was also observed in small-scale paddy (rice) production in Kilombero district by Benard *et al.* (2014). Meyer (2003) argued that Information is one of the most valuable resources for rural development and can assist small-scale farmers in making informed decisions and taking appropriate action. However, Burton (2002) noted that most people in most underdeveloped communities do not know what information they lack, nor do they know that information is available to help them solve their problems. Benard *et al.* (2014) found that the barriers to accessing agricultural information in Kilombero district are associated with lack of information services, inadequate number of extension agents, inadequate funds, lack of awareness of information sources and information not easily accessible.

2.1.7 Constraints in small-scale paddy and sugarcane marketing

Minot and Hill (2007) highlighted that, in developing countries smallholder farmers are subject to a number of constraints that make their participation in the market both costly and risky, often leaving them unconnected. Minot and Hill (2007) categorized marketing constraints as those which raise marketing costs and those which increase the risk associated with commercialization. Those which raise marketing costs include poor transportation networks, lack of market information, and sometimes lack of competitiveness of markets. Poor government policy can also contribute to high marketing costs through overregulation or sporadic intervention, which creates uncertainty and discourages marketing investments.

According to Minot and Hill (2007) constraints that increase the risk associated with commercialization include production risks and marketing risks. Production risks include change in weather condition which results to drought or insufficient rainfall, and occurrence of pests and diseases. These in turn reduce yields. In addition, producing for markets sometimes requires intensive and costly input use, which results in substantial risk for small farmers when yields are uncertain. Marketing risks include low selling price than expected and perishability of the crop. Perishable crops imply additional risk because their prices are more volatile, so the sale prices are more uncertain; the crops may spoil before sale; and, in the absence of competition, farmers don't have the option of returning to the market for better prices another day, so they may be forced to accept very low prices. Regnard (2006) argued that reliable market has been very important in sugarcane since the crop cannot be stored for more than three days after harvesting.

IFAD (2003) reported that smallholder farmers in most parts of the world face difficulties in accessing markets. Since majority of smallholder farmers are residing in rural areas difficulties in accessing markets are due to low population densities in rural areas, remote location which leads to high transport cost, limited or lack of market information, limited negotiating skills and lack of organizations that could give them the bargaining power to interact on equal terms with other, larger and stronger market intermediaries. Also rural producers from developing countries face significant impediments in accessing rich countries' markets.

EUCORD (2012) highlighted that, African paddy (rice) fails to compete with imports because large-scale commercial rice processing is poorly developed or limited, and urban consumers have become used to the look and feel of imported rice. Locally milled rice is generally of poor quality and mainly consumed in rural areas where there is low

population density. It often tends to be contaminated with stones and dust. Even when it is of acceptable quality, it does not sell well in cities, where consumers are acquainted with imported rice. For some people, eating imported rice has even become a status symbol. Therefore, lack of market for locally produced paddy (rice) discourages small-scale producers.

EUCORD (2012) further highlighted that, in Tanzania although substantial volumes of paddy (rice) are produced, the domestic crop is not even very price competitive in the local market vis-a-vis rigidly taxed imports because of relatively high production and transaction costs. The market is dominated by blended rice of a quality that delivers the most adequate nutrition at the cheapest price. UNCTAD (2006) reported that lack of protection for sugarcane out-growers' markets, prices, standards, poor pay, delayed payments, mismanagement and corruption have characterized the sugar industry in East Africa.

Machangu (2005) reported that the marketing of sugarcane produce has a direct relationship to the farmer's income. Timely marketing and finding the right buyers who pay at right time is important in the whole circle of farming. Machangu (2005) further reported that late payment for sold produce makes it difficult for farmers to meet their commitments (weeding, spraying and fertilizer application) in time hence affecting the following season's production and income.

2.1.8 Economics

Economics is a discipline which deals with the allocation of scarce resources among unlimited wants and needs. It helps to answer the question of how best to organise economic activities such that the allocation of available resources will achieve what the

society desires (Witztum, 2011). Operationally, the present study defined economics in terms of the ability of smallholder paddy and sugarcane farmers to best allocate their scarce resources (land, labour and capital) in production of both crops so that to maximize their farm profitability.

2.1.9 Profitability

Profitability is the ability of the business, in this case the farm to earn profit. It is a relative measure of success for the business. Farm profit is the difference between total revenue earned by the farm and total cost incurred. As suggested by Bryant and Stiles (2010), farm profitability can be influenced by farm size, physical efficiencies of production, and economic efficiencies of production, enterprise combinations, fixed cost structure and commodity marketing. If there is profitability problem a complete analysis of these areas of the farm business should be conducted in order to identify source of the problem.

If the farm size is small than profitable farms then the farm size should be increased. Physical efficiency measures include measuring how much output you are getting per unit of input. For crops production, yield per acre is the most used physical efficiency measure. In a livestock enterprise some of the best physical efficiency measures would be average daily gain or average milk production per dairy cow.

Economic efficiency measures include ratios of costs or returns per unit of some inputs. Some of the more common measures are fertilizer expense per acre, insecticide expense per acre, herbicide expense per acre, diesel fuel expense per acre, feed costs per monetary units of gain and rate of capital turnover. In economic efficiency, any variable cost category that can be identified should be examined (Bryant and Stiles, 2010).

In case of enterprises combinations, the key for selecting a profitable enterprises combination is to identify the most limiting resource in the farming operation (usually land) and then select those enterprises with the greatest returns per unit of this limited resource. For fixed costs structure, costs like machinery and building depreciation, interest and general farm overhead costs are included. If they are high relative to the farm size and value of production, steps should be taken to reduce those which will have little or no effect on the level of production. For commodity marketing, the average selling prices should be observed and if the prices are low other marketing strategies should be applied (Bryant and Stiles, 2010). All these factors which affect farm profitability were also observed by Kay (1986). The present study measured farm profitability in terms of gross margin per acre. Moreover, the present study considered farm gross margin as the return to land.

2.1.10 Gross margin

By definition, gross margin is the difference between the annual gross income for an enterprise and the variable costs directly associated with that enterprise (Kuhlmann *et al*., 2012). As stated earlier in the last two sentences of the previous section, the present study considered farm gross margin as the return to land and also as a measure of farm profitability. In calculating gross margin, variable costs are subtracted from the gross income. Gross income normally represents the total sales value for a particular crop/livestock. Variable costs represent all expenses which vary with the size of the enterprise. These are such as pumping costs, casual labour costs (wages), land rent, seed, fertilizer, feed, veterinary and costs. For example; for a crop enterprise variable costs are those which vary with the amount of area planted. Therefore if the area of a particular crop is zero, then the variable costs will also be zero (RMCG, 2011).

The costs which do not vary depending on the size of the enterprise are called Overhead (fixed) costs. These are such as rates, insurance, leasing costs, interest on investment, permanent labour charges, taxes and depreciation. In constructing gross margins, fixed (overhead) costs are ignored, as it is considered that they will be incurred regardless of the level of the enterprise undertaken (Kuhlmann *et al*., 2012).

2.1.10.1 Gross margin as a measure of farm profitability

The gross margin for a farm enterprise is one measure of profitability that is a useful tool for cash flow planning and determining the relative profitability of farm enterprises. Gross margin estimates can help to determine which crops/livestock are more profitable than others. They can also be used to assist in assessing the opportunity to develop new farm enterprises (Heaslip*et al*., 2013). Gross margin analysis is the simplest and most practical method of assessing enterprise profitability. It is widely used in farm management economics rather than other approaches which take in to account fixed costs (Dijkhuizen and Huirne, 1997; Mumba, 2012).

According to Firth (2002) the full cost approach (which takes in to account both variable and fixed costs) is fraught with difficulties as awkward and sometimes arbitrary decisions have to be made concerning the allocation of overhead (fixed) expenses between enterprises. In the report by Canadian Agri-food Policy Institute (CAPI, 2008) it was explained that net farm income (which its calculation take in to accounts fixed costs) is not an indicator of profitability for agricultural enterprises. This is due to the dichotomy that exists between the level and trends in “aggregate” farm income, and the level and trends in farm income for different farm operators, in a diverse agricultural production sector. CAPI (2008) suggested that gross margin is a better measurement of farm profitability across a range of farm types and agricultural businesses.

2.1.10.2 Limitations of gross margin analysis

According to various literatures such as RMCG (2011), Kuhlmann *et al*. (2012) and Heaslip *et al*. (2013), Gross margin analysis is the best tool but it has some limitations.

Gross margins are best used to compare enterprises that make use of the same resources on the farm. They cannot be used where varying capital input is needed for an enterprise. It is possible for different crops to use the same capital resources on the farm but not the case when you compare crops and livestock. Cropping and livestock gross margins can only be compared if all capital resources are already on the farm. In the present study smallholder paddy and sugarcane producers of Kilombero district use the same capital resources for production of paddy and sugarcane. This is why gross margin was selected to measure the relative profitability of paddy and sugarcane.

There is inherent risk in agricultural production, such as pricing in markets, crop failure and variable input costs. If a gross margin analysis showed that there was a single crop that was far more valuable than others, this does not mean that it is the best decision to plant only that particular crop; rather an assessment needs to be made so that the risks can be managed. The result may be that some less profitable crops may be grown alongside the more profitable crop in order for the business to manage risk. For example in Kilombero district smallholder farmers produce both paddy and sugarcane although they consider sugarcane as the more profitable crop than paddy.

Labour can be difficult to allocate as most businesses have permanent labour and casual labour. In a gross margin analysis we tend to focus on the casual (hired) labour involved in various farm operations such as planting, weeding and harvesting. In Kilombero district, smallholder farmers use only casual labour in production of both paddy and sugarcane. They do not have permanent labour.

Gross margins do not take into account overhead costs. Some businesses have high debt loads or high overhead costs or both. If this is the case then a gross margin analysis may show a good result for one particular crop; however after all the overhead costs are included such as in a 'cash flow budget' or a 'profit and loss budget' the business may still make a loss. In Kilombero district smallholder farmers do not take loans for agricultural production due to fear of risks and uncertainties. They usually use their own savings. Also these farmers use the same capital resources in paddy and sugarcane production activities every year. So it is difficult to separate the overheard (fixed) costs for paddy and those for sugarcane at the farm level. This is why in the present study gross margin was chosen as the best measure of farm profitability.

2.1.11 Enterprises combination

An enterprise is a commercial activity undertaken for the aim of producing goods or services for profit (Johnson, 1998). Therefore; agricultural productions or cultivations which are undertaken for the aim of generating profit are also enterprises. The present study considered sugarcane production and paddy production as enterprises. Hence, the present study defined enterprises combination as a situation where by a single farmer produces more than one crop by using his/her available resources (land, labour and capital) for the aim of generating higher farm profit. The present study selected smallholder farmers who use their available resources to produce both paddy and sugarcane. As explained earlier these two crops are the most important crops in Kilombero district for food and for commercial purpose.

2.1.12 Linear programming model

Linear programming (LP) is the field of mathematics concerned with maximizing or minimizing linear functions under constraints. Linear programming models have linear

objective functions that are maximized (or minimized) subject to the identified constraints (Daellenbach, 2001). In case of profit maximization under enterprises combination, linear programming model in its simplest form, has been helpful in determining a profit maximizing combination of farm enterprises that is feasible with respect to the set of fixed farm constraints (Alsheikh and Ahmed, 2002). The use of linear programming model in determining the profit maximizing combination of enterprises was also suggested by many other researchers such as Baniasadi and Zarea (2009), Mohamad and Said (2011), Bamiro *et al.*(2012) and Majeke (2013) to mention a few.

2.1.12.1 Linear programming model assumptions

There are seven important assumptions in linear programming modelling. The first three assumptions deal with the appropriateness of the formulation and the last four assumptions deal with mathematical relationships within the model (Philip, 2007).

Formulation appropriateness assumptions

i) **Objective Function Appropriateness**: This assumption requires the objective function to be the sole criterion for choosing among the feasible values of the decision variables. In land allocation problems, the satisfaction of this assumption is often very difficult as, for example, farmers might base their land allocation plans not only on profit maximisation but also on other factors such as ensuring family survival, minimising the risk associated with crop failure (through diversification), or even maximising leisure time.

ii) **Decision Variables Appropriateness**: It is among the key assumptions. It requires the specification of the decision variables to be appropriate. This assumption requires the decision variables to be fully manipulatable within the feasible region. Moreover,

the assumption requires the manipulation of the decision variables to be under the control of the decision maker. Furthermore, the assumption requires all appropriate decision variables to be included in the model.

iii) **Constraints Appropriateness**: This entails the assumptions that the constraints fully identify the bounds placed on the decision variables by resource availability, technology and the external environment. Consequently, any choice of the decision variables which simultaneously satisfies all the constraints is admissible. Moreover, the assumption requires the resources used and/or supplied within any single constraint to be homogeneous items which can be used or supplied by any decision variable appearing in that constraint. Lastly, the assumption bars the inclusion of constraints which improperly eliminate admissible values of the decision variables.

Assumptions on Mathematical Relationships within the Model

i. **Proportionality** (*i.e.* linearity): This assumption requires the objective function and the constraints' coefficients to be strictly proportional to the decision variables (for instance, if the first hectare of paddy requires 40 man-days of labour, so must the 30th hectare and 60th hectare). Also, implied in this assumption is that the returns to each activity is independent of its level; *i.e.* the profit per hectare of paddy is the same whether the farmer grows a single hectare or ten hectares of paddy. It is important to point out that there are several situations where the proportionality assumption is violated. Such circumstances include cases where the product price depends upon the level of production. Consequently, the contribution per unit of an activity varies with the level of the activity. For instance, the assumption would be violated if the return from a given activity varies with the level of that particular activity, for example decreasing profit per unit area with increasing farm size.

ii. **Divisibility**: This assumption means that non-integer values of the decision variables are acceptable. The formulation assumes that all decision variables can take on any non-negative value including fractional ones; (*i.e.* the decision variables are continuous). This assumption is violated when non-integer values of certain decision variables make little sense. For instance, a decision variable may correspond to the purchase of a tractor or the construction of a building where it is clear that the variable must take on integer values. In such cases, it is appropriate to use integer programming.

iii. **Certainty**: This assumption requires the values for the parameters to be known and constant. This means that the optimum solution so derived is predicted on perfect knowledge of all the parameter values. Since all exogenous factors are assumed to be known and fixed, linear programming models are sometimes known as non-stochastic to distinguish them from models explicitly dealing with stochastic factors. Due to this assumption, studies making use of these models are known as "deterministic" analyses. But in most cases the exogenous parameters of a linear programming model are not known with certainty.

iv. **Additivity:** This assumption requires the terms of the objective function to be additive. Additivity deals with the relationships among the decision variables. Simply put, their contributions to an equation must be additive. The total value of the objective function equals the sum of the contributions of each variable to the objective function. Similarly, total resource use is the sum of the resource utilisation of each variable. This requirement rules out the possibility that interaction or multiplicative terms appear in the objective function or the constraints.

One more additional assumption is **Non-negativity:** Negative values of the decision variables are not allowed. This is mainly because, in the process of making production decisions, negative values do not make sense. For instance, a farmer cannot decide to use minus (-) two bags of fertiliser or produce minus (-) forty tonnes of sugarcane.

2.1.12.2 Validation of linear programming model.

Model validation is an important task in any empirical economic analysis. A model can be utilized with confidence only if it is considered a valid description of the system modelled. According to McCarl and Apland (1986), linear programming (LP) models frequently receive only superficial validation.

According to Philip (2007), model validation is fundamentally subjective. This is mainly because modellers choose the validity tests, the criteria for passing those tests, what model outputs to validate, what setting to test in and what data to use. Thus, the statement "the model was judged valid" can mean almost anything. However, a systematic approach to model validation will provide for a semi-objective evaluation of the strengths and weaknesses of a model. To some extent, two types of validation may be applied to a LP model. These are validation by construct and validation by results (McCarl and Spreen, 1997).

Validation by construct involves assessing procedures used in model construction. If the model was constructed by using sensible techniques motivated by real world observations and if by experience, these techniques are used by other modellers, the model is judged valid. On the other hand, validation by results involves comparing model solutions with corresponding real world outcomes. However, Validation by construct is the most common

type of linear programming model validation (McCarl and Spreen, 1997). The linear programming model used in the present study was validated by construct and it was judged valid. See section 4.3.5 for procedures used in validating the linear programming model used in the present study.

2.2 Theoretical Framework

This study is guided by the theory of the firm in which the objective of a farmer is assumed to be profit maximization. It is common in agricultural economic analyses to assume that farmers are profit maximizers, sometimes also considering the role of risk in decision making (Mishra and Gillespie, 2007). As suggested by Halili (1999) individual farmers must repeatedly make decisions about what commodities to produce, by what method, in which seasonal time periods, and in what quantities. Decisions are made subject to the prevailing farm physical and financial constraints, and often in the face of considerable uncertainty about the planning period ahead. Uncertainty may arise in forecasted yields, costs and prices for the individual farm enterprises, in enterprise requirements for fixed resources and in the total supplies for fixed resources available.

Enterprises selection studies conducted by economists have traditionally utilized the concept of production possibilities frontier and the isorevenue line. Profit is maximized at the combination of enterprises where the isorevenue line become tangent to the production possibilities set (Mishra and Gillespie, 2007). This point is called the profit maximizing combination of enterprises or the most profitable combination of enterprises or the optimal combination of enterprises. At this point is where the firm maximize productivity of its limited resources to their greatest economic return (Mishra and Gillespie, 2007). At this point the Value of the Marginal Products (VMPs) for all products produced given a fixed

quantity of resource(s), are equal (Debertin, 2012). That is; if there are n products to be produced by using a fixed quantity of resource(s) X, profit is maximized where;

$VMP_{X, Y1} = VMP_{X, Y2} = VMP_{X, Y3} = \ldots\ldots = VMP_{X, Yn}$ ..... (1)

But $VMP_{X, Y} = P_Y MPP_{X, Y}$ and

$MPP_{X, Y} = \frac{\Delta Y}{\Delta X}$

Therefore;

$P_{Y1}\frac{\Delta Y_1}{\Delta X} = P_{Y2}\frac{\Delta Y_2}{\Delta X} = P_{Y3}\frac{\Delta Y_3}{\Delta X} = \cdots \ldots = P_{Yn}\frac{\Delta Y_n}{\Delta X}$ ..... (2)

Where;

$VMP_{X, Y}$ denotes the Value of the Marginal Product of X in producing Y.

$MPP_{X, Y}$ denotes the Marginal Physical Product of X in producing Y.

Y denotes the quantity of output.

n denotes the number of outputs to be produced (1,2.....n).

X denotes a fixed quantity of resources (for example; land, labour and capital)

P_{Yn} denotes price of output Yn (n= 1,2.....n).

This means that at the profit maximizing combination of enterprises the opportunity cost of the resource(s) should be equal across all products. That is to say, the value of one output foregone in order to increase the amount of other outputs should be equal for all products (Debertin, 2012).

In Kilombero district smallholder paddy and sugarcane farmers usually allocate their limited resources; land, labour and capital in production of both crops. Therefore to maximize their farm profitability, the Value of the Marginal Products for paddy and

sugarcane given their limited resources (Land, labour and capital) should be equal. In other words the value of one crop foregone in order to increase the amount of the other crop should be equal for both crops. As pointed out earlier in section 2.1.12, linear programming model has been helpful in determining the profit maximizing combination of enterprises given the limited resources (Mishra and Gillespie, 2007; Baniasadi and Zarea, 2009; Mohamad and Said, 2011;Bamiro *et al.,* 2012; Majeke, 2013).

2.3 Empirical Literature

2.3.1 Use of gross margin in measuring farm profitability

There is a rich history of researchers using gross margin analysis as a tool to determine efficiency and profitability of agricultural enterprises. For example; Zulu (2011) used gross margin as a measure of farm profitability to analyze the profitability of cowpea farmers in Zambia. Behjat and Ostry (2013) used gross margin as an indicator of farm profitability in investigating regional farms profitability of British Colombia local health areas. Gross margin analysis was used by Chongela (2008) in determining the relative profitability of paddy and sugarcane produced by smallholder farmers of Ruhembe Out-growers Association in Kilosa district, Tanzania. The same approach was also used by Togolay (2010) in determining the relative profitability of paddy and sugarcane produced by smallholder farmers in Mvomero district, Tanzania. In the present study gross margin analysis was used to determine the relative profitability of paddy and sugarcane produced by smallholder farmers of Kilombero district, Tanzania.

According to RMCG (2011), as agriculture is inherently a risky business, Gross Margin can help farm operators not only to make decision about what crop to grow but also how much input such as water, fertilizer, machinery, and labour they should apply in order to maximize their profit in uncertain and risky situations. Behjat and Ostry (2013) argued

that, although gross margin is not an absolute measure of profit it can determine the best financial result when a number of different crop/livestock alternatives are compared.

2.3.2 Use of linear programming (LP) in determining the profit maximizing combination of enterprises

Linear programming models have been employed by many researchers in determining the profit maximizing combination or the optimal combination of enterprises or in other words, the appropriate allocation of resources given constraints in production.

For example; the study by Ibrahim and Bello (2009) utilized linear programming model to determine the optimal farm plan that can enhance the food security status of farming households in North Central Nigeria. Crops involved were cassava, maize, cowpea, benniseed, groundnut and yam. Bamiro *et al*. (2012) applied linear programming model to determine the optimal enterprise combination in cassava based food crop farming system in Nigeria.

Moreover, study by Majeke (2013) employed linear programming model in determining the optimal combination of crop farm enterprises in small-scale farms of Marondera, Zimbabwe so that to solve the problem of resources allocation. Crops involved were tobacco, maize, soya beans and potatoes. In Tanzania, Philip (2007) employed linear programming model for determination of appropriate allocation of production factors in producing various crops which are used as feed stocks for producing biofuels. Crops involved were sugarcane, paddy (rice), maize, sorghum, cassava, oil Palm and jatropha. In the present study linear programming model was employed to determine the optimal combination (the most profitable combination) of paddy and sugarcane enterprises in Kilombero district, Tanzania.

2.4 Conceptual Frame Work

The conceptual framework of this study (Fig.1) shows the factors affecting farm profitability. This conceptual framework was developed based on knowledge from various literatures such as Daellenbach (2001), Fox *et al.* (1993), and Halili (1999), to mention a few, and the researcher's firsthand knowledge of the study context. Construct of the figure is the researcher's idea.

It can be observed in Fig. 1 that some factors have direct effect on farm profitability while others have indirect effect. The arrows show direction of the effect. Socio- economic factors such as age, gender, marital status, education level, family income, family size and farm size have affect on initial resource endowment, availability of factors of production and on farmer's ability to productively combine the factors of production.

Initial resource endowment, availability of factors of production and farmer's ability to productively combine factors of production have effect on the amount of factors of production employed in the production of paddy and sugarcane, and the methods by which these factors are combined. The amount of factors of production employed in the production process and the methods by which these factors are combined affect yields of paddy and sugarcane which consequently affects their revenues and hence the effect goes to farm profitability.

Therefore if socio-economic factors will bring a positive effect, the whole route will have positive effect, hence farm profitability will increase. Output prices also have effect on revenues of paddy and sugarcane. The lower the prices of paddy and sugarcane, the lower their revenues, hence the lower the total profit of the farm. The converse is true. The amount of factors of production employed in the production process and the way by which

these factors are combined have effect also in the production costs. If they cause increase in the production costs than increase in yield, this will consequently lead to decrease in farm profitability. Production costs are also affected by factor prices. If factor prices (Input prices) will increase, production costs will increase and hence farm profitability will decrease.

Farmer's risk preference has effect on the amount of factors of production employed and the methods by which these factors are combined. For example; If the farmer is not willing to take more risks involved in the production of paddy and sugarcane less amount of factors of production will be employed in the production process and more resources will be employed in the production of another crop (s) or another businesses which the farmer is willing to take more risks on, or which are less risky. This will lower yields of paddy and sugarcane which consequently lower their revenues and hence lower farm profitability.

Moreover, farmer's risk preference affects his decision on enterprises combination. For example in paddy-sugarcane enterprises combination, if a farmer consider sugarcane as a more risky crop than paddy, it is possible for this farmer to produce under inappropriate enterprises combination by allocating more of the limited resource like land in paddy production than in sugarcane production without considering the optimal combination which maximizes farm profitability. Producing at inappropriate enterprises combination will lower farm profitability. Sometimes a farmer may decide to produce only one crop on his/her farm due to fear of taking risks of other crops. This will even lower farm profitability. However, enterprises combination helps a farmer to overcome risks of allocating all resources on production of only one crop. When a farmer is producing more than one crop meaning that his/her resources will be divided to production of those crops

and this means taking moderate risks on production of each crop. So in case a crop(s) fail, other crops can succeed and the farmer can still earn profit.

It can also be observed in Fig. 1 that socio-economic factors have indirect effect on enterprises combination which then affects farm profitability. As explained earlier, Socio-economic factors such as age, gender, marital status, education level, family income, family size and farm size have effect on initial resource endowment, availability of factors of production and farmer's ability to productively combine factors of production. These then affect farmer's decision on enterprises combination. In case a farmer has low initial resource endowment, there is low availability of factors of production and a farmer has poor ability in combining the factors of production, he/she may end up producing under inappropriate enterprises combination or decide to produce only a single crop. In this case farm profitability will be lowered. Enterprises mix is important in increasing farm profitability but producing under appropriate enterprises combination is essential for profit maximization.

Output prices, market demand of a crop, market competition, and government regulations have effect on enterprises combination. Crops with high output prices, high market demand, more competitive in the market and which are supported by government regulations of the country have greater chances of being included in the farmer's plan for enterprises combination. With such crops in a production plan farm profitability can possibly be high.

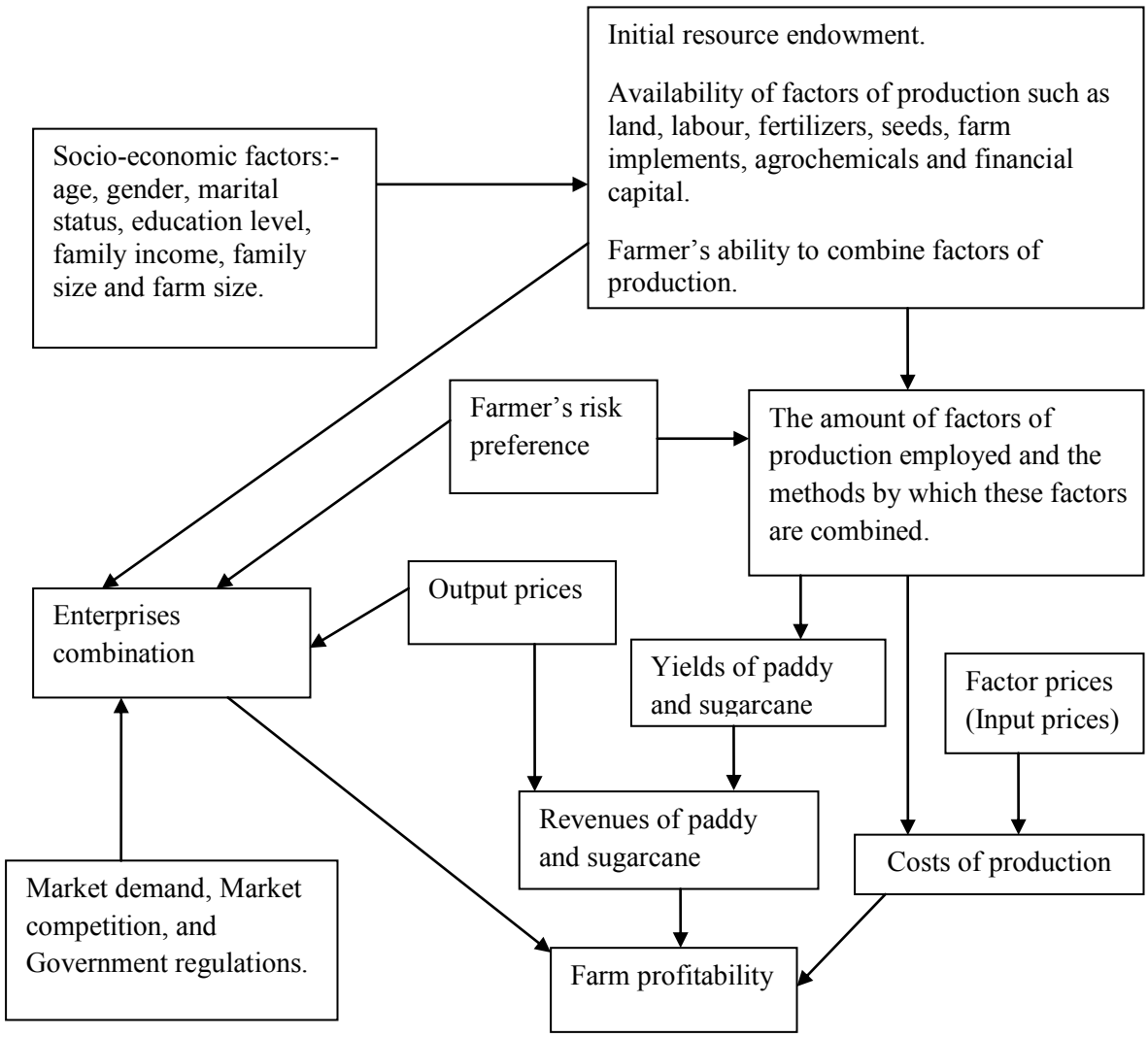

Figure 1: Conceptual framework to show factors affecting farm profitability

Source: Researcher's construct.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location

This study was conducted in Kilombero district, which is among the seven districts of morogoro region in Tanzania. The other districts are Morogoro urban, Morogoro Rural, Mvomero, Gairo, Kilosa and Ulanga. Kilombero district is located within latitude 08°15′0″S and longitude 36°25′0″E.The District extends from the middle to far south-west of Morogoro region. It is bordered with Kilosa district to the north-east. The north and west borders are shared by Mufindi and Njombe districts of Iringa region while at its south and south-east it shares the border with Songea - Rural (Ruvuma region) and Ulanga district respectively. Most of the district lies along Kilombero Valley a part of Rufiji Basin, which extends below the Udzungwa mountains from its east towards the southwest (RIU, 2008). It has a total area of about 14 918 km^2 in which land area is about 13 577 km^2 and water area is about 1341 km^2 (MRCO, 2006).

According to 2012 population and housing census results, Kilombero District has a population of about 407 880 people in which 202 789 are male and 205 091are female (URT, 2013).The dominant tribes in Kilombero district are Wambunga, Wandamba, Wabena and Wahehe. Others are in small proportions (Kato, 2007). Kilombero district was selected for the present study because it is among the potential areas where there is large number of small-scale paddy and sugarcane producers. It is one of the most important, and productive districts in the country, especially for paddy and sugarcane (Buck *et al*., 2013).

3.1.2 Climate and topography

Kilombero District is characterized by a sub humid tropical climate with relative humidity ranging from 70 to 80% and an annual rainfall ranging from 1200 to 1400 mm. Rainfall in the highlands is 1600 mm. Kilombero district has two rainy seasons: a long rainy season in March to May and a shorter one around October to December. Temperatures normally vary from 20 to 30°C (MNRT, 2007). The greater part of the Kilombero Valley consists of large alluvial plains situated at an elevation of slightly less than 300 meters above sea level (m.a.s.l.) (RIU, 2008).

3.1.3 Economic activities in Kilombero district

Majority of villagers are subsistence farmers of paddy, sugarcane, vegetables, maize, banana and they are also involved in livestock keeping and fishing. Paddy and sugarcane were chosen for this study because they are the major crops in the district. Smallholder paddy and sugarcane farmers consider these two crops as their most important crops for income and for food security. Therefore they use their limited resources in production of both crops. Paddy and sugarcane have similar ecological requirements. Hence farmers have to make better decision on the amount of land to allocate to each of these crops. Kilombero District has 19 wards. Paddy is produced in almost all wards but sugarcane is produced in wards near Kilombero Sugar Company. The wards in which sugarcane is produced are Kidatu, Mang'ula, Kiberege, Sanje, Kisawasawa, and Mkula. It is in these wards where majority of smallholder farmers produce both paddy and sugarcane and it is where primary data for this study were collected.

3.2 Research Design

The present study employed cross-sectional research design whereby data were collected at one point in time. The design was chosen because it is cost effective and has the ability

to address the objectives of this study. According to Agresti and Finlay (2009), the design allows a combination of various survey methods for gathering a body of both qualitative and quantitative data and offer quick results with minimal costs.

3.3 Sampling Procedure

3.3.1 Sample size

The population for this study included all smallholder farmers of Kilombero District whose land, location or climate allow them to produce both paddy and sugarcane. The sampling frame was all smallholder farmers who produce both paddy and sugarcane. These farmers accounted for about 10% of all smallholder farmers in Kilombero District. The list of these farmers was obtained from Kilombero Sugar Company in the out-growers department. A sample size of 138 farmers was used in the study. This was determined using the formula proposed by Israel (2012).

$$n = \frac{Z^2 \times pq}{e^2} \quad \text{.....(3)}$$

Where:

n= required sample size

Z = confidence level at 95% (standard value of 1.96)

p = is the estimated proportion of an attribute that is present in the population.

q=1-p

e= margin of error at 5% (standard value of 0.05)

Therefore;

$n = 1.96^2 \text{ x } 0.1 (1- 0.1) / 0.05^2 = 138.3, \approx 138.$

3.3.2 Sampling techniques

Simple random sampling was used to select smallholder farmers who produce both paddy and sugarcane from different villages of the particular wards in which paddy and sugarcane are produced. Simple random sampling was done using computer software known as simple open source random number generator version 1.0.0.1.

3.4 Source of Data

3.4.1 Primary data

Primary data were collected through structured questionnaires and onsite observation. Data were collected on production, marketing and socio-economic aspects of the sampled smallholder farmers.

3.4.2 Secondary data

Secondary data on yield trends, price trends, inputs availability and usage, and marketing conditions in paddy and sugarcane were obtained from district reports, ward reports, out-growers associations, Internet and Sokoine National Agricultural Library (SNAL).

3.5 Validity and Reliability of the Instrument for Data Collection

To ensure that the questionnaire used to collect data addresses the study objectives, its content validity and reliability issues were checked before the actual data collection activity.

3.5.1 Content validity

Content validity refers to how well an instrument includes a representative sample of questions that relate to the content domain being measured (Patten, 2004). To ensure content validity of the questionnaire, review of related literature was done. The

questionnaire developed was checked to determine whether it contain items that can measure study objectives. The other issue which was checked is face validity of the instrument i.e. clarity of printing, font size and type, adequacy of workspace, and language. After the questionnaire was checked, corrections were made and the final instrument was developed (See Appendix 1).

3.5.2 Reliability

Reliability indicates the degree to which a survey instrument is consistent with what it measures (Litwin, 1995). A split half reliability test was conducted to determine the consistency of the survey instrument. To carry out the split half reliability test, the questionnaire was administered to 30 smallholder paddy and sugarcane farmers who were randomly selected from a list of farmers in Ruaha village, Kilosa district. Kilosa district is close to Kilombero district and the two districts have more or less similar characteristics. According to Israel (2012), a sample size greater or equal to 20 can yield meaningful results in a survey study. A Spearman Brown coefficient of 0.78 was obtained which showed that the questionnaire was reliable.

3.6 Data Collection Procedures

Survey research method was used in which structured questionnaires were administered to collect primary data from the respondents. The questionnaires were filled at one point in time with the help of research assistants. Before administration of the questionnaires to farmers, a training of research assistants was conducted to give them skills on data collection.

3.7 Data Analysis

Primary data collected were checked for accuracy, coded, and then entered into a computer program known as Statistical Package for Social Sciences (SPSS), where analysis of quantitative data was conducted to obtain frequencies, percentages and averages with respect to the objectives of the study. Microsoft Excel was used to solve the Linear programming problem for this study.

3.8 Analytical Tools

For specific objective number (i) which aimed at comparing the returns to land for paddy and sugarcane among smallholder farmers, Gross Margin Analysis was used to determine the gross margin per acre for paddy and sugarcane. In addressing specific objective number (ii) which aimed at determining the optimal combination for paddy and sugarcane enterprises, Linear programming model was used. For specific objective number (iii) which aimed at identifying constraints toward better performance in paddy and sugarcane production and marketing descriptive statistics such as frequencies and percentages were employed. Frequencies and percentages of smallholder farmers on each identified constraints were used to show the extent to which farmers are affected by the particular constraints.

3.8.1 Gross margin analysis

Gross margin is the difference between the annual gross income (revenue) for the enterprise and the variable costs directly associated with the enterprise (Kuhlmann *et al*., 2012). Gross margin analysis was chosen because it can be used to measure economic returns per unit of inputs used in production. It aims at estimating the cost of production and the returns to the variable inputs. For a farm enterprise gross margin is one measure of profitability and can be used in determining the relative profitability of farm enterprises

(Heaslip *et al*., 2013). In the present study gross margin was used to evaluate the relative profitability of paddy and sugarcane enterprises. The same approach was also used by other researchers such as Chongela (2008) and Togolay (2010) in determining the relative profitability of paddy and sugarcane as explained in section 2.1.10. Abbot and Makeham (1990) highlighted that although gross margin is not an absolute measure of profitability, it remains the satisfactory measure of resource use efficiency available in small-scale agriculture.

The definitional relationship;

$$GM = TR - TVC \quad \text{.....} \quad (4)$$

Where:

GM is the gross margin of paddy or sugarcane (Tshs/acre) in a year.

TR is the total revenue of paddy or sugarcane (Tshs/acre) in a year. This is equal to the gross income.

TR = price of output (Tshs/tonne) X Quantity of output (tonnes) for paddy or sugarcane.

TVC is the total variable costs incurred in paddy or sugarcane production (Tshs/acre) in a year.

TVC = Summation of all variable costs incurred in production of output either paddy or sugarcane (Tshs/acre).

The variable costs included were ploughing costs, harrowing costs, furrowing costs, purchase of seeds, planting costs, weeding costs, purchase of fertilizers, fertilizer application costs, purchase of agrochemicals, agrochemical application costs, harvesting costs, transportation costs, total charges by Kilombero Sugar Company and Out-growers Associations for the services they offer to smallholder sugarcane farmers.

In the present study the gross margins for paddy and sugarcane were calculated per acre because smallholder farmers were found to use acre as their unit of land. Since paddy is an annual crop, its gross margin per acre was calculated only for production year 2012/13. For sugarcane, since it is a ratoon crop and it has five years of good yields in the study area, the gross margins per acre were calculated for five years and this is for sugarcane planted in 2008/09 for which 2012/13 was its fifth year. The sugarcane gross margins for production year 2008/09 to 2011/12 were compounded using 10% interest rate in order to obtain their values in 2012/13.Then average of the five compounded sugarcane gross margins was calculated in order to get the average gross margin per acre of sugarcane per year (See Appendix 4).

3.8.2 Linear programming model

Linear Programming (LP) is a mathematical procedure that uses a systematic technique to find the most profitable combination of enterprises (Daellenbach, 2001). The linear programming model was chosen for this study because it helps in the allocation of scarce resources such as land to competing enterprises like paddy and sugarcane, in order to maximize farm profitability when there are constraints in the system.

Linear programming models have linear objective functions that are maximized (or minimized) subject to the identified constraints. The linear programming model for this study assumed that farmers are aiming at maximizing farm profitability. This is considered as the objective function for a rational farmer. But farmers normally have other objectives such as ensuring food security and minimizing losses associated with crop failures to mention a few. To take care of other farmers' objectives, ensuring food security and minimizing losses in addition to resources constraints were included in the model.

3.8.2.1 Mathematical presentation of the empirical model

As explained in section 2.1.10 and section 3.8.1, the present study measured farm profitability in terms of farm gross margin. Therefore the objective function of the linear programming model used in the present study was to maximize the overall farm gross margin through production of paddy and sugarcane. Modelling of the linear programming model used in the present study was guided by the model used by Igwe *et al*. (2015), in determination of optimum resource allocation among selected smallholder root and tuber crops farmers in Abia State, Nigeria. Moreover, the modelling used in the present study does not differ much with the modelling used by Philip (2007) in determining appropriate allocation of production factors in producing various crops which are used as feedstocks for producing biofuels in Tanzania. The idea is the same, what differs is the model presentation. Also in the model used by Philip (2007) land hiring was not among the decision variables while in the model used in the present study land hiring is among the decision variables.

Therefore, the form of the linear programming model used in the present study followed the following pattern.

$$\text{Maximize } Z = \sum_{j=1}^{2} G_j X_j - \sum_{j=1}^{2} R_j A_j - \sum_{t=1}^{3} W_t L_t \quad \text{..... (5)}$$

Subject to constraints;

$$\text{Land availability: } \sum_{j=1}^{2} a_j X_j \leq B + \sum_{j=1}^{2} A_j \text{ (j= 1, 2)} \text{.....(6)}$$

$$\text{Labour availability: } \sum_{j=1}^{2} l_{jt} X_j \leq H_t + L_t \quad \text{(t=1, 2, 3)} \text{..... (7)}$$

$$\text{Working capital availability: } \sum_{j=1}^{2} C_{jt} X_j \leq C_t \quad \text{(t=1, 2, 3)} \text{..... (8)}$$

Family survival: $X_1 \geq 1.34$, for food security

$X_2 \geq 1$, for income earning

Limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company as the only market for sugarcane from out-growers:

$$X_2 \leq 2.7$$

Non-negativity constraint; in this study it is applicable for A_j and L_t.

That is; $A_j, L_t \geq 0$

Where;

Z is total farm gross margin (Tshs) per year.

j indicates a number of crop production activity (There are two (2) crops to be produced which are paddy and sugarcane. Therefore j=1 for paddy production and j= 2 for sugarcane production.

G_j is the gross margin of j^{th} crop production activity (Tshs/acre) per year.

X_j is acres of j^{th} crop to be cultivated. That is to say;

X_1 = acres of paddy to be cultivated

X_2 = acres of sugarcane to be cultivated

R_j is the cost of hiring one acre of land (Tshs) per year for j^{th} crop activity.

A_j is numbers of additional acres of land to be hired for j^{th} crop activity.

t=1 period 1 (December to February)

t=2 period 2 (March to May)

t=3 period 3 (June to August)

Periods 1, 2 and 3 are labour and capital restriction periods which were considered in the model.

W_t is the cost per unit of labour (Tshs/man-day) in t^{th} period.

L_t is the quantity of additional labour (man-days) to be hired in t^{th} period

a_j is input coefficient of land which is an acre of the j^{th} crop production activity.

B is the total land (acres) used by a farmer for production of both crops.

l_{jt} is input coefficient of labour which is the quantity of labour in man-days required per acre of the j^{th} crop production activity in the t^{th} period.

H_t is the total labour (man-days) used by a farmer in the t^{th} period.

One man-day is equal to 8 working hours.

C_{jt} is input coefficient of working capital which is the working capital required in Tshs per acre of the j^{th} crop production activity in the t^{th} period.

C_t is the total working capital in Tshs available to a farmer in the i^{th} period.

Working capital includes money for purchase of seeds, agrochemicals and fertilizers, payment for transportation of crops from the fields and payments for some service charges to Sugarcane Out-growers Associations and to Kilombero Sugar Company. It also includes ploughing costs since in the study area farmers usually hire tractors to plough their farms. It further includes harvesting costs for sugarcane because farmers cannot use their own labour to harvest their sugarcane and they are also not allowed to hire labour themselves for harvesting their sugarcane. Harvesting is arranged by the Out-growers Associations who find contractors for harvesting and farmers are just required to pay harvesting costs. It excludes land hiring costs and labour hiring costs because they are already subtracted as shown on the objective function.

Activities in the model; The activities in the model are grouped in to crops production activities (X_1 and X_2), land hiring activities (A_1 and A_2) and labour hiring activities which are restricted to three periods (1, 2 and 3) in both paddy and sugarcane. Therefore labour hiring activities are L_1, L_2 and L_3

Hence; X_1, X_2, A_1, A_2, L_1, L_2 and L_3 are the decision variables in the model.

Restriction periods for labour and capital requirements and availability;

Period 1- December to February (t=1): Is the period for ploughing, harrowing, furrowing, purchase of seeds and planting.

Period 2- March to May (t=2): Is the period for purchase of fertilizers and application, purchase of agrochemicals and application, and weeding.

Period 3- June to August (t=3): Is the period for harvesting, transportation of produce from the fields and payments of some service charges to sugarcane out-growers associations and to Kilombero Sugar Company.

3.8.2.2 Description of the scenarios considered

The linear programming model for the present study was run under two different scenarios. In the first scenario limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company by out-growers was considered among the constraints to the objective function. This constraint limits the production of sugarcane to 2.7 acres (see section 4.3.3). In the second scenario limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company by out-growers was not considered among the constraints to the objective function. This was done in order to determine and compare the maximum farm gross margins and the optimal solutions with and without limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company and hence to provide recommendation accordingly. Equations for the linear programming model are shown in Appendix 10.

3.8.3 Descriptive statistics

These included frequencies and percentages of smallholder farmers on each identified production and marketing constraint. As pointed out earlier, frequencies and percentages were computed using Statistical Package for Social Sciences (SPSS). They were used to show the extent to which farmers are affected by the particular constraints.

3.9 Hypothesis Testing

The research hypothesis tested in the present study states that; the returns to land for sugarcane and paddy produced by smallholder farmers are not statistically different. This was the null hypothesis ($\mu_1=\mu_2$).The alternative hypothesis was that; the returns to land for sugarcane is greater than the returns to land for paddy ($\mu_1>\mu_2$). Hypothesis testing was done at 5% level of significance (Appendix 13).

The test statistic used was Z- statistic because the sample size is greater than 30 (n>30) ie 138 farmers. The formula used to calculate the Z-statistic was as follows;

$$Z=\frac{\left(\bar{x}_1-\bar{x}_2\right)-\left(\mu_1-\mu_2\right)}{\sqrt{\frac{{s_1}^2}{n_1}+\frac{{s_2}^2}{n_2}}}$$

Where;

$\overline{X_1}$ =Mean gross margin of sugarcane (Tshs/acre)

$\overline{X_2}$ = Mean gross margin of paddy (Tshs/acre)

μ_1=Population gross margin of sugarcane (Tshs/acre)

μ_2=Population gross margin of paddy (Tshs/acre)

S_1=Sample standard deviation for sugarcane gross margin (Tshs/acre)

S_2=Sample standard deviation for paddy gross margin (Tshs/acre)

n_1= Sample size for smallholder sugarcane farmers

n_2= Sample size for smallholder paddy farmers (Tshs/acre)

This formula is usually used when testing the difference between two means in the situation where the sample sizes drawn from the population(s) are $n \geq 30$ and the population standard deviations are unknown. As the sample size (n) becomes large, sample standard deviation approaches population standard deviation.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of Respondents

4.1.1 Age of respondents

The research results in Table 1 show age categories of small-scale paddy and sugarcane farmers of Kilombero district. These results show that 66.7% of the respondents were aged between 15 to 44 years. Farmers of this age group are many in the society compared to other age groups because they are still young, strong and able to perform a lot of production activities which help in generating income to the society. About 27.5% of the respondents were people of age from 45 to 64 years and about 5.8% were in the group of old people aged 65 years and above. It can be observed that as the farmers become old their number decreases in the society. This may be because of the life expectancy in the study area. We do not expect many old farmers. According to Tanzania Population and Housing Census results of 2012, in Kilombero district people of age category 65 years and above were only about 4.2% of the total population, where as people of age category 15 to 64 years were about 55.9% and people of age category below 15 years were about 39.8 % (URT, 2013).The results in Table 1 therefore imply that paddy and sugarcane production in Kilombero district is dominated by people of active labour force. Hence there is possibility of yields improvement and continuity of paddy and sugarcane production in the area.

Table 1: Age categories of respondents

Age categories of respondents	Frequency	Percent
15-24	4	2.9
25-34	16	11.6
35-44	72	52.2
45-54	26	18.8
55-64	12	8.7
>=65	8	5.8
Total	138	100.0

4.1.2 Gender of respondent

Table 2 shows that 73.9 % of the respondents were males while 26.1% were females. This implies that most of smallholder farmers who produce both paddy and sugarcane are males. A study by Chongela (2008) revealed that most of sugarcane production activities are governed by men. Togolay (2010) observed the same situation in small-scale paddy production. Togolay (2010) argued that in African tradition where marriage plays an important role in the society and husbands in most cases are household heads, it is common to find that resources are mostly controlled by males. That is why males dominate agricultural activities and making the proportional of females owning resources be small. Only females who had never got married, widowed and few who are married have access to own resources. This was also reported by Losindilo *et al*. (2010) in their study on some factors that hinder women participation in social, political and economic activities in Tanzania.

Table 2: Distribution of respondents by gender

Gender	Frequency	Percent
Male	102	73.9
Female	36	26.1
Total	138	100.0

4.1.3 Marital status of the respondents

Looking at the marital status of the respondents (Table 3), it can be observed that 91.3% of small-scale paddy and sugarcane farmers were married, 5.8% were widowed and 2.9%were divorced. There was no farmer who never got married. It therefore shows that small-scale paddy and sugarcane production in Kilombero district is dominated by adult people and majority of them are married couples. This can be attributed to the fact that married couples are not as mobile as widowed, divorced and single because of family responsibilities and they have more family labour which may encourage then to participate in agricultural activities than widowed, divorced and single.

Kalimanga'si *et al.* (2014) in their study on contribution of contract cocoa production on improving livelihood of smallholder farmers, which was conducted in Kilombero and Kyela districts also found the dominance of married people in cocoa production. Kalimanga'si *et al*. (2014) reported that married producers had more labour force for agricultural production than single and divorced. Makauki (2000) in his study on factors affecting the adoption of agro forest farming system, which was conducted in Turiani division also found the dominance of married people in agro forest farming.

Table 3: Marital status of respondents

Marital status	Frequency	Percent
Married	126	91.3
Divorced	4	2.9
Widowed	8	5.8
Total	138	100.0

4.1.4 Education level of the respondents

The survey results in Table 4show that 71.7% of the sampled smallholder paddy and sugarcane farmers were primary school leavers, 22.5% were form four leavers, 2.9 % were form six leavers and 2.9 %did not attend school. This indicates that small-scale paddy and sugarcane production is dominated by farmers who have primary education followed by those with form four secondary education. Similar situation was also observed by TASGA (2007) who found that 69% of cane growers had primary education and quarter had secondary education. The reasons behind these findings can be the fact that nowadays in Tanzania the number of people who have never gone to school is very low and people of higher education levels have opportunities for employment outside farm activities. As education level of a person increases, the opportunity for employment outside farm activities increases.

The fact that small-scale paddy and sugarcane production is dominated by farmers with primary education and those of form four secondary education implies that majority of these farmers can be trained in various production aspects such as proper use of agricultural inputs and resources, proper cultivation methods and harvesting practices with minimum difficulties. They can also be educated on farm record keeping, the importance of savings and credit societies, banking and marketing issues.

Table 4: Distribution of respondents by levels of education

Education level	Frequency	Percent
No formal education	4	2.9
primary	99	71.7
Form four	31	22.5
Form six	4	2.9
Total	138	100.0

4.1.5 Households composition of the sampled smallholder farmers

Table 5 summarizes the households' composition of the sampled small-scale paddy and sugarcane farmers in the study area. The results in Table 5 show that their total households' population was 488 of which children of less than 15 years were 214 which account for 43.8% of the total households' population. Adults aged 15 to 64 years which constitute an active labour force were 260.This account for 53.3% of the total households' population. Adults aged 65 years and above were 14 which account for 2.9% of the total households' population. These results indicate that the society has more active labour force than children and adults above 64 years. This implies that majority of households members can participate in various production activities and hence the society is economically stable.

Table 5: Household composition of the sampled smallholder farmers

Age group	Male	Female	Total	Percent
<15	103	111	214	43.8
15-64	142	118	260	53.3
>=65	4	10	14	2.9
Total	249	239	488	100.0

4.1.6 Respondent's main source of income

The research results in Table 6 show that 95.7% of the respondents depend on farming as their main source of income, 2.9 %depend on business where as1.4% depend on seasonal employment. This indicates that farming is the most important economic activity in the study area. Green (2012) reported that most Tanzanians derive their income from farming. Tanzania Household Budget Survey Report 2007confirmed that most Tanzanians are still smallholder farmers and they depend on agriculture as their important economic activity (URT, 2007). Benard *et al*. (2014) reported that agriculture is the main source of income

for 90% of rural populations in Africa. Therefore it is not surprising that 95.7% of the respondents in the study area depend on farming as their main source of income.

Table 6: Respondent's main source of income

Main source of income	Frequency	Percent
Farming	132	95.7
Seasonal employment at Kilombero sugar company	2	1.4
Business	4	2.9
Total	138	100.0

4.1.7 Important crops produced by smallholder paddy and sugarcane farmers in Kilombero district

The research results in Table 7 show that 71.7% of interviewed farmers produce only paddy and sugarcane as their important crops. The remaining 28.3 % produce three crops; paddy, sugarcane and maize as their important crops. Looking at the results (Table 7) it can be observed that all 138 sampled farmers produce paddy and sugarcane as their important crops. Among them only 39 farmers produce maize as their third important crop. These results therefore indicate that majority of paddy and sugarcane producers in Kilombero district consider only paddy and sugarcane as their important crops. Only few farmers among them consider maize as their third important crop. MAFC (2011) reported that in Kilombero district paddy (rice) is the key crop cultivated across the district, both as a food crop and a cash crop. Maize is grown primarily for subsistence purposes and as insurance in case paddy fails or has low market prices. For some farmers, if the paddy harvest is good, and attracts high prices then maize is often left un-harvested in the fields. Therefore in Kilombero district maize is not as important as paddy and sugarcane. Kamuzora (2011) reported that about 40-50% of sugarcane in Kilombero district is

produced by smallholder farmers. The remaining percentage is produced by Kilombero Sugar Company. According to PASS (2013), Sugarcane is one of the important food and commercial crops of Tanzania. It is the main source of sugar produced for both export and domestic consumption. The sugar industry in Tanzania provides direct employment to about 30 000 people. Sugar production and employment plays a vital role in rural areas in the development and provision of social amenities including schools, hospitals, water supply, townships and farm roads.

Table 7: Important crops produced by smallholder farmers in Kilombero district

Crops	Frequency	Percent
Paddy and sugarcane	99	71.7
Paddy, sugarcane and maize	39	28.3
Total	138	100.0

4.1.8 Farm size for paddy, sugarcane and maize production

The research results in Table 8 show the acreage of paddy, sugarcane and maize cultivated by smallholder paddy and sugarcane farmers in 2012/13 season. The results show that farm sizes of sugarcane ranged from 1 to 25 acres with an average of approximately 3.28 acres. Paddy was produced in farm sizes ranging from 0.75 to 20 acres with an average of approximately 3.28 acres. Maize farms ranged from 0.5 to 2 acres with an average of 1.22 acres. It can be observed that the average farm size for maize produced by smallholder paddy and sugarcane farmers in Kilombero district was smaller than the average farm size for paddy and for sugarcane. This can be because farmers who produce maize reported that they produce the crop mostly for consumption purpose. As it was observed by MAFC (2011) in Kilombero district maize is grown primarily for subsistence purposes and as

insurance when failure occurs in paddy production or when paddy has low market prices. And for some farmers, if the paddy harvest is good, and attracts high prices then maize is often left un-harvested in the fields.

From the research findings (Table 8) it can also be observed that the average farm sizes for paddy and sugarcane were exactly the same, although the maximum and minimum acres were smaller in paddy than in sugarcane. This indicates that in case of land allocation paddy and sugarcane are given almost equal priority. This is because paddy and sugarcane are their most important crops. Paddy is for both consumption and commercial purposes where as sugarcane is mostly for commercial purpose. They depend on these two crops for income and for food security.

As it was reported by MAFC (2011), in Kilombero district paddy (rice) is the key crop cultivated across the district, both as a food crop and a cash crop. Djurfeld *et al*. (2005) also reported that in Kilombero district paddy (rice) is the dominant staple food and cash crop. Benard *et al*. (2014) reported that Paddy (rice) is among the most important commercial and food crop in Tanzania. It is among the major sources of employment, income and food security for Tanzania farming households. The same was also reported by RLDC (2009).

Siyao (2012) argued that sugarcane is an important cash and export crop in Tanzania and a source of income for many small-scale growers, also earning the country foreign currency. PASS (2013) reported that sugarcane is one of the important food and commercial crops of Tanzania. The same was also reported by Nkonya and Barreiro-Hurle (2012), and Tarimo and Takamura (2001).

Table 8: Farm size for paddy, sugarcane and maize by smallholder farmers in Kilombero district, 2012/13 season

		Farm size in acres		
Crop	n	Minimum	Maximum	Mean
Paddy	138	0.75	20.00	3.28
Sugarcane	138	1.00	25.00	3.28
Maize	39	0.50	2.00	1.22

4.2 Return to Land from Paddy and Sugarcane

In the study area paddy is planted and harvested once every year while sugarcane is planted once but harvesting is done at the end of each production year, in five consecutive years of good yield. Paddy is an annual crop where as sugarcane is a ratoon crop. In the present study data about average yields, average revenues, average costs and average gross margins per acre for paddy were taken for production year 2012/13(Appendix 2) but for sugarcane the same data were taken for sugarcane planted in production year 2008/09 for which 2012/13 was its fifth year (Appendices 3 and 4). Selling prices for paddy are set per tin or per bag but for sugarcane the price per tonne is set depending on the sucrose content sugarcane has. It is Kilombero Sugar Company which measures the sucrose content of sugarcane from smallholder farmers and it is the one which set price of sugarcane per tonne for each sucrose content.

In the interview conducted with the head of out-growers department at Kilombero Sugar Company, it was found that the average sucrose content for sugarcane from out-growers is 10%. The average prices per tonne of sugarcane for this average sucrose content in each production year from 2008/09 to 2012/13 were given as shown in Appendix 4. The same information and prices were obtained from out-growers associations. These prices were the ones used in the calculation of total revenues of sugarcane per acre for each production

year in those five years. This is because almost all interviewed farmers reported that they don't know the sucrose content of their sugarcane and they don't even know how the sucrose content is measured. They also reported that they don't remember the prices per tonne for their sugarcane, what they can remember is the total payment they received from Kilombero Sugar Company.

Farmers suggested that if the researcher need price information, she may get from the records of out-growers associations. The out-growers associations in Kilombero districts are KCGA (Kilombero Cane Growers Association), KICGA (Kidatu Cane Growers Association), MUCGA (Msolwa Ujamaa Cane Growers Association), MKUCGA (Mkula Cane Grower Association) and AMCO (Association of Mang'ula Cane Out-growers).

Since sugarcane prices were obtained from the records of out-growers associations, the researcher also decided to take sugarcane yields data from the records of out-growers associations. According to the records provided by KCGA, which is the main out-growers' association in Kilombero district, the average yields per acre for sugarcane from out-growers in 2008/09 was 27.78 tonnes, in 2009/10 was 26.99 tonnes, in 2010/11 was 27.26 tonnes, in 2011/12 was 25.72 tonnes and in 2012/13 was 25.9 tonnes. The overall average yield per acre per year in those five years was found to be 26.73 tonnes (Appendix 4).The research findings in Appendix 2 show that the average yield per acre for paddy in the production year 2012/13 was 1.7 tonnes.

The average gross margin per acre for paddy was found to be 148 389.62 Tshs (Appendix 2). The average gross margins for sugarcane from production year 2008/09 to 2011/12 were compounded to 2012/13 production year using 10% interest rate in order to obtain their values in 2012/13(Appendix 4).To get average gross margin per acre of sugarcane per

year, average of the five compounded gross margins was calculated and found to be 832 439.87Tshs per acre per year (Appendix 4).

In comparing the average gross margins for paddy and sugarcane it can be observed that sugarcane has higher gross margin per acre per year than paddy (Appendices 2 and 4). The difference between paddy and sugarcane gross margins was tested by using a Z-test statistic at 5% level of significance and it was found to be significant (Appendix 13). These results therefore indicate that in the study area sugarcane has higher return to land than paddy. Hence sugarcane is more profitable than paddy. Although there is a huge difference in the returns to land from paddy and sugarcane, farmers are still producing paddy because this crop is their main staple food. Moreover, due to some challenges which occur in sugarcane production and marketing farmers decide to produce paddy in order to be on the safe side. When they need money and things are not well in sugarcane they sell paddy in order to earn income. Some challenges which occur in sugarcane production and marketing include fire accident(s) in sugarcane farms, delay of sugarcane payments by Kilombero Sugar Company, poor harvests or low yields in some years and sometimes out-growers miss the opportunity to harvest their sugarcane in some years. These challenges are explained in section 4.4 and 4.5.

4.3 Determination of the Most Profitable Enterprises Combination

As explained in section 3.8.2 determination of the most profitable combination of paddy and sugarcane enterprises was done by using linear programming model. In the present study farm profitability was measured in terms of farm gross margin and therefore the objective function for the linear programming model was to maximize overall farm gross margin through production of paddy and sugarcane. Moreover, in the present study maximization of overall farm gross margin by smallholder paddy and sugarcane farmers of

Kilombero district was considered to be constrained by resources requirement and availability, family survival purposes (in terms of food security and income) and limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company by out-growers (Section 3.8.2.1 and Appendix 10).

4.3.1 Resources requirement and availability

4.3.1.1 Land availability

In the present study it was found that smallholder farmers use both own and hired land for agricultural production activities. The findings from the present study also show that, on average a smallholder paddy and sugarcane farmer in Kilombero district can own 6.05 acres which is equivalent to 2.42 ha. It was also found that the average acreages for paddy and sugarcane by a smallholder farmer for the production year 2012/13 were 3.28 acres for each of the two crops (Table 8). These acreages therefore indicate that, on average a smallholder farmer used a total land of 6.56 acres which is equivalent to 2.62 ha for production of both paddy and sugarcane. This total average land (6.56 acres) used included both own and hired land. Therefore, in the linear programming model of the present study total land available was considered as the total average land a farmer used in production of paddy and sugarcane (6.56 acres), plus additional land (acres) to be hired for the attainment of the profit maximizing combination of enterprises.

4.3.1.2 Cost of hiring land

The average costs of hiring land for paddy and sugarcane production in the production year 2012/13 were 72 465 Tshs/acre and 99 810 Tshs/acre respectively. Although these crops are produced on the same type of land their costs for hiring land differ because paddy is an annual crop which lasts for only one production period. After that the land is returned to the owner and then a farmer can sign a new contract. But sugarcane lasts for

five years of good yields. Therefore the hired land is not returned to the owner until the fifth harvest and then a new contract can be signed. Therefore land owners usually consider the time value of money and the high returns which are obtained by producing sugarcane than the returns obtained by producing paddy.

4.3.1.3 Labour requirement and availability

In the present study labour requirement and availability were divided in to three periods; December to February as period 1, March to May as period 2 and June to August as period 3. These periods were divided depending on the farm operations which are taking place in each period. Other periods have high labour demand while others have low labour demand. Farm operations which are taking place in each period are as described in section 3.8.2.1. Labour requirement in man-days/acre for paddy and sugarcane production in each period (1, 2 and 3) were calculated by adding up the average quantities of labour (man-days/acre) used by smallholder farmers in different farm operations which are taking place in each period. Tables 9, 10 and 11 show the average quantities of labour (man-days) required per acre of paddy and sugarcane in periods 1, 2 and 3 respectively.

Table 9: Labour requirement per acre of paddy and sugarcane in period 1

	Average quantity of labour required	
	Paddy	Sugarcane
Farm operations	(Man days/acre)	(Man days/ acre
Harrowing	7.3	7.3
Furrowing	0	7
Planting	7.5	8
Total	14.8	22.3

Table 10: Labour requirement per acre of paddy and sugarcane in period 2

Farm operations	Average quantity of labour required	
	Paddy (man-days/acre)	Sugarcane (man-days/acre)
Fertilizer application	1	1
Weeding	11.09	11.62
Agrochemical application	1	1
Total	13.09	13.62

Table 11: Labour requirement per acre of paddy and sugarcane in period 3

Farm operation	Average quantity of labour required	
	Paddy (man-days/acre)	Sugarcane (man-days/acre)
Harvesting	8.3	0

Land ploughing in Kilombero district is usually done in period one (December to February). Smallholder farmers in the district mostly use tractors for ploughing. It is not common for them to use human labour. This is why in Table 9 labour (man-days/acre) required for ploughing was not included. Moreover, it can be observed in Table 11 that labour requirement for sugarcane harvesting is given a value of zero. This is because in Kilombero district it is not an obligation of a smallholder farmer to find labour for sugarcane harvesting. They are also not allowed to harvest sugarcane on their own. Sugarcane harvesting is arranged by out-growers associations who find contractors for harvesting. Farmers are just required to pay harvesting costs.

As explained earlier, in the present study the average quantity of labour required for production of a crop was considered as the average quantity of labour used by a farmer in

production of a crop. Therefore, total average quantities of labour used by a farmer per acre of each crop (paddy and sugarcane) in each period (1, 2 and 3) are the totals in Tables 9, 10 and 11. These totals are shown together in Table 12.

Table 12: Total average quantities of labour used per acre in periods 1, 2 and 3.

Periods	Total average quantities of labour used	
	Paddy (man-days/acre)	Sugarcane (man-days/acre)
1 (December - February)	14.8	22.3
2 (March - May)	13.09	13.62
3 (June - August)	8.3	0

In the linear programming model of the present study, total quantity of labour available in each period (1, 2 and 3) was considered as the total average quantity of labour a farmer used for production of both paddy and sugarcane in the particular period, plus additional labour to be hired in that period. Total average quantities of labour a farmer used for production of both paddy and sugarcane in all three periods were calculated as shown in Appendix 5.The summary is given in Table 13

Table 13: Total labour used in production of paddy and sugarcane in each period

Periods	Total average quantity of labour used (man-days)
1 (December - February)	121.69
2 (March - May)	87.61
3 (June - August)	27.22

4.3.1.4 Labour costs

Table 14 show the average costs per man-day of labour in periods 1, 2 and 3. Details on the calculation of average costs per man-day are found in Appendix 6, 7 and 8.

Table 14: Average costs per man-day of labour in periods 1, 2 and 3

Periods	Average costs (Tshs/man-day)
1 (December - February)	4 686.36
2 (March - May)	4 784.65
3 (June - August)	4 929.88

The average cost/man-day of labour in period 3 include only harvesting cost per man-day in paddy harvesting. This is because as explained earlier in Kilombero district smallholder sugarcane farmers are not the ones who find labour for sugarcane harvesting. They neither use their family labour nor hired labour for harvesting. Sugarcane harvesting is arranged by out-growers associations who find contractors for harvesting and farmers are just paying harvesting costs. Therefore in linear programming sugarcane harvesting cost was included in working capital.

4.3.1.5 Working capital availability

In Kilombero district it is not common for paddy and sugarcane smallholder farmers to take loans for agricultural production activities. But it is common for these farmers to use their own savings for agricultural production activities. All 138 interviewed farmers (100%) responded that they usually use their own savings for agricultural production. Fear of crops failures as a result of factors such as unreliable rainfall, pests and diseases and fire accidents to mention a few, make farmers afraid to take loans. Therefore capital is very limited to paddy and sugarcane smallholder farmers of Kilombero district because they only use their own savings for agricultural production activities.

Working capital availability was also included among the constraints to the objective function. As explained in section 3.8.2.1 working capital included money for purchase of seeds, agrochemicals and fertilizers. It also included payment for transportation of crops from the fields and payments for some services charges to sugarcane out-growers associations and to Kilombero Sugar Company. Sugarcane harvesting cost was also included. Poughing cost was also included in working capital since farmers are using tractors for ploughing and not human labour. Labour hiring and land hiring costs were not included in the working capital. This is because in the objective function of the linear programming model labour and land hiring costs were subtracted separately to see if the attainment of the optimal solution will require land and/or labour hiring, and by what amount. In the present study working capital availability was also divided into three periods as in labour availability.

Working capital required per acre in each crop (paddy and sugarcane) in periods 1, 2 and 3 was calculated by adding up the average costs incurred per acre of a crop in exclusion of labour hiring costs in each period (1, 2 and 3)and exclusion of land hiring cost in period 1. Working capital required per acre of a crop in each period was also considered as the working capital used per acre of a crop in each period. In the production year 2012/13 these costs were as shown in Tables 15, 16 and 17.

Table 15: Working capital required per acre in period 1

	Working capital required	
Farm operations	Paddy(Tshs/acre)	Sugarcane(Tshs/acre)
Ploughing	43 299.62	43 299.62
Purchase of seeds	29 818.00	198 000.00
Total	73 117.62	241 299.62

Table 16: Working capital required per acre in period 2

	Working capital required	
Farm operations	Paddy(Tshs/acre)	Sugarcane(Tshs/acre)
Purchase of fertilizer	38 237	85 008
Purchase of agrochemicals	12 403	24 160
Total	50 640	109 168

Table 17: Working capital required per acre in period 3

	Working capital required (Tshs/acre)	
Farm operations	Paddy(Tshs/acre)	Sugarcane(Tshs/acre)
Harvesting	0	257 300.73
Transport	28 766	247 151.41
Charges by KSC and Out-growers Associations.	0	62 810.15
Total	28 766	567 262.29

It can be observed in Table 17 that working capital required for paddy harvesting was given a value of zero because the costs incurred in paddy harvesting are labour costs and as explained earlier, labour costs were subtracted separately in the objective function.

In the present study, working capital available for production of both paddy and sugarcane in each period (1, 2 and 3) was considered as the total working capital used in production of both paddy and sugarcane in each period. Table 18 show the working capital available for production of both paddy and sugarcane in periods 1, 2 and 3. Details on the calculations of working capital available for production of both paddy and sugarcane in each period (1, 2 and 3) are found in Appendix 9.

Table 18: Working capital available for production of both paddy and sugarcane

Periods	Total working capital available (Tshs)
Period 1(December-February)	1 031 288.55
Period 2 (March-May)	524 170.24
Period 3(June-August)	1 954 972.79

4.3.2 Production of paddy and sugarcane for farmers' family survival

The findings from the present study revealed that about 96 % of interviewed smallholder farmers are not willing to stop producing either paddy or sugarcane. They said that these two crops are the most important crops in their lives. They need paddy mostly for food security and sugarcane mostly for income earning purpose. They also said that, they depend on these two crops because they are highly supported by their environment. To put this situation into consideration it was found that, on average a single family of a smallholder farmer needs approximately 1370 kg of rice for consumption per year. These can be obtained from approximately 2283 kg of paddy which is equivalent to 2.283 tonnes. According to the findings of the present study, the average yield of paddy per acre in the study area is 1.7 tonnes. Hence, 2.283 tonnes of paddy can approximately be obtained from 1.34 acres.

Moreover, the present study found that sugarcane being the crop of highest gross margin in the study area (Appendix 4), the minimum acreage for sugarcane production by smallholder farmers was found to be 1 acre (Table 8). Therefore in order to ensure family survival of a smallholder farmer in terms of food and income, the study included the minimum acreages of paddy and sugarcane production among the constraints to the objective function. The production of paddy should not be less than 1.34 acres and the production of sugarcane should not be less than 1 acre.

4.3.3 Market limit for sugarcane

During the survey conducted for this study it was also found that Kilombero Sugar Company is the only market for sugarcane produced by smallholder farmers in Kilombero district. The Company can take on average 570 000 tonnes of sugarcane from out-growers per production year and there are approximately 8000 out-growers. Therefore, each smallholder sugarcane producer (Out grower) can deliver on average 71.25 tonnes of sugarcane to the company per production year. Since the average yield of sugarcane was found to be 26.73 tonnes per acre per year, 71.25 tonnes of sugarcane can be obtained from approximately 2.7 acres. Therefore, in order to ensure that approximately each sugarcane out-grower gets opportunity to sell his/her sugarcane every year the study included the constraint that the production of sugarcane by smallholder farmers should not exceed 2.7 acres. In case of paddy, smallholder farmers do not depend on a single buyer and there is no limitation on the quantity of paddy to be delivered to the market.

4.3.4 Linear programming model results

By using Microsoft Excel the linear programming model results for the first and second scenarios were obtained. As explained in section 3.8.2.2, the first scenario included limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company among the constraints to maximization of overall farm gross margin, while the second scenario excluded limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company among the constraints to maximization of overall farm gross margin.

In the first scenario it was found that, for a smallholder paddy and sugarcane farmer to maximize the overall farm gross margin at the same time give opportunity to other smallholder sugarcane farmers to sell their sugarcane every year, 3.88 acres of paddy and 2.7 acres of sugarcane should be produced. In order to attain this enterprises combination

an average smallholder farmer will need to hire 0.024 acres for paddy production so as to add to the previously total land used which was found to be 6.56 acres. An average smallholder farmer will also need to hire 5.01 man-days of labour in period 3 (June - August) to add to the previously labour used. The maximum farm gross margin with this enterprises combination was found to be 2 797 444.71Tshs per year (Appendix 11 (a)).

Limiting factors in the first scenario were found to be land, labour in period 2(March-May), labour in period 3 (June - August) and limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company. Shadow prices for the limiting factors were found to be 72 465 Tshs for land, 2674.30 Tshs for labour in period 2 (March- May), 4929.88Tshs for labour in period 3(June - August) and 723 550.87 Tshs for limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company. These shadow prices tells us by how much the overall farm gross margin will change if the right hand side of the corresponding constraint will change by one unit, while other factors remain unchanged. But these shadow prices are true only within the limits given in the allowable increase and decrease columns as shown in Appendix 11 (b).

For example, in case of limitation on the quantity of sugarcane to be delivered to Kilombero sugar Company ($X_2 \leq 2.7$). The allowable increase and decrease of the right hand side of this constraint are 0.58 and 1.7 respectively (Appendix 11 (b)). To get the upper limit 0.58 is added to 2.7 and to get the lower limit 1.7 is subtracted from 2.7. Therefore, the shadow price for the limitation on the quantity of sugarcane to be delivered to Kilombero sugar Company remains true only within the range from 1 acre to 3.28 acres. Interpretation for this shadow price is that, if the right hand side of the limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company (2.7 acres) will change by one unit within a range from 1 acre to 3.28 acres while other factors remain unchanged,

the overall farm gross margin will change by 723 550.87 Tshs. To decide whether the overall farm gross margin will increase or decrease will depend on whether the change in the right hand side of the constraint (acres of sugarcane to be produced) make the constraint less restrictive or more restrictive.

If the change in acreage will be an increase, it will make this constraint less restrictive. Therefore increase in the right hand side by 1 acre will increase the overall farm gross margin by 723 550.87 Tshs. If the change in acreage will be a decrease, it will make this constraint more restrictive. Therefore decrease in the right hand side by 1 acre will decrease the overall farm gross margin by 723 550.87 Tshs. Interpretation of the shadow price for limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company guides interpretation for the shadow prices of other limiting factors.

To put the optimal solution of the first scenario more practical to farmers the study suggests that, for maximization of overall farm gross margin and hence farm profitability per year, smallholder paddy and sugarcane farmers should produce 4 acres of paddy and 2.5 acres of sugarcane. Production of 2.5 acres of sugarcane will help farmers to reduce the risk of missing the opportunity to sell their sugarcane in some years. Acres of sugarcane to be produced will change depending on the change on the allowable quantity of sugarcane to be delivered to the sugarcane market. With this enterprises combination an average smallholder farmer will not need to hire more land but will need to hire 5 man-days of labour in period 3(June - August) so as to add to the previously used labour.

In the second scenario where limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company was excluded it was found that, for a smallholder paddy and sugarcane farmer to maximize farm gross margin, 3.28 acres of paddy and 3.28 acres of

sugarcane should be produced. To attain this optimal combination an average smallholder farmer will not need to hire more land and more labour to add to the previously used land and labour. The maximum farm gross margin with this enterprises combination was found to be 3 217 101.01 Tshs per year (Appendix 12 (a)). Limiting factors were found to be land, labour in period 3(June - August) and working capital in period 3(June - August).Shadow prices for the limiting factors were found to be 68 744.44 Tshs for land, 4929.88TShs for labour in period 3 and 1.35Tshs for working capital in period 3. Allowable increase and decrease in the right hand side of the limiting factors are as shown in Appendix 12 (b). Explanation about shadow prices which was given in the first scenario guides interpretation of the shadow prices in this scenario.

When comparing the maximum farm gross margins obtained in the first and second scenarios, it can be observed that the maximum farm gross margin obtained without limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company is higher (3 217 101.01 Tshs per year) than the maximum farm gross margin obtained when there is limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company (2 797 444.71Tshs per year). Therefore limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company prevents smallholder sugarcane farmers from getting higher farm profits.

Smallholder paddy and sugarcane farmers of Kilombero district complained that because of limitation on the quantity of sugarcane to be delivered to the sugar company some years pass without their sugarcane being harvested. About 50 % of the interviewed farmers complained on the presence of biasness in harvesting, with no proper harvesting timetable. They said that some farmers get opportunity to sell their sugarcane every year while others do not. Farmers suggested the establishment of another sugar factory(s) in Kilombero

district in order to help them get the market to deliver all sugarcane they produce every year. They also suggested preparation of proper and unbiased harvesting time table.

In second scenario, although the limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company was excluded the optimal solution came up with production of 3.28 acres of paddy and 3.28 acres of sugarcane for maximization of farm profitability. This is because calculation of capital available was based on the assumption that the amount of capital used is equal to the amount of capital available. As pointed out earlier, smallholder farmers in the study area usually use their own savings for production of paddy and sugarcane. They do not take loans to add to their own capital. But if these farmers could be able to get additional capital to add to their own savings, they could be able to add their areas of production and more labour when the need arise. Therefore, in addition to the limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company which was confirmed in the first scenario, capital is also the most limiting factor to smallholder paddy and sugarcane producers of Kilombero district. These farmers need to be educated and encouraged to take loans, and crop insurance should be introduced in order to reduce farmers' fear of crop failures.

4.3.5 Linear programming model validation

As explained in section 2.1.12.2, two types of validation may be applied to linear programming models. These are validation by construct and validation by results. Validation by construct involves assessing procedures used in model construction whereas validation by results involves comparing model solutions with corresponding real world outcomes (McCarl and Spreen, 1997).

The linear programming model used in the present study was validated by construct through the following guidelines;

First, the model was constructed by using appropriate procedures which are believed to be right by other model builders. This included construction of the model based on experience from previous researchers' models and writings, and based on theory. Moreover, data which were used in the model were specified by using reasonable scientific estimations and accounting procedures. Furthermore, the raw data were obtained through a detail survey conducted with smallholder paddy and sugarcane farmers of Kilombero district.

Second, nominal examination of model results was done and found that they do not contradict the model builder's, users, and/or associated experts' perceptions of reality. For example in the first scenario where limitation on the quantity of sugarcane to be sold to Kilombero Sugar Company was included, it was not expected for the optimal solution to come up with acres of sugarcane more than 2.7 acres. Moreover, the results of the model in the first scenario also show that since sugarcane is a crop of higher gross margin and the maximum limit is 2.7 acres, it is better to produce sugarcane at maximum limit so as to get high farm gross margin. What was found in Kilombero district is that, the average acreage for paddy and sugarcane by smallholder farmers for production year 2012/13 were 3.28 acres for each of the two crops (Table 8). This shows that farmers have already realized the effect of limitation on the quantity of sugarcane to be sold per year; hence they limit themselves not to allocate more land to sugarcane production although it is a more profitable crop than paddy.

Third, special constraints were imposed in order to restrict the model to realistic solutions. The imposition of minimum acreage for paddy and sugarcane to be 1.34 acres and 1 acre respectively is important because farmers do not only aim at profit maximization. They

have other objectives such as ensuring family survival. Hence, imposition of minimum acreages for paddy and sugarcane in order to ensure that enough food is produced to satisfy the families and farmers are able to earn some income makes the model valid by construct. In additional to the description given in the first and second guidelines it is reasonable to state that "the model is valid".

Validation by results was not used in the present study because of less clarity obtained on the real world outcomes. For example; it was not easy to get the correct amount of capital available to a farmer because farmers could easily cheat. Therefore in this study it was just assumed that the amount of capital used by a farmer in production of both paddy and sugarcane was the amount of capital available to a farmer. This discredits validation by results for the present study because it is possible that the amount of capital used in the production of paddy and sugarcane is not the only amount of capital available to a farmer. Hence validation by construct was chosen as the best option.

4.4 Constraints in Paddy and Sugarcane Production

Research findings in Table 19 show constraints in paddy and sugarcane production, as identified by smallholder farmers in Kilombero district. Frequency and percentages show the extent to which farmers are affected by the particular constraints.

Table 19: Constraints in paddy and sugarcane production

Constraints in production	Paddy		Sugarcane	
	Frequency	Percent	Frequency	Percent
Unreliable rainfall.	102	73.9	84	60.9
Lack of improved irrigation technologies.	21	15.2	23	16.7
Low access to improved farm inputs	121	87.7	113	81.9
Lack of knowledge on how to use or combine farm inputs (factors of production).	26	18.8	24	17.4
Low access to fertile land	110	79.7	115	83.3
No proper harvesting time table	0	0	69	50
Low access to extension services.	20	14.5	14	10.1
Pest and diseases.	85	61.6	70	50.7
Difficulties in hiring labour	62	44.9	75	54.3
Shortage of capital	23	16.7	19	13.8
Labourers are not faithful.	56	40.6	56	40.6
Fire accidents	0	0	36	26.1

As it can be observed in Table 19, about 87.7% of interviewed farmers reported that paddy production in Kilombero district is affected by low access to improved farm inputs. They said that improved farm inputs are sold at very high prices which in most cases they cannot afford. Sometimes these inputs are not easily available in the area or they are obtained while it is too late.Low access to fertile land was reported by 79.7% of interviewed farmers. They said that unused fertile land is scarce in the area because majority of residents are farmers and large areas are in use by large scale farmers such as Kilombero Sugar Company Limited (KSCL) and Kilombero Plantations Limited (TPL). The cost of hiring or purchasing land is usually high.About73.9% of interviewed farmers reported

unreliable rainfall as a problem. Pests and diseases were reported by 61.6% of interviewed farmers.Difficulties in acquiring hired labour were reported by 44.9 % of interviewed farmers. They said that the cost of hiring labour is high and sometimes to get someone to hire as a labourer is difficult. About 40.6% of the interviewed farmers reported that labourers are not faithful. They take work from more than one farmer as a result they fail to accomplish their work on the agreed time. The other identified constraints in paddy production are as shown in Table 19.

Moreover, it can be observed in Table 19 that about 83.3% of interviewed farmers reported that sugarcane production in Kilombero district is affected by low access to fertile land since most of the fertile land is already in use for agricultural activities and if it is available it is obtained at high cost either by hiring or buying. Low access to improved farm inputs was reported by 81.9% of the interviewed farmers. Unreliable rainfall was reported by 60.9% of the interviewed farmers. About 54.7% reported on difficulties in acquiring hired labour as the cost of hiring is high and sometimes it is difficult to get someone to hire as a labourer. Pests and diseases were reported by 50.7% of the interviewed farmers. About 50% of interviewed farmers complained on the problem of unproper harvesting time table. In Kilombero district sugarcane harvesting is organized by out-growers associations and there is no proper harvesting time table in each year. It is not clear to farmers at which time of the year their sugarcane will be harvested, where will the harvesting start and where will it end. Farmers complained on the presence of biasness in harvesting. It happens that some farmers get the opportunity to harvest their sugarcane every year while others do not. Labourers being not faithful were also reported to be a constraint in sugarcane production by 40.6% of the interviewed farmers as in paddy production. Fire accidents were reported by 26.1% of the interviewed farmers. The other identified constraints in sugarcane production are as shown in Table 19.

There are other studies which were done and revealed some similar production constraints to smallholder farmers. For example; a study by Lwezaura *et al*. (2011) revealed that the most burning production constraints faced by smallholder farmers in Tanzania are unreliable rainfall, lack of capital and high cost of farm inputs. Afari-sefa (2012) reported the same constraints and added some others such as poor access to improved seeds and fertilizers, insect, pests and diseases, low access to fertile land, poor access to credit facilities and poor access to extension services. Togolay (2010) found that small-scale paddy production in Mvomero district is highly affected by pests and diseases and inadequate rainfall. Msuya (2003) reported that Tanzania sugarcane out-growers are faced with a number of constraints including poor physical, technological and financial infrastructure, inadequate extension services and shortage of farm inputs such as pesticides, fertilizers and herbicides. Regnard (2006) reported that land scarcity is the most important constraint facing sugarcane out-growers in Tanzania.

4.5 Constraints in Paddy and Sugarcane Marketing

Research findings in Table 20 show constraints in paddy and in sugarcane marketing, as identified by smallholder farmers in Kilombero district.

Table 20: Constraints in paddy and sugarcane marketing

	Paddy		Sugarcane	
Constraints in marketing	Frequency	Percent	Frequency	Percent
Poor quality of paddy produced	15	10.9	35	25.4
Low selling price	131	94.9	119	86.2
Inability to set produce price	72	52.2	98	71
Delay of payments after selling.	0	0	104	75.4
Presence of only one buyer	0	0	93	67.4
High transport costs	37	26.8	29	21
Farmers are not involved in weighing their produce	0	0	88	63.8
Charges by Kilombero sugar company and out-growers associations	0	0	73	52.9
Importation of produce from outside	12	8.7	12	8.7

As it can be observed in Table 20, about 94.9% of interviewed farmers reported that paddy marketing in Kilombero district is affected by low selling price. Farmers said that low selling price affects them so much because they end up getting low profit from paddy production and sometimes loss. Inability to set produce pricewas reported by 52.2% of the interviewed farmers. They said that majority of buyers when they come, they usually announce the price at which they are going to buy paddy and they do not give farmers opportunity to negotiate on the selling price. Since paddy farmers are not in groups, every farmer sells his/her paddy at any time he/she wants. Therefore, they usually end up selling their paddy at low prices. But if paddy farmers were united, they could be able to set a reasonable price for their produce and stick to that price. Buyers would have no other option but to buy paddy at farmers' price. Landa (2013) reported that, in Tanzania most of the rice farmers are dealing with their existing problems individually. There are only few farmers' organizations in the sector and mostly limited to small production groups of 20-40

members at the village level. Further up, there is no collective representation of rice producers both at regional and national levels.Other identified constraints in paddy marketing are as shown in Table 20.

The introduction of the Warehouse Receipt System (WRS) in Tanzania in 2005 was sought to provide a viable solution to marketing problems such as quality, price stability, bargaining power, tax collection and bulky yields, but there has been a number of challenges demoralising farmers (Satoyama *et al*., 2014).According to Satoyama *et al*. (2014), one of the challenges of WRS to rice farmers in Tanzania is that, the advantages of WRS are largely felt by progressive rice farmers especially in irrigated ecosystems, who are able to set aside 30 or more bags (50 kg each) of paddy from their production. Smallholder farmers in rainfed and upland environments are not able to see the profitability through individual stocking at WRS. Hence there is a need for smallholders to form groups and engage in collective storage.

According to MAFC (2012), ignorance of how the system works is another challenge facing the WRS in Tanzania. Most farmers and stakeholders in general are still unfamiliar with how the WRS works, a situation stakeholders said needed urgent intervention by conducting public awareness to make it known. Political interference is also a challenge in the operations of the WRS in Tanzania. For example; for the case of Lindi and Kilombero in Morogoro, as far as rice and sesame production is concerned, “Politicking distorts the performance of the WRS because it allows inclusion of personal interests for personal gains at the expense of farmers” (Msita, 2013).

On the other hand, as it can be observed in Table 20, about 75.4% of the interviewed farmers reported that sugarcane marketing in Kilombero district is affected by low selling

price. In Kilombero district, sugarcane price is set by Kilombero Sugar Company depending on the sucrose content. The higher the sugarcane sucrose content the higher the price per tonne. Through the interview conducted with the head of out-growers department at Kilombero Sugar Company it was found that these sucrose contents range from 6% to 16% and the price varies from year to year. The mean sucrose content for sugarcane from out-growers is 10%. Therefore on average out-growers end up selling at low price and hence they find less profit than expected. Farmers complained that they don't even know how these sucrose contents are measured. They need to know and they also need to have a representative in measurements of sucrose contents of their sugarcane.

Delay of payment from the potential buyer was another constraint in sugarcane marketing which was reported by 75.4 % of the interviewed farmers. Farmers said that 90% of their payment is done after 15 days and the remaining 10% is paid after 2 months. They said that they are not comfortable with this time lag between the first and the second payment. They need their money to be paid as early as possible so that they can be able to solve their financial problems which were pending during the production period.

About 71% of the interviewed farmers complained on the inability to set price for their sugarcane. They said that they need to be involved in measuring the sucrose level of their sugarcane and to have a good cane pricing formula which will take into consideration production costs and sucrose content among other things. Presence of only one buyer was reported as a constraint in sugarcane marketing by 67.4% of the interviewed farmers. Farmers said that due to the presence of Kilombero Sugar Company as the only buyer they lack opportunity to negotiate on the price of their sugarcane and they also miss the chance to deliver all sugarcane they produce every year. This is due to the fact that Kilombero Sugar Company can absorb only part of sugarcane produced by sugarcane out-growers

every year. The farmers suggested establishment of another sugar factory(s) in Kilombero district.

Moreover, about 63.8% of interviewed farmers complained on the problem of not being involved in weighing their sugarcane in terms of tonnes. They said that they need to be involved in weighing their sugarcane so that they can be able to know the amount of tonnes they deliver to the sugar factory on the spot.

Additionally, about 52.9% of the interviewed farmers complained on many charges deducted by Kilombero Sugar Company and out-growers associations from sugarcane income. They said that Kilombero sugar company and out-growers associations deduct a lot of money from sugarcane income of out-growers as charges for the services they offered and for some social contributions without willingness of the out-growers themselves. These charges are such as harvesting costs, transportation costs, road maintenance contribution, association fees, secondary school contribution, community services contribution, grab loader contribution and office construction development fund to mention a few. Other identified constraints in sugarcane marketing are as shown in Table 20.

Some other studies were done and revealed some similar marketing constraints to smallholder farmers. For example; the study by Togolay (2010) revealed that small-scale paddy farmers are affected by inability to set price for their produce, failure to get better markets and the use of overfilled bags (*Rumbesa*) by middlemen. Kamugisha (2006) reported that farmers in most cases are price takers because they do not have information on price of produce from other areas or from distant markets. In case of paddy, middlemen are the ones who in most cases are the price setters because they have greater power of

negotiation for prices and can easily secure means of transport and market information (Nyange *et al*., 2000).

In case of sugarcane, in Tanzania the sugar companies usually set price at which they are going to buy sugarcane from out-growers (Chongela, 2008). Matango (2006) reported that in 2005/06 production season sugarcane out-growers of Mtibwa asked for negotiation on sugarcane price with Mtibwa Sugar Estate, but the agreed price was still low. Farmers had no other choice but to sell their sugarcane to Mtibwa Sugar Estate because of logistical problems including distances to other sugar factories, the perishable nature of sugarcane and its bulkiness. Matango (2006) argued that low prices are disincentive to sugarcane out-growers. Moreover, Matango (2006) pointed out that, delays of payment to farmers of Mtibwa out-growers Association (MOA) since 1998 have been between 2 months to six months, while arrears have been lasting for one year.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The present study aimed at determining the profitability of paddy and sugarcane produced by smallholder farmers in Kilombero district and the profit maximizing combination of the two crops. More specifically the study aimed at comparing the returns to land for paddy and sugarcane among smallholder farmers in the study area; determining the most profitable combination for paddy and sugarcane enterprises and identifying constraints toward better performance in paddy and sugarcane production and marketing in the study area.

In comparing the returns to land from paddy and sugarcane produced by smallholder farmers in the study area, the study findings show that sugarcane gives high returns per acre of land than paddy. The average yield per acre of sugarcane per year was found to be 26.73 tonnes while that of paddy was found to be 1.7 tonnes. By using gross margin analysis the average gross margin of sugarcane was found to be 832 439.87Tshs per acre per year while that of paddy was found to be 148 389.62 Tshs per acre per year. In view of these findings the present study concludes that sugarcane production is more profitable than paddy production. Although there is a huge difference in paddy and sugarcane profitability farmers in Kilombero district are still producing paddy mainly for food security and as insurance of income if failures occur in Sugarcane production and marketing.

In determining the most profitable combination for paddy and sugarcane enterprises by using linear programming model it was found that, for smallholder paddy and sugarcane

farmers of Kilombero district to maximize their total farm profitability they should cultivate 4 acres of paddy and 2.5 acres of sugarcane. With this enterprise combination smallholder farmers will be able to maximize their total farm profitability per year at the same time reduce, if not avoid the risk of missing the opportunity of selling their sugarcane in some years. The present study concludes that limitation on the quantity of sugarcane to be delivered to the sugarcane market (Kilombero Sugar Company) is the most limiting factor to smallholders' maximization of their total farm profits.

Through the results of the linear programming model in the second scenario the study found that, even without limitation on the quantity of sugarcane to be delivered to the sugarcane market (Kilombero Sugar Company), smallholder farmers are also limited by capital. They only use their own savings in production of paddy and sugarcane. They do not take loans to add to their own capital due to fear of crop failures. As a result they remain with small areas of production and little labour. The present study also concludes that limited capital is among the major barriers to smallholder farmers in maximization of their farm profits.

In identifying constraints toward better performance in paddy and sugarcane production and marketing, by using frequency and percentages of smallholder farmers, the present study found that paddy and sugarcane productions in Kilombero district are highly affected by unreliable rainfall, low access to improved farm inputs, low access to fertile land, pests and diseases, high labour cost and scarcity of labour. In case of sugarcane only there is a problem of improper and biased harvesting time table, and fire accidents in sugarcane farms. Other identified constraints in paddy and sugarcane productions are lack of improved irrigation technologies, lack of knowledge on how to use or combine factors of production, low access to extension services and shortage of capital.

Furthermore, the findings of the present study show that paddy and sugarcane marketing in Kilombero district are highly affected by low selling prices and inability to set produce prices. In case of sugarcane only there is delay of payments after selling, presence of Kilombero Sugar Company as the only buyer, farmers being not involved in measuring the tonnage and sucrose content of their sugarcane, and a lot of charges deducted from sugarcane income by Kilombero Sugar Company and Out-growers Associations. Other identified constraints in paddy and sugarcane marketing are high transport costs and importation of produce from outside. The present study further concludes that the presence of these production and marketing constraints to smallholder farmers consequently affects maximization of their farm profits.

5.2 Recommendations

i. The government should encourage, if necessary support investors of Kilombero Sugar Company to increase the processing capacity of their factory or should encourage other investors to establish another sugar factory (s) in Kilombero district. This will increase the market for sugarcane produced by smallholder farmers and hence help to remove limitation on the quantity of sugarcane to be delivered to the market.

ii. The government should increase the number of qualified extension officers and should make sure that these extension officers perform their responsibilities especially on capacity building to farmers. For example educating farmers on how to properly combine their factors of production such as land, labour and capital. This will help farmers to increase their productivity, reduce unnecessary production costs and hence improve their farm profitability.

iii. In order to reduce farmers' dependency on rain fed agriculture, improved irrigation technologies should be increased in the study area, local irrigation schemes should be improved and rain water harvesting technology should be introduced so that water can be available for irrigation.

iv. The government should continue subsidizing farm inputs such as fertilizers, agrochemicals, seeds and implements and make these inputs available to farmers on time. This will increase farmers' access to improved farm inputs. More farmers will be encouraged to use improved inputs and hence be able to increase their farm productivity which will consequently increase their farm incomes. Subsidization of farm inputs will also reduce production costs and hence increase farm profitability.

v. In order to increase farmers' access to additional capital financial institutions should encourage smallholder farmers to take loans through trainings and by imposing favorable conditions in the process of taking loans. Farmers were found to avoid taking loans due to fear of crop failures. Therefore, insurance companies should think of introducing crops insurance favorable to smallholder farmers. This will help farmers reduce their fear of crop failures and accept to take loans.

vi. In order to increase smallholder farmer' access to fertile land the village governments should make efforts to divide fertile land to smallholder farmers at affordable prices and the process should not be bureaucratic.

vii. As it is in sugarcane, paddy farmers should also establish their associations which will help them to solve their production and marketing problems together. For example; to have collective bargaining power, to put their paddy in warehouse as an association instead of putting as an individual in order to get more profit, to organize irrigation schemes and to purchase farm inputs as an association in which they can get discount.

viii. In order for smallholder sugarcane farmers to get better prices for their sugarcane they should make sure that they produce sugarcane of better quality which will have high sucrose content. The higher the sucrose content sugarcane has the higher the price. The converse is correct. To ensure that farmers are getting better price for their sugarcane the owners of sugar factors should make sure that they decide a fair cane pricing formula through which both the farmers and the factories owners will benefit and neither part will be hart.

ix. Cane growers associations and sugar factories should make sure that there is no delay of payments to farmers. They should also make sure that only necessary and if possible few charges are deducted from sugarcane income of out-growers.

x. Out-growers associations should prepare proper and unbiased harvesting time table to ensure that every smallholder farmer get the opportunity for his/her sugarcane to be harvested and sold in every year.

5.3 Areas for further studies

According to the findings of the study, further studies can be conducted in the following areas.

i. Efficiency of Warehouse Receipt System (WRS) operation for paddy marketing in Kilombero district.

ii. Introduction of crops insurance as a way to secure farmers from crops risks and uncertainties.

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APPENDICES

Appendix 1: Farmer's Questionnaire in Kilombero District

Section A: Background Information

Interviewer's Name: ……

Name of Respondent…….

Village…… Ward ……

Section B: Farmer's Characteristics.

1. Age…….

2. Gender 1=Male 2= Female ( )

3. Education level: 1= Primary 2= Form four 3= Form six 4=Certificate 5=Diploma

6= First degree 7= Others (Specify) ( )

4. Marital status 1= Single 2=Married 3=Divorced 4= Widow

5= Others (Specify)……

5. Respondent's household size

Sex	Under fifteen Yrs	15-64 Yrs	65 Yrs and Above	Total
Male				
Female				

6. Respondent's main source of Income……

Section C: Crop Production, Costs and Returns

1. What types of crops are you growing in your farm(s) 1. Paddy 2. Sugarcane 3.Other(s) (specify) ……
2. Rank the crops you produce in order of importance. Start with number 1 the most important……

3. Indicate the land cultivated and the total output obtained from your crops as required in the table below.

Crop	Years	Land cultivated (acres)	Total output (bags) or (Tonnes)	Yield (Tonnes/acre) or (Bags(100kg)/acre)
Paddy	2012/13			
Sugarcane	2008/09			
	2009/10			
	2010/11			
	2011/12			
	2012/13			
Other important crop(specify)	2012/13			

4. Indicate the produce prices for each crop as required in the table below.

Crop	Year	Price per bag(100kg) in Tshs	Price per tonne in Tshs
Paddy	2012/13		
Sugarcane	2008/09		
	2009/10		
	2010 /11		
	2011/12		
	2012/13		
Other important crop(s) (Specify)			

5. Indicate the variable costs you incurred from production of each important crop as shown in the table below.

Crop 1: Paddy

Type of Variable costs incurred	Year 2012/13
	Payment (Tshs/acre)
Land preparation	
Purchase of seeds	
Planting	
Weeding	
Purchase of fertilizer	
Fertilizer application	
Purchase of Agro-chemicals	
Agro-Chemicals applications (Spraying)	
Security guard expenses	
Harvesting	
Transportation	
Storage	
Marketing	
Others(Specify)	
Total	

Crop 2: Sugarcane

Type of Variable costs incurred	Years and payments				
	2008/ 09	2009/ 10	2010/11	2011/ 12	2012/ 13
	Payment (Tshs/ acre)	Payment (Tshs/ acre)	Payment (Tshs/ acre)	Payment (Tshs/ acre)	Payment (Tshs/ acre)
Land preparation					
Purchase of seeds					
Planting					
Weeding					
Purchase of fertilizer					
Fertilizer application					
Purchase of Agro-chemicals					
Agro-Chemicals applications					
Security guard expenses					
Harvesting					
Transportation					
Storage					
Marketing					
Others(Specify)					
Total					

Other important crop(s) (Specify)……..……

NB: For annual crop like paddy fill the payments information for the year 2012/13.

For a ratoon crop like sugarcane (if any) fill the payments information from 2008/09 to 2012/13

Type of Variable costs incurred	2008 /09	2009/10	2010/11	2011/12	2012/13
	Payment (Tshs/acre)	Payment (Tshs/acre)	Payment (Tshs/acre)	Payment (Tshs/acre)	Payment (Tshs/acre)
Land preparation					
Purchase of seeds					
Planting					
Weeding					
Purchase of fertilizer					
Fertilizer application					
Purchase of Agro-chemicals					
Agro-Chemicals applications (Spraying)					
Security guard expenses					
Harvesting					
Transportation					
Storage					
Marketing					
Others(Specify)					
Total					

Section D: Resources Availability and Requirement

I. Land

1. What is the total land area you own for crops production? ……... (ha)

2. How did you acquire this land? 1=Bought, 2=Hired, 3=Inherited, 4= Given by the village government, 5= Others (Specify)…… ( )

3. Is the land you own enough for your crops production? 1=Yes, 2=No. ( )

4. If No, How do you think you can increase your land area for production? 1=by buying, 2=by hiring, 3=Inherit, 4= given by the village government, 5=others (Specify)…… ( )

5. If you are hiring land what is the cost of hiring 1 acre of land per year? .....Tshs

6. Indicate the problems you experience from acquiring land. 1=No problem, 2=Bureaucracy, 3= High cost, 4.Others…… ( )

II. Labour

5. Mention the type of labour you are usually using in crop production. 1=family labour, 2= Hired labour, 3=Both ( )

6. Indicate the quantity of labour (man days/acre) used per year for each of the following farm operation.

(a) Crop(s): Paddy and other important annual crop(s)

Farm operation	Quantity of Labour used in man-days/acre in a year (2012/13)			
	Paddy production		Other Important annual crop (Specify)……	
	Family labour	Hired labour	Family labour	Hired labour
Land preparation -Ploughing -Harrowing -Furrowing				
Planting				
Weeding				
Fertilizer application				
Spraying of chemicals				
Harvesting				
Security guard				
Others (Specify)				

(b) Crop: Sugarcane and other important perennial/Ratoon crop (if any).

I. For production year 2008/09

Farm operation	Quantity of Labour used in man-days/acre in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Family labour	Hired labour	Family labour	Hired labour
Land preparation -Ploughing -Harrowing -Furrowing				
Planting				
Weeding				
Fertilizer application				
Spraying of chemicals				
Harvesting				
Security guard				
Others (Specify)				

II. For production year 2009/10

Farm operation	Quantity of Labour used in man-days/acre in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Family labour	Hired labour	Family labour	Hired labour
Land preparation -Ploughing -Harrowing -Furrowing				
Planting				
Weeding				
Fertilizer application				
Spraying of chemicals				
Harvesting				
Security guard				
Others (Specify)				

III. For production year 2010/11

Farm operation	Quantity of Labour used in man-days/acre in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Family labour	Hired labour	Family labour	Hired labour
Land preparation -Ploughing -Harrowing -Furrowing				
Planting				
Weeding				
Fertilizer application				
Spraying of chemicals				
Harvesting				
Security guard				
Others (Specify)				

IV. For production year 2011/12

Farm operation	Quantity of Labour used in man-days/acre in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Family labour	Hired labour	Family labour	Hired labour
Land preparation -Ploughing -Harrowing -Furrowing				
Planting				
Weeding				
Fertilizer application				
Spraying of chemicals				
Harvesting				
Security guard				
Others (Specify)				

V. For production year 2012/13

Farm operation	Quantity of Labour used in man-days/acre in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Family labour	Hired labour	Family labour	Hired labour
Land preparation -Ploughing -Harrowing -Furrowing				
Planting				
Weeding				
Fertilizer application				
Spraying of chemicals				
Harvesting				
Security guard				
Others (Specify)				

7. Was it possible to get more than the amount of labour you used in each of your farm operation? 1=Yes, 2=No. ( )

8. If yes, indicate the maximum amount of labour you could get for each of your farm operation as required in the following table.

Farm operation	The maximum Quantity of Labour you could get in man-days/acre in a year.					
	Paddy production		Sugarcane production		Other Important crop (s) (Specify) ……..	
	Family labour	Hired labour	Family labour	Hired labour	Family labour	Hired labour
Land preparation -Ploughing -Harrowing -Furrowing						
Planting						
Weeding						
Fertilizer application						
Spraying of chemicals						
Harvesting						
Security guard						
Others (Specify)						

9. Specify the months in which the following farm operations are done during a year.

Farm operation	Months in a year
Land preparation -Ploughing -Harrowing -Furrowing	
Planting	
Weeding	
Fertilizer application	
Spraying of chemicals	
Security guard	
Harvesting	
Others (Specify)	

10. What is the cost of hiring one man-day of labour for each farm operation?

Farm operation	The cost of hiring one man-day of labour (Tshs) in each farm operation.			
	For Paddy production	For sugarcane production	For Other Important crop(s) (Specify)	
Land preparation -Ploughing -Harrowing -Furrowing				
Planting				
Weeding				
Fertilizer application				
Spraying of chemicals				
Harvesting				
Security guard				
Others (Specify)				

11. Indicate the problems you experience from acquiring labour. 1=no problem, 2=High cost, 3= others (Specify)…… ( )

III. Capital

12. What is your source of additional capital for your farming activities? 1= Own servings, 2= Credit (Loan), 3= Grants, 4= both own servings and loans, 5= Others (Specify)…… ( )

13. Indicate the amount of own and/or borrowed capital (in Tshs/acre) used in each of your farm expense per year as required in the table below.

(a) Crop: Paddy and Other important annual crop.

Farm expenses	Amount of own and borrowed capital(Tshs/acre) in 2012/13			
	Paddy production		Other Important annual crop (Specify)……	
	Own capital	Borrowed capital	Own Capital	Borrowed capital
Land preparation -Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of agrochemicals				
Spraying of agrochemicals				
Security guard				
Harvesting				
Storage				
Marketing expenses				
Others (Specify)				

(b) Crop(s): Sugarcane and other important perennial/ratoon crop (if any).

I. For production year 2008/09

Farm expenses	Amount of own and borrowed capital (Tshs/acre) in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Own capital	Borrowed capital	Own Capital	Borrowed capital
Land preparation -Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of Agrochemicals				
Spraying of chemicals				
Security guard				
Harvesting				
Storage				
Marketing expenses				
Others (Specify)				

II. For production year 2009/10

Farm expenses	Amount of own and borrowed capital (Tshs/acre) in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Own capital	Borrowed capital	Own Capital	Borrowed capital
Land preparation -Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of Agrochemicals				
Spraying of chemicals				
Security guard				
Harvesting				
Storage				
Marketing expenses				
Others (Specify)				

III. For production year 2010/11

Farm expenses	Amount of own and borrowed capital (Tshs/acre) in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Own capital	Borrowed capital	Own Capital	Borrowed capital
Land preparation -Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of Agrochemicals				
Spraying of chemicals				
Security guard				
Harvesting				
Storage				
Marketing expenses				
Others (Specify)				

IV. For production year 2011/12

Farm expenses	Amount of own and borrowed capital (Tshs/acre) in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)……	
	Own capital	Borrowed capital	Own Capital	Borrowed capital
Land preparation -Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of Agrochemicals				
Spraying of chemicals				
Security guard				
Harvesting				
Storage				
Marketing expenses				
Others (Specify)				

V. For production year 2012/13

Farm expenses	Amount of own and borrowed capital (Tshs/acre) in a year.			
	Sugarcane production		Other Important ratoon crop (Specify)…… …	
	Own capital	Borrowed capital	Own Capital	Borrowed capital
Land preparation -Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of Agrochemicals				
Spraying of chemicals				
Security guard				
Harvesting				
Storage				
Marketing expenses				
Others (Specify)				

14. Was it possible to get more than the amount of capital you used in each of your farm operation? 1=Yes, 2=No. ( )

15. If yes, indicate the maximum amount of capital you could get for your farm operations.

Farm operation	The maximum amount of capital you could get in Tshs/acre in a year.					
	Paddy production		Sugarcane production		Other Important crop(s)(Specify)……	
	Own capital	Borrowed capital	Own Capital	Borrowed Capital	Own Capital	Borrowed Capital
Land preparation -Ploughing -Harrowing -Furrowing						
Purchase of seeds						
Planting						
Weeding						
Purchase of fertilizer						
Fertilizer application						
Purchase of agrochemicals						
Spraying of agrochemicals						
Security guard						
Harvesting						
Storage						
Marketing expenses						
Others (Specify)						

16. Indicate the amount of capital you borrowed, the cost of that capital and the farm operations in which you used that capital as required in the following tables.

(a) Crop: Paddy

(b) Crop: Sugarcane production

Farm expenses	Loan 1(Tshs) ……	Loan 2(Tshs) ……	Loan 3 (Tshs) ……	etc
	Interest (%) ……	Interest (%) ……	Interest (%) ……	
	Amount used(Tshs)	Amount used(Tshs)	Amount used(Tshs)	
Land preparation Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of agrochemicals				
Spraying of Agrochemicals				
Security guard				
Storage				
Marketing expenses				
Others(Specify)				

I. For production year 2008/09

Farm expenses	Loan 1(Tshs) ……	Loan 2(Tshs) …….	Loan 3 (Tshs) ……	etc
	Interest (%) …….	Interest9%) …….	Interest (%) ……	
	Amount used(Tshs)	Amount used(Tshs)	Amount used(Tshs)	
Land preparation Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of agrochemicals				
Spraying of Agrochemicals				
Security guard				
Storage				
Marketing expenses				
Others(Specify)				

II. For production year 2009/10

Farm expenses	Loan 1(Tshs) ……	Loan 2(Tshs) ……	Loan 3 (Tshs) ……	etc
	Interest (%) …….	Interest9%) ……	Interest(%) ……	
	Amount used(Tshs)	Amount used(Tshs)	Amount used(Tshs)	
Land preparation Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of agrochemicals				
Spraying of Agrochemicals				
Security guard				
Storage				
Marketing expenses				
Others(Specify)				

III. For production year 2010/11

Farm expenses	Loan 1(Tshs) ……	Loan 2(Tshs) ……..	Loan 3 (Tshs) …….	etc
	Interest (%) ……	Interest9%) ……..	Interest (%) …….	
	Amount used(Tshs)	Amount used(Tshs)	Amount used(Tshs)	
Land preparation Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of agrochemicals				
Spraying of Agrochemicals				
Security guard				
Storage				
Marketing expenses				
Others(Specify)				

IV. For production year 2011/12

Farm expenses	Loan 1(Tshs)…….....	Loan 2(Tshs) ……..	Loan 3 (Tshs) ……	etc
	Interest (%) ……	Interest9%) ……	Interest(%) ……	
	Amount used(Tshs)	Amount used(Tshs)	Amount used(Tshs)	
Land preparation Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of agrochemicals				
Spraying of Agrochemicals				
Security guard				
Storage				
Marketing expenses				
Others(Specify)				

V. For production year 2012/13

Farm expenses	Loan 1(Tshs) ……	Loan 2(Tshs) ……..	Loan 3 (Tshs) …….	etc
	Interest (%) ……	Interest9%) ……..	Interest(%) …….	
	Amount used(Tshs)	Amount used(Tshs)	Amount used(Tshs)	
Land preparation Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of agrochemicals				
Spraying of Agrochemicals				
Security guard				
Storage				
Marketing expenses				
Others(Specify)				

(c) Other Important crop(s)Specify……

Farm expenses	Loan 1(Tshs) ……	Loan 2(Tshs) ……..	Loan 3 (Tshs) …….	etc
	Interest (%) ……...	Interest9%) ……..	Interest(%) …….	
	Amount used(Tshs)	Amount used(Tshs)	Amount used(Tshs)	
Land preparation Ploughing -Harrowing -Furrowing				
Purchase of seeds				
Planting				
Weeding				
Purchase of fertilizer				
Fertilizer application				
Purchase of agrochemicals				
Spraying of Agrochemicals				
Security guard				
Storage				
Marketing expenses				
Others(Specify)				

Section E: Constraints in paddy and sugarcane production and marketing

1. What are the constraints toward better performance in **paddy production**? Use the table below to identify the constraints. Put a tick on the constraint and give explanation if any.

Constraints in paddy production	Tick	Explanation
Unreliable rainfall		
Lack of improved irrigation technologies		
Limitations in using the available water for irrigation		
High costs of improved farm inputs		
Improved farm inputs are not easily available in the area		
Lack of knowledge on how to use or combine farm inputs(factors of production)		
Low access to extension services		
Low access to fertile land		
Inability to get farm inputs on time		
Bureaucracy in acquiring farm inputs such fertilizers, seeds and agrochemicals		
Others (Specify)		

2. What are the constraints toward better performance in **sugarcane production**? Use the table below to identify the constraints. Put a tick on the constraint and give explanation if any.

Constraints in paddy production	Tick	Explanation
Unreliable rainfall		
Lack of improved irrigation technologies		
Limitations in using the available water for irrigation		
High costs of improved farm inputs		
Improved farm inputs are not easily available in the area		
Lack of knowledge on how to use or combine farm inputs(factors of production)		
Low access to extension services		
Access to fertile land		
Inability to get farm inputs on time		
Bureaucracy in acquiring farm inputs such fertilizers, seeds and agrochemicals		
Others (Specify)		

3. What are the constraints toward better performance in **paddy marketing**? Use the table below to identify the constraints. Put a tick on the constraint and give explanation if any.

Constraints	Tick	Explanation
Poor quality of paddy produced		
Low selling price		
Inability to set price of your produce		
Far distance to the better market		
Poor infrastructure		
High transport costs		
Others (Specify)		

4. What are the constraints toward better performance in **Sugarcane marketing**? Use the table below to identify the constraints. Put a tick on the constraint and give explanation if any.

Constraints	Tick	Explanation
Poor quality of sugarcane produced		
Low selling price		
Payment time taken between sellers and buyers		
Inability to set price of your produce		
Procedures set in selling sugarcane		
Presence of few/only one buyer		
Poor infrastructure		
High transport costs		
Others (Specify)		

5. What factors encourage you to produce both paddy and sugarcane?

(i)…….....

(ii)……

(iii)……

etc……

6. Are you thinking of dropping one crop? 1=Yes, 2=No.

7. If yes, which one and why?

……

……

……

THANK YOU FOR YOUR COOPERATION!

Appendix 2: Average yield, revenue, costs and gross margin per acre of paddy in production year 2012/13

Item	**Value**
Average yield (Tonnes per acre)	1.70
Average selling price (Tshs) per bag (170kg)	53699.00
Average selling price (Tshs/tonne)	315876.47
Average revenue (Tshs per acre)	**536990.00**
Average cost of ploughing (Tshs/acre)	43299.62
Average costs of harrowing (Tshs/acre	36293.36
Average cost of purchasing seeds (Tshs/acre)	29818.00
Average cost of planting (Tshs/acre)	30179.00
Average cost of weeding (Tshs/acre)	46725.00
Average cost of purchasing fertilizer(Tshs/acre)	38237.00
Average cost of fertilizer application(Tshs/acre)	4581.40
Average cost of purchasing agrochemicals(Tshs/acre)	12403.00
Average cost of agrochemical application (Tshs/acre)	4915.00
Average Harvesting cost (Tshs/acre)	40918.00
Average transportation cost (Tshs/acre)	28766.00
Average cost of hiring land (Tshs/acre)	7246.00
Average total cost (Tshs/acre)	**388600.38**
Average gross margin(Tshs/acre)	**148389.62**

Appendix 3: Average costs per acre for sugarcane production

Costs	2008/09	2009/10	2010/11	2011/12	2012/13
Average cost of ploughing (Tshs/acre)	38116.76	0.00	0.00	0.00	0.00
Average cost of harrowing (Tshs/acre)	30321.32	0.00	0.00	0.00	0.00
Average cost of furrowing(Tshs/acre)	28455.08	0.00	0.00	0.00	0.00
Average cost of purchasing seeds (Tshs/acre)	150040.00	0.00	0.00	0.00	0.00
Average cost of planting(Tshs/acre)	28203.84	0.00	0.00	0.00	0.00
Average cost of weeding(Tshs/acre)	58156.00	55914.00	60739.00	60756.00	61238.00
Average cost of purchasing fertilizer(Tshs/acre)	65907.00	74445.00	73885.00	76517.00	85008.00
Average cost of fertilizer application(Tshs/acre)	4233.37	4282.90	4419.90	4545.80	4597.10
Average cost of purchasing agrochemicals(Tshs/acre)	17134.00	18903.00	18926.00	22725.00	24160.00
Average cost of agrochemical application(Tshs/acre)	4420.60	4536.70	4739.10	4978.50	5131.10
Average Harvesting cost (Tshs/acre)	187170.00	200400.00	220710.00	225090.00	248240.00
Average transportation cost (Tshs/acre)	207210.00	217080.00	253290.00	241110.00	239480.00
Average total charges by KSC and out-growers associations (Tshs/acre)	45893.00	49918.00	53774.00	48034.00	60859.00
Average cost of hiring land (Tshs/acre)	98760.00	98900.00	99250.00	99530.00	99810.00
Average total cost (Tshs/acre)	**964020.97**	**724379.60**	**789733.00**	**783286.30**	**828523.20**

Appendix 4: Average yields, revenues, total costs and gross margins per acre for sugarcane from 2008/09 to 2012/13

Item	2008/09	2009/10	2010/11	2011/12	2012/13
Average yield (Tonnes per acre)	27.78	26.99	27.26	25.72	25.9
Average selling price (Tshs/tonne) at average sucrose content of 10%	43855	52918	55060	67000	69000
Average revenue (Tshs per acre)	1218291.90	1428256.82	1500935.60	1723240	1787100
Average total cost (Tshs/acre)	964020.97	724379.60	789733.00	783286.30	828523.20
Average gross margin(Tshs/acre)	254257.04	703877.22	711202.6	939953.70	958576.80
Compounded gross margin(Tshs/acre)	372257.73	936860.58	860555.15	1033949.07	958576.80
Average of the compounded gross margins is 832439.87Tshs/acre					

Appendix 5: Total average quantities of labour used in periods 1, 2 and 3.

Period 1 (Dec-Feb)	**Total average quantity of labour used for production of a crop in period 1 is equal to average quantity of labour used per acre of a crop in period 1 times average number of acres produced.**		
	Average quantity of labour used (man-days/acre)	acres	Total average quantity of labour used for a crop(man-days)
In paddy	14.8	3.28	14.8X 3.28=48.544
In sugarcane	22.3	3.28	22.3X 3.28=73.144
Total average quantity of labour used in period 1 is equal to total average quantity of labour used for paddy production in period 1 plus total average quantity of labour used for sugarcane production in period 1.			
Total average quantity of labour used in period 1			48.544 + 73.144 **= 121.69**
Period 2 (March-May)	**Total average quantity of labour used for production of a crop in period 2 is equal to average quantity of labour used per acre of a crop in period 2 times average number of acres produced.**		
	Average quantity of labour used (man-days/acre)	acres	Total average quantity of labour used for a crop (man-days)
In paddy	13.09	3.28	13.09 X 3.28= 42.94
In sugarcane	13.62	3.28	13.62 X 3.28 = 44.67
Total average quantity of labour used in period 2 is equal to total average quantity of labour used for paddy production in period 2 plus total average quantity of labour used for sugarcane production in period 2.			
Total quantity of labour used in period 2			42.94 + 44.67 = **87.61**
Period 3 (March-May)	**Total average quantity of labour used for production of a crop in period 3 is equal to average quantity of labour used per acre of a crop in period 3 times average number of acres produced.**		
	Average quantity of labour used (man-days/acre)	acres	Total average quantity of labour used for a crop (man-days)
In paddy	8.3	3.28	8.3 X 3.28= 27.22
In sugarcane	0	3.28	0 X 3.28=0
Total average quantity of labour used in period 3 is equal to total average quantity of labour used for paddy production in period 3 plus total average quantity of labour used for sugarcane production in period 3.			
Total average quantity of labour used in period 3			27.22 + 0 =**27.22**

Appendix 6: Average costs per man-day in periods 1

1st Farmoperation	**Harrowing**			Cost(Tshs/ man-day)
Required man-days/acre in paddy production	7.3	Total labour cost (Tshs/acre)	36293.36	=36293.36/7.3 = 4971.69
Required man-days/per acre in in sugarcane production	7.3	Total labour cost (Tshs/care)	36293.36	=36293.36/7.3 = 4971.69
Average cost/man-day in harrowing			(4971.69+4971.69)/2=4971.69	
2nd Farm operation	**Furrowing**			
Required man-days/acre in paddy production	Nill	Total labour cost (Tshs/acre)	Nill	Nill
Required man-days/per acre in sugarcane production	7	Total labour cost (Tshs/care)	34530.20	=34530.2/7 = 4932.89
Average cost/man-day in Furrowing			= 4932.89	
3nd Farm operation	**Planting**			
Required man-days/acre in paddy production	7.5	Total labour cost (Tshs/acre)	30179	=30179/7.5 =4023.87
Required man-days/per acre in sugarcane production	8	Total labour cost (Tshs/care)	34280.89	= 34280.89/8 = 4285.11
Average cost/man-day in Planting			(4023.87+4285.11)/2= 4154.49	
On average, the cost/man-day in period 1 =(4971.69+ 4932.89+4154.49)/3 = **4686.36**				

Appendix 7: Average costs per man-day in period 2

1st Farm operation	**Fertilizer application**			Cost(Tshs/man-day)
Required man-days/acre in paddy production	1	Total labour cost (Tshs/acre)	4581.4	=4581.4/1 =4581.4
Required man-days/per acre in in sugarcane production	1	Total labour cost (Tshs/care)	4597.1	=4597.1/1 =4597.1
Average cost/man-day in Fertiliser application			(4581.4+4597.1)/2= 4589.25	
2nd Farm operation	**Agrochemical application**			
Required man-days/acre in paddy production	1	Total labour cost (Tshs/acre)	4915	=4915/1 =4915
Required man-days/per acre in sugarcane production	1	Total labour cost (Tshs/care)	5131.1	=5131.1/1
Average cost/man-day in Agrochemical application			(4915+5131.1)/2=5023.05	
3rd Farm operation	**Weeding**			
Required man-days/acre in paddy production	11.09	Total labour cost (Tshs/acre)	46725	=46725/11.09 =4213.26
Required man-days/per acre in sugarcane production	11.62	Total labour cost (Tshs/care)	61238	=61238/11.62 =5270.05
Average cost/man-day in Weeding			(4213.26+5270.05)/2= 4741.65	
On average, the cost/man-day in period 2 =(4589.25+5023.05+4741.65)/3=**4784.65**				

Appendix 8: Average costs per man-day in period 3

Farm operation	**Harvesting**			Cost(Tshs/man-day)
Required man-days/acre in paddy production	8.3	Total labour cost(Tshs/acre)	40918	=40918/8.3 =4929.88
Average cost/man-day in harvesting				=4929.88
On average, the cost/man-day in period 3				=**4929.88**

Appendix 9: Working capital available

Period 1 (Dec-Feb)	**Working capital available for production of a crop in period 1 is equal to working capital used in one acre of a crop in period 1 times average number of acres produced.**		
	Working Capital used(Tshs/acre)	acres	Working capital available for a crop(Tshs)
In paddy	73117.62	3.28	73117.62 X3.28= 239825.79
In sugarcane	241299.62	3.28	241299.62 X 3.28=791462.75
Total working capital available in period 1 is equal to working capital available for paddy production in period 1 plus working capital available for sugarcane production in period 1.			
Total working capital available in period 1	239825.79 + 791462.75= **1031288.55**		
Period 2 (March-May)	**Working capital available for production of a crop in period 2 is equal to working capital used in one acre of a crop in period 2 times average number of acres produced.**		
	Working Capital used(Tshs/acre)	acres	Working capital available for a crop(Tshs)
In paddy	50640	3.28	50640 X 3.28=166099.20
In sugarcane	109168	3.28	109168 X 3.38 =358071.04
Total working capital available in period 2 is equal to working capital available for paddy production in period 2 plus working capital available for sugarcane production in period 2.			
Total working capital available in period 2	166099.20+358071.04=**524170.24**		
Period 3 (March-May)	**Working capital available for production of a crop in period 3 is equal to working capital used in one acre of a crop in period 3 times average number of acres produced.**		
	Working Capital used(Tshs/acre)	acres	Working capital available for a crop(Tshs)
In paddy	28766	3.28	28766 X 3.28=94352.48
In sugarcane	567262.29	3.28	567262.29 X 3.28=1860620.31
Total working capital available in period 3 is equal to working capital available for paddy production in period 3 plus working capital available for sugarcane production in period 3.			
Total working capital available in period 3	94352.48+1860620.31=**1954972.79**		

Appendix 10: Linear programming model equations for the present study

Maximize Z, where;

$Z= 148389.62X_1 + 832439.87X_2 -72465A_1 - 99810.00A_2 - 4686.36L_1 - 4784.65L_2 - 4929.88L_3$

Subject to constraints;

Land:

$X_1 + X_2 \leq 6.56 + A_1 + A_2$

Labour in period 1 (December - February):

$14.8X_1 + 22.3X_2 \leq 121.69 + L_1$

Labour in period 2 (March - May):

$13.09X_1 + 13.62X_2 \leq 87.61 + L_2$

Labour in period 3 (June - August):

$8.30X_1 \leq 27.22 + L_3$

Working capital in period 1(December - February):

$73117.62X_1 + 241299.62X_2 \leq 1031288.55$

Working capital in period 2 (March - May):

$50640X_1 + 109168X_2 \leq 524170.24$

Working capital in period 3 (June - August):

$28766X_1 + 567262.29X_2 \leq 1954972.79$

Family survival: $X_1 \geq 1.34$, for food security

$X_2 \geq 1$, for income earning

Limitation on the quantity of sugarcane to be delivered to Kilombero Sugar Company:

$$X_2 \leq 2.7$$

Non-negativity constraint: A_1, A_2, L_1, L_2 and $L_3 \geq 0$

Appendix 11: Linear programming model results, first scenario

(a) Optimal values of the decision variables and the overall farm gross margin

Decision variable	**Optimal Value**
Acres of paddy to be produced (X_1)	3.88
Acres of Sugarcane to be produced (X_2)	2.7
Acres to be hired for paddy (A_1)	0.024
Acres to be hired for sugarcane (A_2)	0
Labour to be hired in period 1(L_1)	0
Labour to be hired in period 2 (L_2)	0
Labour to be hired in period 3(L_3)	0
Maximum farm gross margin (Tshs/year)	2797444.71

(b) Limiting factors for the first scenario

Limiting factors	**Shadow prices**	**Constraint right-hand side**	**Allowable increase**	**Allowable decrease**
Land	72465.00	6.56	0.024	1E+30
Labour period 2	2674.30	87.61	3.54	0.31
Labour period 3	4929.88	27.22	5.01	1E+30
Limitation on the quantity of sugarcane to be sold to KSC	723550.87	2.7	0.58	1.7

Where; 1E+30 in Microsoft Excel means infinity.

Appendix 12: Linear programming model results, second scenario

(a) Optimal values of the decision variables and the overall farm gross margin

Decision variable	**Optimal Value**
Acres of paddy to be produced (X_1)	3.28
Acres of Sugarcane to be produced (X_2)	3.28
Acres to be hired for paddy (A_1)	0
Acres to be hired for sugarcane (A_2)	0
Labour to be hired in period 1(L_1)	0
Labour to be hired in period 2 (L_1)	0
Labour to be hired in period 3 (L_1)	0
Maximum farm gross margin (Tshs)	3217101.006

(b)Limiting factors for the second scenario

Limiting factors	**Shadow prices**	**Constraint right-hand side**	**Allowable increase**	**Allowable decrease**
Land	68744.44	6.56	0	0
Labour in period 3	4929.88	27.22	0	1E+30
Working capital in period 3	1.35	1954972.79	0	1227771.54

Where; 1E+30 in Microsoft Excel means infinity.

Appendix 13: Procedures for Hypothesis testing

1. Original claim
   - The returns to land for sugarcane and paddy produced by smallholder farmers are not statically different. For the present study this asserts that there is no statistical difference between sugarcane gross margin per acre and paddy gross margin per acre in small-scale production.
2. Hypotheses

   H_0: The returns to land for sugarcane and paddy produced by smallholder farmers are not statically different ($\mu_1 = \mu_2$)

   H_1: The returns to land for sugarcane is greater than the returns to land for paddy ($\mu_1 > \mu_2$)
3. Level of significance: 5%
4. Test statistic

$$Z = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where;

$\overline{X_1}$ =Mean gross margin of sugarcane (Tshs/acre)

$\overline{X_2}$ = Mean gross margin of paddy (Tshs/acre)

μ_1=Population gross margin of sugarcane (Tshs/acre)

μ_2=Population gross margin of paddy (Tshs/acre)

S_1=Sample standard deviation for sugarcane gross margin (Tshs/acre)

S_2=Sample standard deviation for paddy gross margin (Tshs/acre)

n_1= Sample size for smallholder sugarcane farmers

n_2= Sample size for smallholder paddy farmers (Tshs/acre)

Data

$\overline{X_1}$ =832439.87Tshs/acre ≈ 832440Tshs/acre

$\overline{X_2}$ = 148389.62 Tshs/acre ≈ 148390 Tshs/acre

From the null hypothesis (H_0): $\mu_1=\mu_2$

Therefore; $\mu_1-\mu_2 = 0$

S_1=118920Tshs/acre

S_2=21199 Tshs/acre

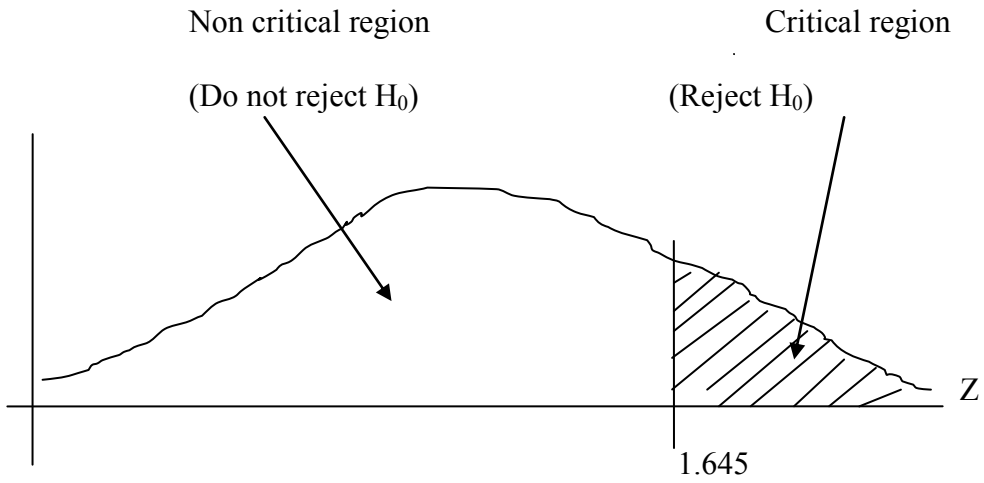
n_1= 138

n_2= 138

5. Determination of critical region (Rejection region).

   With 5% level of significance (0.05), the tabulated Z-statistic is 1.645

   The alternative hypothesis call for a right tailed test.



6. Calculation of Z-statistic

$$Z = \frac{(832440 - 148390) - 0}{\sqrt{\frac{118920^2}{138} + \frac{21199^2}{138}}}$$

Therefore the calculated Z=66.52

7. Decision concerning H_0

Since the calculated Z-statistic (66.52) is greater than the tabulated Z-statistic (1.645), it means that the calculated Z-statistic is in the critical region.

Decision: The null hypothesis is rejected at 5% level of significance.

8. Conclusion

- There is sufficient evidence at 5% level of significance to reject the original claim which states that the returns to land for sugarcane and paddy produced by smallholder farmers are not statically different. Hence the study supports the alternative hypothesis which states that the returns to land for sugarcane is greater that the return to land for paddy.