DETERMINING THE IMPACT OF BIOTECHNOLOGY ON SMALLHOLDER FARM INCOMES:

Prospects and Constraints of *NERICA* Rice in Nyando District of

Kisumu County in Kenya

By

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Declaration:

I hereby declare that this thesis is my original work and has not been presented for any degree at any other university.

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Dedication:

I would like to dedicate this work to my two brothers Africanus and Lawrence Oyugi, whom despite their superb academic abilities could not proceed to secondary school due to financial constraints. Though didn't proceed beyond primary, Africanus and Lawrence have both preached the importance of education to every open ear in the family and beyond.

May God Bless you

Abstract.

The advancement in biotechnology has been advocated for by many scientists as carrying the ultimate cure to Africa's poverty and food insecurity. There is, however, another school of thought opposed to this advocacy; one that view biotechnology as a disaster in the making to both the environment and human livelihoods. This thesis examines the economic relevance of biotechnology to small scale farmers amid growing concerns that most Kenyan farmers are too poor to benefit from biotechnology. To find answers to the raised concerns, a total of 80 rice farmers from Nyando in Kisumu County were sampled and interviewed in a bid to determine suitability and economic potential of biotechnology to smallholder farmers. Whereas the 80 farmers represented the smallholder farmers in general, the New Rice for Africa (NERICA) represented biotechnology. The study employed both cost-benefit and linear programming analyses. As part of the cost-benefit analysis, the Farm profit model was used to generate data on the profitability of the various enterprises with each being analyzed separately. In this regard, conventional rice was found to generate the highest gross margin per acre followed by NERICA, maize and sorghum respectively. To take into account the resource constraints facing farmers, the costs and benefits associated with the various crop enterprises were subjected to linear programming (LP) analysis, where all the possible enterprises were evaluated jointly. The LP results showed that with the current yield,

prices, input costs and resource availability, conventional rice is the most competitive followed by NERICA, maize and sorghum respectively.

Turning to the economic potential of biotechnology, it was established that the NERICA technology has capacity to improve smallholder farmers' incomes by up to 300%. The sustainability of such potential benefits however requires provision of adequate support in terms of credit and yield enhancing research. Given the needs of the nation, available resources and the income generation capacity of biotechnology, stakeholders should promote and effectively support development of biotechnology. This will avail benefits to farmers and provide a solution to one of the country's headaches, food security.

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LIST OF ACRONYMS AND ABBREVIATIONS

BT	Bacillus Thuringiensis
DNA	Deoxyribonucleic Acid
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GM	Gross Margin
GoK	Government of Kenya
HA	Hectare
IRR	International Rice Research
KARI	Kenya Agricultural Research Institute
KG	Kilogram
LBDA	Lake Basin Development Authority
NERICA	New Rice for Africa
SACRED	Sustainable Agriculture Centre for Research and Development
SSA	Sub Saharan Africa
TCPA	Total Cost per Acre
UN	United Nations

CHAPTER 1

INTRODUCTION

1.1Background Information

Agriculture remains the backbone of the national economies of most countries in Sub-Saharan Africa (SSA). Environmental degradation, overreliance on traditional methods of farming and unfavourable climate that is also difficult to predict are some of the factors that have adversely affected agriculture leading to persistent poverty and food insecurity. Thus there is need to raise the level of commitment and involvement in fighting poverty and food insecurity at both individual and institutional levels.

In Kenya, Agriculture dominates the economy and accounts for 26% of the country's GDP and 65% of export earnings, (GoK, 2010). The sector also plays a very important role of providing markets for manufactured products. In spite of these contributions to the economy of the nation, it still lacks modern technologies that may fast track productivity improvement.

The government of Kenya has recognized the importance of Agriculture in economic development and has continuously promoted the sector through rural development initiatives. Such efforts have however, met a number of challenges such as natural disasters, declining soil fertility, inadequate capital and markets.

The United Nations report on world population (United Nations, 2011) indicates that world population is rapidly growing and it is expected to reach 9.3 billion by the year 2050 while the available farm land will basically remain the same. Africa and Kenya in particular faces the same problem of growing population and decreasing available farm land. To overcome these challenges, the government, through the Ministry of Agriculture has spelt out a ten year (2010-2020) Strategy for Agriculture Sector Development Strategy whose vision is “A food secure and prosperous nation (GoK, 2010). Specific strategies include empowering local communities, promoting pro-poor agricultural research, initiating priority projects and training of farmers in agribusiness skills. In this regard, the Ministry of Agriculture through the Kenya Agricultural Research Institute (KARI) has realized that improving agricultural productivity is the only viable option to ensure food security for all. KARI has therefore implemented some of the strategies especially those focusing on emerging technologies for improvement of agricultural production. Improving such farm productivity while conserving the natural resource base is a daunting task for which Agricultural biotechnology can be of significant help. The use of biotechnology either in isolation or in combination with conventional breeding methods can improve food production by tailoring crops to harsh environmental conditions and enhancing the nutritive value of the food. Development of hardier crops that are resilient to these factors may allow food production in low-potential areas and thus help ensure food security. Kenya’s food security revolves around increasing yield and nutritive content of the four most important cereal crops namely maize, wheat, rice and sorghum in that order.

Changes in employment patterns have considerably changed food preferences from traditional grains like Maize and sorghum in favour of the more easy-to-cook foods like rice (Otsuka, 2006). Such changes in consumption habits are likely to call for production of more rice. Whereas maize and wheat are mainly rain-fed, over 95% of the domestic rice production is under irrigation practiced in Mwea, Bura, West Kano and Ahero irrigation schemes while less than 5% is rain-fed. Dependency on traditional irrigated rice varieties that are highly susceptible to diseases and pests has led to low rice output in the country leading to a large deficit between production and consumption. For the period 2004-2010, national rice production ranged between 21,881 to 64,840 tons while national consumption ranged between 210,000 and 410,000 tons for the same period (GoK, 2011). Of particular importance however, is the rapidness and consistence with which consumption is growing year after year relative to low and unstable production. National consumption of rice has rapidly risen from 270,200 tons in the year 2004 to 410,000 tons in 2010 whereas national production has actually stagnated if not reduced over the same period. Kenya produced 49,290 tons and 44,467 tons in 2004 and 2010 respectively which translates to about 10% drop in production. Table 1.1 below illustrates the national rice production and consumption for the period 2004 to 2010.

TABLE 1.1: RICE PRODUCTION AND CONSUMPTION IN KENYA 2004-2010

Year		**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Area (ha)		13,322	15,940	23,106	16,457	16,734	21,829	20,181
Production								
	50 Kg bags	985,801	1,158,829	1,296,811	954,118	437,628	844,036	889,357
	Tons	49,290	57,942	64,840	47,256	21,881	42,202	44,467
Average Yield (bags/ha)		74.00	72.70	56.12	53	26.2	38.7	44
Consumption (tons)		270,200	279,800	286,000	293,722	210,000	410,000	410,000
Imports (tons)		223,190	228,206	196,000	203,000	202,000	398,000	398,000
Total Value (billion Kshs.)		1.30	0.90	4.5	2.5	3.3	-	3.33

Source: GoK 2011. *Economic Review of Agriculture*

The large deficit is therefore met through rice importation that heavily drains the badly needed foreign exchange. Food security is however not just a supply issue but also a function of income and purchasing power. The low purchasing power among many Kenyans therefore makes such imported food very expensive thus limiting its availability to the poor. This calls for low cost rice production techniques that will ensure better farm returns and adequate food supply to cater for the local demand.

The advancement in Agricultural biotechnology has enabled scientist to come up with a new rice variety commonly referred to as the New Rice for Africa (NERICA), which is seen as a big step in solving Africa's food crisis (Carl *et al.*, 2006). According to Food and Agriculture Organization (FAO, 2004), Agricultural Biotechnology refers to the application of scientific research tools to understand and manipulate the genetic makeup of organisms for use in agriculture. This study adopts the definition of biotechnology as the latest scientific tool for developing new crop varieties which can help to improve agricultural productivity by reducing production costs and enhancing yields.

There are a number of such tools that are being used to improve agricultural productivity in many parts of the world with the common ones being genetic engineering, embryo rescue, and tissue culture. NERICA rice was developed by the use of embryo rescue which involved crossing two species of rice; the African rice *oryza glaberrima* with the Asian rice *oryza sativa*. Generally, it is a cross between an ancient hardy African rice species and a high yielding Asian species. Being of different species the resultant embryo would not have survived naturally, hence the need to 'rescue' the embryo by culturing it in a suitable medium that allowed its development to a viable plant. The motivation behind development of NERICA rice was to come up with a type of rice that could do well under African socio-economic and agro-ecological conditions of inadequate farm inputs, frequent droughts and numerous diseases and pest.

Some of the already proven characteristics of NERICA rice include better response to fertilizer, tolerance to low moisture stress and higher protein content (Jones, 2006). Many countries including Ivory Coast, Benin, Nigeria and more recently Uganda have fully embraced NERICA rice for both income generation and household food production with reports thus far indicating impressive performance of the new rice (Atera *et al*., 2011). KARI in collaboration with Japanese International Cooperation Agency (JICA) and the SACRED Africa has been undertaking field trials for the crop in various parts of the country including Bungoma, Teso, Mwea, Nyando and Busia with impressive results being recorded. The yield show an average of 3.5 tons per ha in the neighbouring Uganda compared to the 2.8 tons per ha registered in 2006 for the conventional rice in Kenya (Otsuka *et al*., 2006). Successful release of NERICA rice to the public is eagerly awaited but being a relatively new technology, farmers may first need some reliable information on the economic superiority of the crop before they change from their traditional rice.

1.2 Problem Statement

About 67.1% of the population in Nyando consists of small scale farmers “stuck” on traditional farming methods that earn them a gross monthly income of less than KSh 2500, (Hellen *et al*., 2010). Going by the prevailing rates of more than KSh 85 per US dollar, 67.1% of Nyando farmers are below the World Bank poverty line of US$ 1 per day. Some of the crops commonly grown from which Nyando farmers generate their income include conventional rice, maize and sorghum.

The frequent harsh weather conditions such as floods and droughts, high incidences of crop pests and diseases as well as land degradation are overwhelming the prevailing farming systems hence worsening the already low agricultural productivity and poverty among Nyando farmers. Low productivity especially in crops such as rice has lead to massive rice importations, thus depleting the scarce foreign exchange which would otherwise be used to import say machinery that could spark the countries industrialization and poverty reduction. The government has in the recent past responded to the need to increase rice production and improve fight poverty in the rice producing areas by reviving rice producing irrigation schemes including West Kano and Bunyala. This has however not alleviate the problem as poverty is still high and domestic demand rice is yet to be met with the country importing about 90% of the rice consumed in the year 2010, (GoK, 2011).

According to Carl et al., (2006), Africa's poverty and food insecurity can be addressed by embracing Agricultural biotechnology in cereal crops. There is however, very limited information on the economic superiority of the various agricultural biotechnologies over the type of farming presently practiced in Nyando District. Without adequate information on how the new agricultural biotechnology could positively impact on their incomes, farmers would have no motivation to change hence will continue engaging in their traditional practices. This study therefore was to determine the potential impact of NERICA on farm incomes given the profitability of the current farming systems and the prevailing opportunities and constraints. Information obtained will go a long way in guiding Nyando farmers to make informed farming choices that could increase farm incomes and alleviate poverty in the District.

1.3 purpose and Objectives

The purpose of this study is to evaluate the potential impact of *NERICA* rice on farm incomes of smallholder farmers in Nyando District in Kenya.

The specific objectives are:

1. To identify opportunities and/or constraints facing farmers in Nyando district
2. To evaluate the profitability of the maize, sorghum, conventional rice and NERICA
3. To assess the competitiveness of NERICA rice in comparison to maize, sorghum and conventional rice enterprises given the prevailing resource constraints.
4. To evaluate the potential impact of NERICA rice on farm incomes in Nyando District.

1.4 Hypothesis tested

The following hypothesis was tested:

1. There is no difference in gross margins among the four crop enterprises comprising maize, sorghum, conventional rice and NERICA
2. NERICA will have no impact on farm incomes among rice farmers in Nyando District

1.5 Research Question

1. What opportunities and/or Constraints face rice farmers in Nyando District?
2. Is NERICA more competitive than conventional rice, maize and sorghum?

1.6 Justification of the Study

This study established the comparative economic position NERICA relative to the common crops and the potential impact of introducing it (NERICA) into the prevailing farming systems. The information obtained is important in guiding choice of enterprises and resource allocation not only among Nyando farmers but for government, extension agencies and researchers alike. Data on constraints will help in focusing development efforts on key issues that limit the ability of the people of Nyando to increase farm incomes and reduce poverty. The information on profitability and competitiveness of the various enterprises will on the other hand help farmers choose which crops to produce and how much of each in any one given season.

With the right attention to prevailing constraints and opportunities, farmers in Nyando will unlock their agricultural productivity potential, earn more income and reduce poverty. In so doing, more rice will be available for domestic consumption hence reduce or eliminate the high rice importation bills that deplete the country's foreign exchange. Availing more affordable rice will also make food more accessible to poor households hence improved food security. The importance of this study cannot therefore be overemphasized.

1.7 Organization of the Thesis

The rest of the thesis is organized as follows: Chapter 2 covers literature review of the recent work done in this research area as well as theoretical premises on which the study is based. By comparing the various methods previously used, the chapter further highlights the appropriate research approaches that should be used in filling some of the existing knowledge gaps. Chapter 3 provides the methodology used for this research by providing the conceptual framework, the empirical models, area of study and the data collection procedures. Chapter 4 presents and discusses the results of the study. Costs, revenue and gross margins expected from the four crops are compared with intentions of choosing the most profitable combination of crops. A number of computer based statistical approaches such as descriptive statistics and Linear programming are used and the results thereof explained. Chapter 5 gives the summary and conclusions made from the results of the study. The chapter in essence makes conclusions on the hypotheses tested and gives answers to the research questions posed in the first chapter of the this thesis. Chapter 6 provides recommendations aimed at making agriculture more profitable by suggesting the most appropriate farming systems in terms of which crops should be grown and how. The chapter also recommends remedial steps against other constraints such as low levels of awareness and limited credit facilities. The last section covers References and Appendices respectively.

CHAPTER 2

LITERATURE REVIEW

2.1 Agricultural Research and Poverty reduction in rural areas

Majority of the population in Africa are poor small holder farmers living and farming in unfavorable agricultural zones such as arid and semi arid areas, (Christin et al., 2012). The call for more support to agriculture in most countries in the sub-Saharan region is therefore warranted. This is so because farming is the main source of livelihood to majority of the population and supporting it will mean supporting majority of the citizens. In fact, a World Bank report (2008) indicates that growth in agriculture is vital for stimulating growth in other sectors of the economy.

Norton (2004) supports “the agriculture for development” argument by indicating that unlike manufacturing which is found to reduce poverty only in urban areas, an improvement in agricultural productivity reduces poverty in both rural and urban areas. The study also points out that increased agricultural growth was not only important in reducing rural poverty, but that it is in fact, more effective than industrial growth in reducing urban poverty. One way of increasing agricultural growth and farm incomes is by adoption of superior technologies (Prakash et al., 2009). It is therefore important for agriculture based countries to invest in research aimed at delivering superior agricultural technologies in order to enhance income generation and reduce poverty.

2.2 Constraints affecting smallholder farmers' ability to benefit from new technologies

Though agricultural research has benefited farmers and consumers in many regions of the world, Bellon (2006), noted that many poor farmers in developing countries have not shared in the benefits. According to Bellon, one of the reasons for poor farmers missing out on research benefits is their location in difficult environment characterized by unreliable rainfall, poor soils, heterogeneous topography, and lack or poor infrastructural facilities such as bad roads, limited credit facilities and lack of irrigation facilities. In addition, Aina (2007) identified lack of adequate information on the available superior technologies as one of the reasons why poor farmers usually miss out on the benefits of research. Where the new and superior technologies are comparatively more expensive than the existing less productive technologies, lack of reliable produce markets can also be a discouraging factor to adoption (GoK, 2007).

It is therefore clear from the foregoing discussion that although technological change is beneficial to farmers, there are some underlying constraints which should be addressed if small scale farmers are to benefit from such technological advancements. The superiority of each technology should therefore be assessed against the prevailing farm level opportunities and constraints. In summary, the prevailing socio-economic circumstances should be taken into account.

2.3 Agricultural Biotechnology: Is it innovative enough for Smallholder Farmers?

Modern agricultural biotechnology, which F.A.O (2004) defines as "a range of different molecular technologies such as gene manipulation and gene transfer, DNA typing and cloning of plants and animal" is being critically evaluated and advocated as a tool to make crop research benefit poor farmers in marginal areas (Mauricio 2006). As mentioned earlier, small holder farmers have unique constraints that require really innovative technologies to overcome. In general terms, Dillen et al., (2008) defined an innovative technology as a marketable good which allows farmers to surmount an agricultural problem. The question that has persisted on many peoples' mind therefore is whether biotechnology is innovative enough to handle these unique smallholder farmer's constraints.

According to Gómez-Barbero (2006), farm-level profitability of biotechnology crops is a function of some key variables such as:

• Differences in yield (Bt crops are expected to reduce yield losses attributed to pests);

• Reductions in insecticide costs (some Bt crops are expected to reduce insecticide use);

• Reductions in weed management costs (HT crops are expected to save costs through simpler and more flexible weed management regimes based on a single or few herbicides);

• Differences in seed prices (GM seeds are more expensive than conventional counterparts);

Given that biotechnology has the potential to affect both the cost and output components of the production equation, farmers and policymakers alike need to understand the net effect of biotechnology adoption. In particular, it is crucial to determine whether biotechnology is innovative enough to surmount production constraints and deliver higher net returns to smallholder farmers. In search for an answer, several studies have been undertaken, both in developing and developed countries and among small and large scale farmers. Bayer *et al*., (2008) show that modern agricultural biotechnologies, including Genetically Modified (GM) crops, have demonstrated high potential to provide significant benefits for developing countries. Such potential has been observed in China and India where most of the Bt cotton production is by small-scale farmers. Impact studies in these countries have shown that farmers benefit significantly from adopting the Bt. technology especially in terms of reductions in pesticide use and higher effective yields. On average, Bt adopting farmers were found to realize pesticide reductions of about 40%, and yield advantages of 30-40%, while profit gains were estimated to be US $60 per acre (Crost et al. 2007). Where nationwide benefits of biotechnology adoption are to be evaluated, the extent of benefits may sometimes be affected by the importance of the crop to the farmers and the level of adoption. This was observed by Demont et al., (2006) that reported welfare gains of between 0.8 and 16 million Euros in Hungary among three crops namely transgenic maize, Sugar beet and Oil seed rape. Adoption of biotechnology in a crop that is more important in terms of size of production was found to give more welfare gains to the nation than its counterpart which is grown on a lesser scale. Falck-Zepeda et al. (2000) did an early attempt to estimate the economic surplus generated by HT soybean the year after its introduction in the US (1997). A two-region model was used (US and Rest of the World) to estimate economic surplus generated for the 1997 season. Data source was limited to a small area representing about 15% of the total US soybean production. Total world surplus varies between e884 million and e364 million, depending on the assumptions used for US supply elasticity. In all cases, US farmers adopting the HT technology captured the highest share of total welfare created (76% of Euros 884 million and 29% of Euros 364 million). Though rice is rapidly gaining popularity in the whole of East Africa, government's statistics indicate that maize is still the most important crop in Kenya (G.o.K. 2007). Given the importance of maize, KARI has been conducting trials on Bt maize in collaboration with the International Maze and Wheat Improvement Center (CIMMYT). Trial data show that by adopting the insect resistant Bt maize, Kenya stands to gain economic surplus of $ 208 million over 25 years against a cost of $ 6.76 (De Groote et al., 2003). In addition to the direct economic benefits, there are also environmental benefits that biotechnology has potential to deliver. Increased adoption of genetically engineered crops has shown a significant effect in reducing the effective amount of pounds of herbicides applied in corn and soybean fields, (Alexandre et al., 2008).

There are however, other cases where the same biotechnology application has shown different results under small and large scale farming conditions. Taking the adoption of Herbicide tolerant soybeans for example, Fernandez-Cornejo et al. (2002) did not find statistically significant differences in profits between genetically modified and conventional soybean farmers in the US. It was however observed that adopting the HT soybean increased farmers' profitability by an average of 19 Euros per hectare in Argentina, representing an increase of 8.5% over the gross margin obtained by conventional soybean farmers. It also emerged that the increase in gross margin was higher for the group of smaller farmers than for larger farms in Argentina (Qaim et al., 2005). This may be due to higher efficiency among smallholder farmers.

Despite the apparent potential benefits, there are concerns with respect to the sustainability of such benefits over time. It is feared, for example that pest populations might eventually become resistant to Bt., especially when refuge strategies are not enforced, as is often the case in smallholder agriculture. Moreover, secondary pests that are not controlled by Bt. might turn into primary pests (Wang et al., 2006). Both factors could potentially entail diminishing pesticide savings and yield advantages over time. In addition, given that most GM crops so far have been commercialized by private sector multinationals, there are fears that monopolistic market structures might increasingly prevail. This could lead to excessive prices being charged for biotechnologically produced seeds, resulting in lower farm profits and restricted technology access, especially for resource-poor farmers (Lalitha, 2004). Related to the power of multinationals is the question of distributional equity. Concerns have been raised regarding distribution of benefits arising from adoption of Biotechnology. The question of distributional equity is especially important now days since wealth distribution is becoming an important measure of economic development in any society. Many opponents of biotechnology have argued that multinational seed companies will take all, if not most of the benefits arising from biotechnology. They argue that biotechnology companies will use their monopolistic powers to price products in a way that makes the cost of crop production high thereby lowering farm profits as well as raising food prices. Such a scenario would injure both farmers and consumers economically. But empirical evidence such as Demont et al (2006) revealed that 52 to 70% of these benefits go to farmers and consumers while the rest go to the seed companies.

Most of the studies on the impact of biotechnology indicate more benefits than cost. There are however, some concerns that are difficult to measure, for example some people have raised questions regarding the ethical correctness in modifying the God created organisms. Such may not be exhaustively handled since they are beyond the scope of this study.

2.4 Assessing the Impact of Biotechnology among Small scale Farmers:

Given that a particular technology may have different impact on different communities depending on the unique socio-economic conditions facing the community in questions. There for the conclusions made about the impact of Biotechnology are highly dependent on the methods used (Sydorovych et al., 2007). Whereas some studies that have focused on the environmental impacts (both negative and positive), some have restricted themselves on the measurable monetary benefits. In Kenya for example, De Groote et al, (2003) used the economic surplus approach to estimate the potential benefits of adopting Bt. Maize in Kenya. His choice of maize was well informed since it is one of the very important crops in the country. By using the economic surplus, De Groote was able to estimate how much the country as a whole stands to gain by adopting the Bt. maize. Policy makers at national level would find such information important for developing nationwide strategies but for farmers, the most important unit of analysis is his or her farm business. Given the increasing demand for bottom- up approaches to technology development and adoption, the economic surplus model, which does not give farmers specific information may not be the most appropriate.

In appreciation of the fact that biotechnology may have both marketable and non marketable impacts, Scatasta et al., (2004) combined ecological and economic models to assess the sustainability of both GMO and non GMO farming taking into account the economic and environmental aspects. Scatasta' study however does not put any figures to the expected welfare change. It only described the various crop farming systems as being preferable, acceptable, regular, poor and unacceptable. In order to develop a more convincing case for or against biotechnology, it is important that stakeholders be informed of the likely quantitative gains or losses associated with the new technology. This is particularly important in biotechnology since farmers are already using conventional technologies for which they know the value of benefits. They therefore need figures expected from biotechnology to be compared with the current farming practices in order to make informed choices.

IFPRI (2000) applied Net present value techniques to in its comparison of costs and benefits of research. Though this takes into account the time value of money, it may not appropriately apply to a situation where individual farmers did not directly contribute resources towards research fund. Furthermore, rate of return may not be easily understood by the common farmer or policy maker with little or no knowledge in economics. According to Smale et al (2007), some fundamental aspects that should be tested in economic impact evaluation include changes in yield, amounts and costs of inputs and profits. In estimating the impact of research on poverty reduction in Malawi, Alwang' et al., (2003) estimated the potential change in farm incomes due to technological change. A farm income model was applied in which change in incomes were decomposed as coming from cost reduction, yield increment, and price change, essentially capturing the parameters suggested by Smale. To a profit motivated small scale farmer, information regarding inputs costs, yield and profit dynamics is of essence.

Most of literature and government strategic plans have consistently identified resource limitations as a major obstacle in small scale farming. The resource limitation has often been worsened by the fact that most small scale farmers engage in multiple farming enterprises simultaneously. This has sometimes made farmers to allocate too little resources to each enterprise, there by loosing on economies of scale and suffering loses. It is therefore crucial that impact assessment tools be tailored to capture this twin condition of resource limitation and multiplicity of farming enterprises. In most cases, farmers and policy makers need know the most profitable way to allocate the scarce resources.

Kalentiz et al., (2003) used linear programming to determine the most profitable resource allocation in broiler enterprises in Greece while Kearnev (1994) used the same approach for pip fruit orchard. The two studies, just like many other resource allocation studies looked at how much profit will be realized if resources are allocated as suggested from the results of the linear programming. The farmer/entrepreneur will however not only be interested in total net profit, but in change in such net profit on changing from one enterprise mix to the other as well. Where we already have some form of farming system and enterprises in place, and a new enterprise has potential of being introduced, it is important that a linear programming analysis is done on the existing enterprise to establish what their total profit would be under optimal resource allocation before being compared to what would be new profit with introduction of the new enterprise.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 The Conceptual Framework:

The study conceptualized farmers as consumers of agricultural technology with the objective of maximizing farm incomes by reducing costs of production, increasing yields and improving quality of their product. As farm income maximizers, farmers are expected, to choose the alternative technology that gives them highest farm income. The effective adoption of a new technology is further conceptualized as a behavioral response where farmers rationally evaluate and chose different technologies based on the production inputs at their disposal. In so doing, farmers also put into consideration the prevailing socio-economic and agro-ecological conditions (constraints and opportunities). This study assumed that farmers put the following prevailing conditions into consideration:

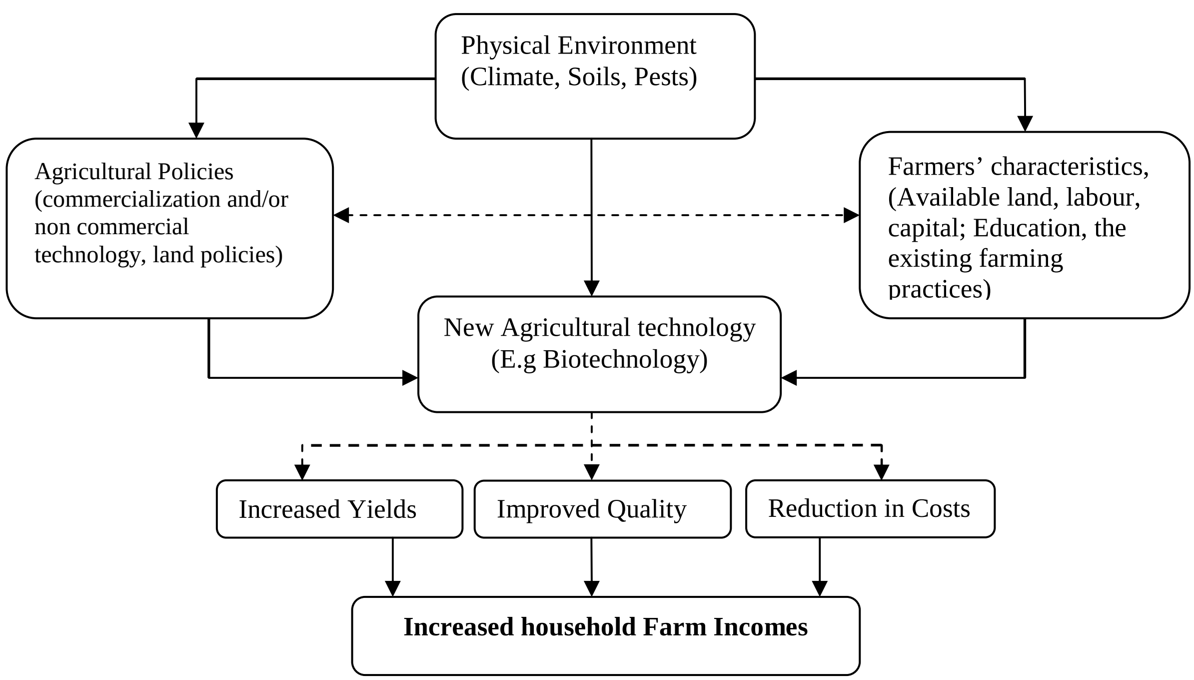
- The agro-climatic requirements,
- Input requirements,
- Market potential
- Government policies and regulatory framework.
- The available farm level resources (land, labour capital).

In this case, agro-climate encompasses soil type, water requirements, temperature, humidity and pests and disease levels. For the purpose of this study, a given piece of land only qualified as being available, if it met the agro-climatic requirement of the new technology (which in this case is NERICA) and/or the existing farming practices (Maize, Sorghum and Conventional rice). Government policies and regulatory frame work is relevant due to the controversies surrounding biotechnology. Important here is whether the particular type of biotechnology under study has been allowed for commercialization or not.

After considering the prevailing conditions, a new technology is then assessed against the existing practices to determine whether it is actually superior. In case there is potential for positive change in farm income, farmers respond to the availability of such superior technology by allocating more resources to it. This means changes both in the total farm income and the relative contribution of the various enterprises to the total farm income.

This interaction is illustrated in the figure below.

FIG 3.1: CONCEPTUAL FRAMEWORK



3.2.0 Empirical Models:

From literature, it was clear that farmers are particularly concerned with input costs, yields and profits. But to capture this, researchers must take into consideration some salient features such as resource constraints and the fact that farmers engage in multiple enterprises at any one given time. In order to incorporate the two requirements, this study used two models, namely the Farm profit model and the linear programming model.

3.2.1 Farm profit model:

The study used the profit function as suggested by Chiang (1984). The model was used to estimate farm incomes (economic benefits) associated with maize, sorghum, and rice. The profit model has revenue, costs and gross margin as its components. Revenue and costs are the independent variables while gross margin forms the dependent variable. Both revenue and costs are functions of total output (Q) as indicated below:

R = R(Q) ……………………… Total Revenue function …………………… (1)

C = C(Q) …………………….... Total Cost function ……………………….. (2)

Profit is estimated as the excess of revenues over costs, thus:

Profit (π) = R(Q) – C(Q). ……………………………………………………..

(3)

The profit given the expression in equation 3 is the excess of total revenue over total costs for one enterprise. This is a general form that is applicable to all sectors whether farming or not. For farming activities involving changes in acreage and yields in more than one farming enterprise, Alwang' (2003) specified the particular components forming both revenues and costs shown with the following expression:

$$\boldsymbol{\pi_i} = A_iY_iP - A_iC_i \quad \ldots\ldots\ldots\ldots (4)$$

Where $\boldsymbol{\pi_i}$ is profit (gross margin) from the ith farm enterprise, $\boldsymbol{A_i}$ is acreage allocated to the ith enterprise, $\boldsymbol{Y_i}$ is yields per acre of the ith enterprise, $\boldsymbol{P_i}$ *is* the per-unit price of the ith enterprise, and $\mathbf{C_i}$ is the per-acre costs of production. A_iY_iP therefore represents the total revenue component while A_iC_i captures the total cost component of the profit function. The Total profit from all the considered enterprises may therefore be expressed as:

$$\boldsymbol{\pi_T} = \sum_{i=1}^{i=n} A_iY_iP - A_iC_i$$

For most farmers, it is difficult to precisely determine all the specific costs incurred from agronomy to marketing. This is because small scale farmers tend to combine farm business activities with nonfarm activities. To exclude the nonfarm activities and related cost from the direct farm activities, the total cost function described in equation (2) above only considered the direct costs associated with production up to farm gate level. The revenue on the other hand was arrived at by determining the product of output and farm gate price (output * farm gate price). The implication is that the study focused on gross margin rather than the net profit. The difference between the two is that whereas net profit considers both the direct and indirect costs, the gross margin only considers the direct costs incidental to the production process. Thus:

Gross Margin **(π_G)** = R(Q) – C_F(Q), where C_F(Q) is the total cost up to farm gate.

The profit function as presented above is limited in the sense that it does not capture the resource constraints facing farmers. Farmers may not always have all the resources they need in order to maximize their farm incomes. Another weakness of the farm profit model is that it tends to determine the profitability of the various enterprises separately. Most farmers however engage in more than one farming enterprise simultaneously thereby distributing the limited resources among a number of enterprises. In order to determine the competitiveness of the various farm enterprises and the potential change in gross margins resulting from technological change and optimal resource allocation, it is important to capture the prevailing farming systems and the resource constraints facing farmers, thus the need to use linear programming.

3.2.2 Linear Programming:

Linear programming is a planning methodology used in optimization of an objective function given relationships of factors of production and their constraints (Loukakis, 1994). In the case of Nyando farmers, the study will use profit maximization as the objective function to be maximized, thus the need to estimate profit by use of the farm profit model. The Linear Programming model is required for purposes of simulating the comparative advantage of the various enterprises in situations where a resource constrained farmer is engaged in more than one enterprise.

For multiple enterprises, Kalentiz et al., (2003) suggests the linear programming algebraic expression of the form:

$$\text{Max. } C_1X_1+C_2X_2+\ldots\ldots+C_nX_n \qquad \text{(Objective function)}$$

s.t

$$\left.\begin{array}{l}
a_{11}x_1+a_{12}x_2 + \ldots + a_{1n}x_n = b_1 \\
a_{21}x^1+a_{22}x_2 + \ldots + a_{2n}x_n = b_1 \\
\ldots \ldots \quad \ldots\ldots \qquad \ldots\ldots \quad \ldots \\
\ldots \ldots \quad \ldots\ldots \qquad \ldots\ldots \quad \ldots \\
\ldots \ldots \quad \ldots\ldots \qquad \ldots\ldots \quad \ldots \\
a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n=b_m
\end{array}\right\} \qquad \text{(Constraints)}$$

$$x_1, x_2 \ldots x_n = 0 \qquad \text{(Non negativity requirement)}$$

The study will adopt the above expression by limiting the choice variables to maize, Sorghum, Conventional rice and NERICA rice. The objective function on the other hand has the profit estimated by gross margin ($\boldsymbol{\pi}_{\mathbf{GT}}$) as the component to be maximized. The problem is therefore specified as:

$$\text{Max. } \boldsymbol{\pi}_{\mathbf{GT}} = \boldsymbol{\pi}_{\mathbf{G}1}X_1 + \boldsymbol{\pi}_{\mathbf{G}2}X_2 + \boldsymbol{\pi}_{\mathbf{G}3}X_3 +\boldsymbol{\pi}_{\mathbf{G}4}X_4 \qquad \text{(Objective Function)}$$

s.t

$$L_1x_1+L_2x_2 + L_3x_3 + L_4x_4 \leq L_T \qquad \text{(Land constraint)}$$

$$K_1x_1+K_2x_2 + K_3x_3+ K_4x_4 \leq K \qquad \text{(Capital Constraint)}$$

$$X_1, X_2, X_3 \text{ and } X_4 \geq 0 \qquad \text{(Non-negativity constraint)}$$

Where:

$\boldsymbol{\pi}_{GT}$ is the sum of gross margins from the four enterprises while $\boldsymbol{\pi}_{G1}$, $\boldsymbol{\pi}_{G2}$, $\boldsymbol{\pi}_{G3}$ and $\boldsymbol{\pi}_{G4}$ represents the enterprise gross margins coefficients for maize, sorghum, conventional rice and NERICA respectively.

X_1, X_2, X_3 and X_4 represents the number of acres under Maize, Sorghum, Conventional rice and NERICA respectively.

L and K represent the units of land and capital respectively, required for one acre of an enterprise. One acre of each of the enterprises requires one acre of land. The L in the land constraint expression will therefore take the value of one (1) all through. The L may therefore be removed without changing the validity of the land constraint, but will be retained for purpose of consistence in the expression.

To determine the competitiveness of the four crop enterprises, the study used a linear programming analysis with all the four crops (maize, sorghum conventional rice and NERICA rice). The crop that contributes highest income is regarded as the most competitive given the resource constraints facing farmers.

To determine the potential change in farm incomes, the study estimated the amount of extra income expected after the introduction NERICA over and above what the farmer used to get from the three enterprises (maize, sorghum and conventional rice) before the introduction of NERICA. The resource base of the farmer was held constant in the two scenarios.

Assumptions of the linear programming model:

- Certainty: that the parameter values are known with ***certainty.***
- The objective function and constraints exhibit ***constant returns to scale.***
- Additivity: no interactions between the decision variables.
- The Continuity assumption: Variables can take on any value within a given feasible range.
- Multiplication assumption: that an activity can be added to or subtracted from the objective function without incurring start up or close down cost.

It is however important to note that it is difficult or even generally impossible to adhere to all the above assumptions in their strict sense given the dynamism of farming. The assumption of continuity however directly applies to smallholder farming since such farmers tend to subdivide their resources without adhering to any specific measure. A rice farmer may, for example, plant a fraction of an acre. He or she does not have to plant all units of acreage at his/her disposal.

3.3 Area of Study

The study was conducted in the former Nyando District (now part of Kisumu County) in Nyanza Province of Kenya. For the purpose of this study and there being no any new administrative boundaries created by the constitution that would accurately represent Nyando district as it were during the study, this thesis retained the former administrative boundaries hence continue to refer to the area of study as Nyando district. Nyando district was one of the 12 districts in Nyanza Province curved out of the Kisumu District in 1998 before the recent change to county governance. It borders Kisumu on the west, Nandi to the north, Kericho on the east and Rachuonyo to the south. The district has a small shore line on the west where it touches L. Victoria. It lies between longitude 34’4’ east and latitude 0^o23^o south and 0^o50^o south.

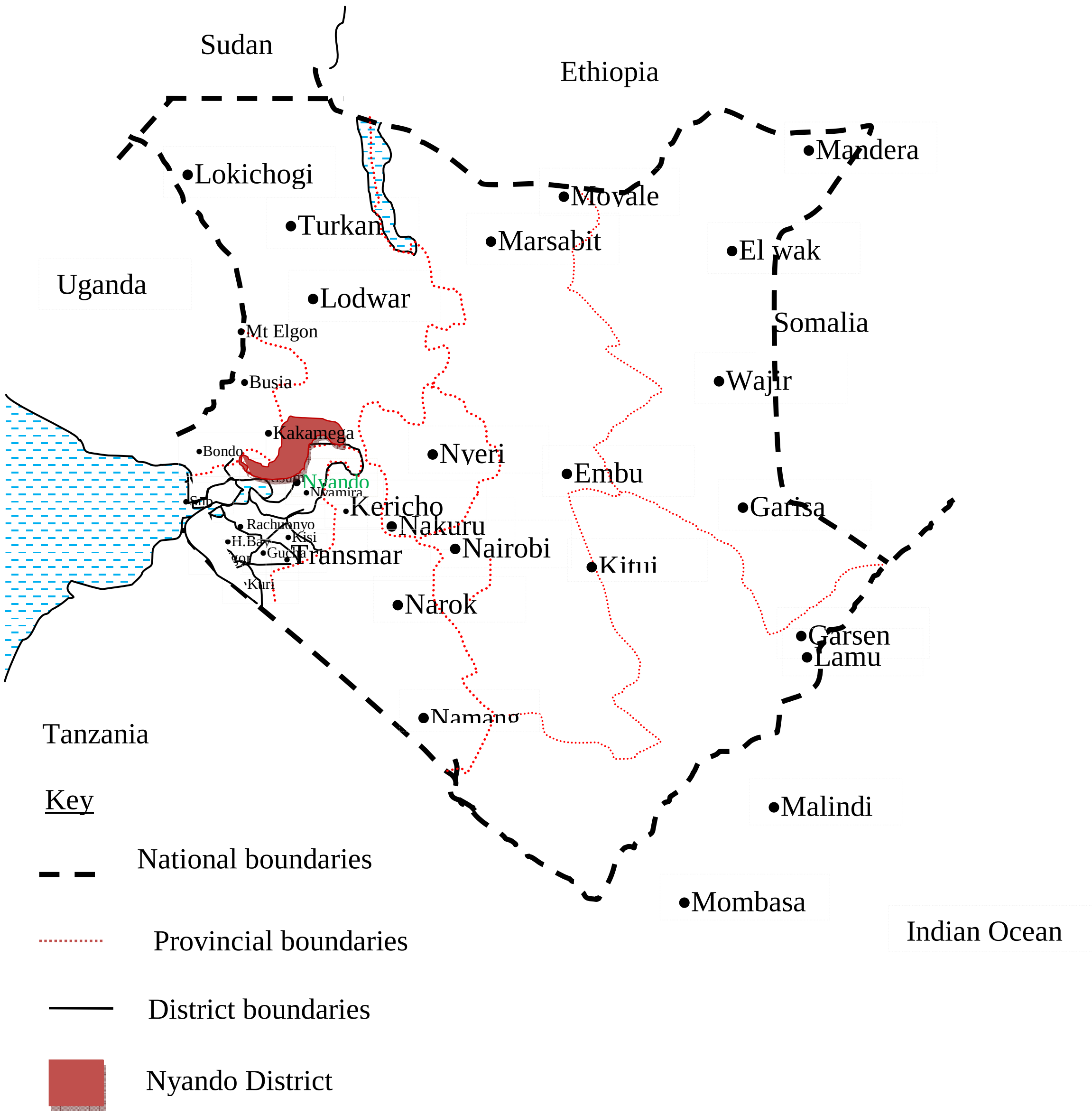
Nyando district has total land area of $1168.4km^2$ and divided into five administrative divisions namely Upper Nyakach, Lower Nyakach. Miwan, Muhoron and Nyando divisions.

TABLE 3.1: ADMINISTRATIVE DIVISIONS OF NYANDO DISTRICT

Division	**Area (km^2)**	**No. of Locations**	**No. of Sub-Locations**	**Pop. Density (2002) (No. of people per KM^2)**
Upper Nyakach	176	6	11	407
Lower Nyakach	182.6	8	17	299
Miwan	225.7	3	14	284
Muhoron	334.8	6	17	210
Nyando	249.3	6	17	287
Total	**1,168.4**	**29**	**76**	**284.6 (average)**

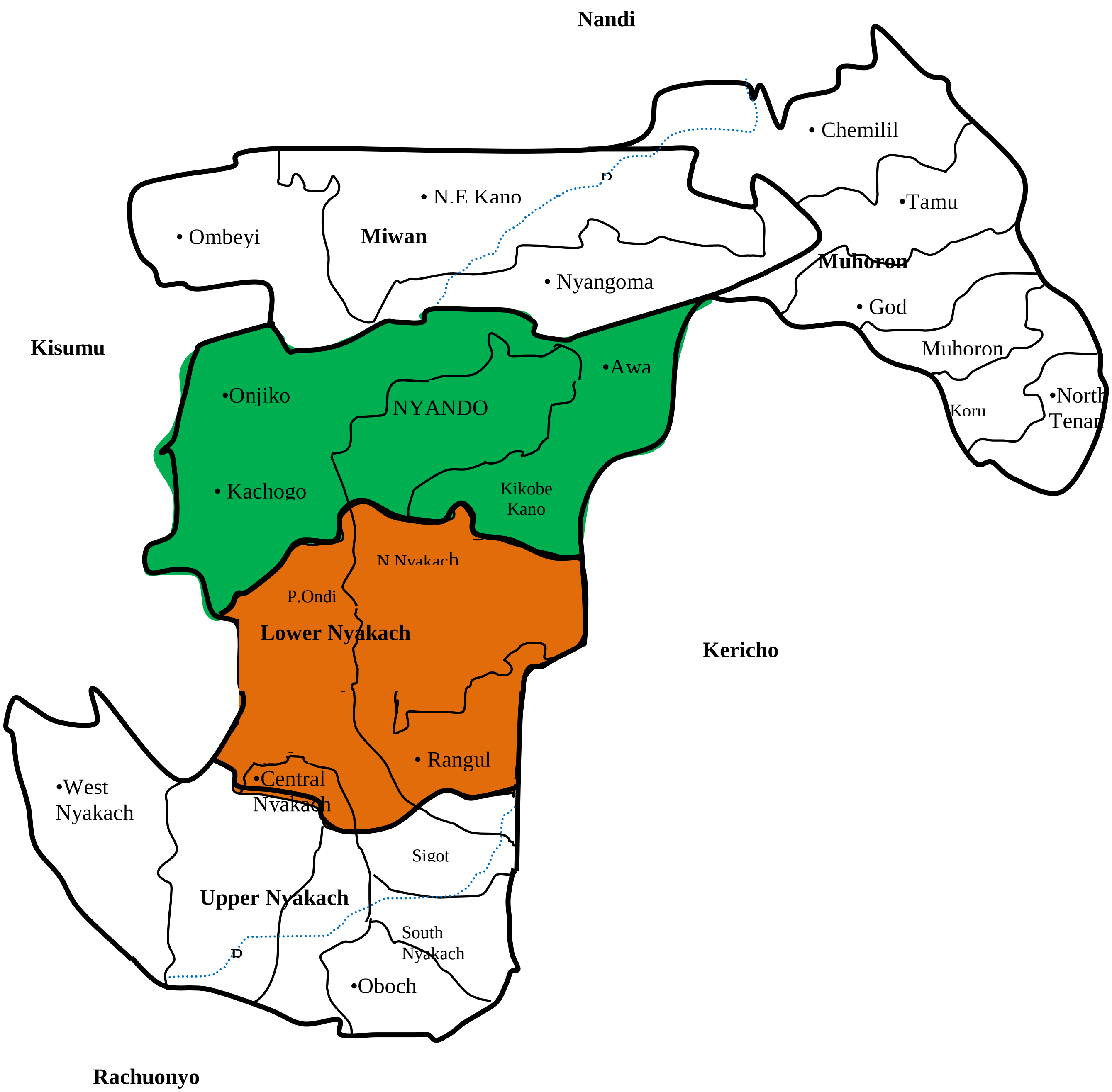
Source: Republic of Kenya, Nyando District Development Plan (2002-2008).

FIG 3.2: MAP OF KENYA SHOWING NYANDO DISTRICT



Source: GoK, Nyando District Plan, 2006

MAP OF NYANDO DISTRICT



Source: GoK, Nyando District Plan, 2006

The district lies in the Eastern part of the large low land surrounding the Nyanza gulf, much of it in the Kano plains. It can be divided into three main topographical land formations namely the Nandi hills, the Nyabondo plateau and the Kano plains. The Kano plains comprise predominantly black cotton clay soils of moderate fertility and poor drainage with the rest of the district having sandy clay loam soils derived from igneous rocks.

The altitude ranges from 1800m *A.S.L* in Nyabondo plateau to 1100m *A.S.L* along the Kano plains experiencing bimodal rains with long rains coming between March and May while short rains come between September and November. The mean annual rainfall for the district ranges between 600mm to 1630mm while temperatures range between 20^{o} to 35^{o}c.

The district has two major rivers namely Sondu Miriu and Nyando Rivers. A smaller river, Awach also forms part of the source of water in the district. Nyando River drains from the Nandi hills where relatively high rains are received to Lake Victoria through Kano plains where it is a major cause of persistent flooding. The Awach River is another source of floods in the area though under normal circumstances, the two rivers provide water for rice growing by irrigation.

The climate and soils in the district are suitable for sugar cane growing especially in Muhoron and Miwan while the swamps along rivers Nyando and Awach in Miwan, Nyando and Lower Nyakach are suitable for irrigated rice farming. Kano plains are however suitable for cotton growing while the higher altitude Nandi hills are good for coffee and dairy farming.

According to the GoK, Nyando district plan, the district has approximately 68,400 households with average household size of 4.4 and farm sizes of between 2ha and 10ha. The district still has over 27,550 ha of uncultivated land available for agricultural expansion with 7,400ha having potential for small holder irrigation. Although Nyando has an apparently high potential for income generation through farming, absolute poverty in the area is still very high at 68.9%, (GOK, 2006).

The main food crops for the district are maize, cassava, sorghum and sweet potatoes while main cash crops are rice, sugarcane, cotton and coffee. Due to the importance of food, it is very rare to find a farmer who only concentrates on cash crops without any food crop. Maize is usually mixed with sorghum before being milled into flour for domestic consumption, thus the need to have the two food crops in the analysis.

Because of the suitable agro-climatic conditions and the knowledge of the local people in rice farming, the district is suitable for growing NERICA rice. Given that conventional rice is already being grown in the area, introduction of NERICA rice is likely to be seen as an improvement on the current farming activities rather than a foreign technology being imposed on the local people. This is expected to boost acceptance and success of NERICA rice in Nyando district. Nyando district was chosen because of its long history of rice production and high Poverty levels.

3.4 Sources of Data

The study used primary data from three main sources namely Rice farmers, Lake Basin Development Authority and research Institutions. Each of these sources gave different types of data according to their areas of specialization and knowledge. A Summary of data types and sources is given in table 3.2 below.

TABLE 3.2: DATA TYPES AND SOURCES

Data Source□Data types□□ Data types□□ □ Farmers□1. Farming System□□□2. Common Constraints facing farmers□□□3. Farmers awareness about NERICA□□□4. Factors determining enterprise superiority□□ 1. Farming System□□□2. Common Constraints facing

farmers3. Farmers awareness about NERICA4. Factors determining enterprise superiority2. Common Constraints facing farmers3. Farmers awareness about NERICA4. Factors determining enterprise superiority2. Common Constraints facing farmers3. Farmers awareness about NERICA4. Factors determining enterprise superiority2. Common Constraints facing farmers3. Farmers awareness about NERICA4. Factors

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□5. Land availability□□
5. Land availability□□
□□6. Capital availability.□□
□6. Capital availability.□□
6. Capital availability.□□
□□7. Labour availability.□□
□7. Labour availability.□□
7. Labour availability.□□
□□8. Production Costs for the different crops. □□□9. Yield levels for different crops□□□10. Price levels for different crops□□
□8. Production Costs for the different crops. □□□9. Yield levels for different crops□□□10. Price levels for different crops□□
8. Production

Costs for the different crops. □□□9. Yield levels for different crops□□□10. Price levels for different crops□□

□□9. Yield levels for different crops□□□10. Price levels for different crops□□

□9. Yield levels for different crops□□□10. Price levels for different crops□□

9. Yield levels for different crops□□□10. Price levels for different crops□□

□□10. Price levels for different crops□□

□10. Price levels for different crops□□

10. Price levels for different

crops□□
□

KARI/LBDA□
11. NERICA production cost and yields□□□12. Suitability of NERICA in the region□□□13. Expected Gross margin from NERICA in the region□□
□□12. Suitability of NERICA in the region□□□13. Expected Gross margin from NERICA in the region□□
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region□□ □□13. Expected Gross margin from NERICA in the region□□ □13. Expected Gross margin from NERICA in the region□□ 13. Expected Gross margin from NERICA in the region□□

From the above data, it was possible to come up with information on the various enterprises practiced in the area, resource availability and profitability coefficients for the various key enterprises**.**

3.5 Sampling Procedure

Two administrative divisions were purposively selected with the objective of getting respondents whose major agricultural activity is rice farming. The study therefore focused on Nyando and Upper Nyakach Divisions. Lists of rice farmers in the two Divisions were obtained from the Divisional Agricultural office. The study used the two lists, one from each of the Divisions as the sampling frames. Systematic random sampling was applied to each of the lists to get the 80 respondents who were interviewed. It is worth noting here that of the 80 respondents, 31 were from Upper Nyakach while 49 were from Nyando Division. The inequality in respondents from the two Divisions was occasioned by the higher number of rice farmers in Nyando division list which had 149 farmers compared to the Upper Nyakach Division list of 94 farmers. Every third person was picked for interview. To get the experts' opinions, three researchers drawn from KARI, LBDA and the National Irrigation Board (Nyando, district) were interviewed separately.

3.6 Data Collection

The process of data collection started with pretesting of the structured questionnaire with the assistance of one of the research assistants recruited from the area of the study. The research assistant identified six farmers at Ahero shopping centre. Though the six farmers were on their off farm businesses, they volunteered and answered all the questions in the farmers' section of the questionnaire. Minor changes were then made on the questionnaire to make it more clear and precise. The research assistants were also advised on how best to pose the questions to farmers.

Data was then collected by use of structured questionnaires administered to 80 farmers. Semi-structured interviews with KARI, NIB and LBDA researchers were also conducted to get experts opinion and field trial data on costs and yields for NERICA rice. Given that NERICA rice was yet to be commercialized as at the time of study, the price of conventional rice was used as proxy for the expected NERICA price. This was guided by the opinion of the research experts who have been working on NERICA rice in the area.

In addition to the questionnaire and the semi structured interviews, direct observations and informal discussions with farmers also informed the research in identifying production constraints and opportunities. The study made some deviations from the conventions on the following fronts in data collection:

Labour availability: Contrary to the conventional use of man hours from the family as a proxy for the labour at the disposal of any given farmer, the study sought to consider the two important realities in the current labour market and especially among rice farmers in the area of study:

- *That most of the labour used in rice farming is hired*. Though most farmers are small scale with less than four acres, they tend to both hire in labour when it is time for attending to their farms and hire out their own labour once they are through with a particular activity in their own farms or as they await for their crop to reach a given stage that requires their attention.
- Just like is the case in the rest of the country, *labour is readily available for hire* and anybody willing and able to pay will almost certainly get the required amount of labour. Though most of the rice farming activities requires some skills and experience, such "semi-skilled" labour is available. This is so because rice has been grown in the area for years and most if not all rural based people have the necessary skills needed for say planting, weeding or harvesting.

Labour at the disposal of a given farmer was therefore arrived at by estimating the man hours provided by family members. Each adult and physically able family member was assumed to provide seven man hours per day and this applied to both male and female members. The services of school going children were assumed negligible due to holiday tuitions that took most of the holidays including weekends. Any extra labour used in the farm other than from family members was assumed to be hired. Given the Kenyan situation where labour is readily available for hire, it would be incorrect to take family labour as the total labour available. The study therefore found it more appropriate to "monetize" both the available family labour and the enterprise labour requirements. Labour was therefore treated as any other non land expense. To take care of the available family labour, such labour was valued and added to capital at the disposal of the farmer.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents results obtained from analysis of the various types of data collected from the field. The chapter further discusses the reasons behind the observed results both from a theoretical view and as supported by additional evidence/observations from the field. The first sub section covers profitability of the four major farming enterprises. The second sub section presents and discusses competitiveness of the various four crops. The section first determines the different resources at the disposal of the farmers for investment in the four crops followed by linear programming which incorporates gross margins and resource constraints into the analysis to determine competitiveness. This is followed by the production costs of the various enterprises. The last subsection covers the Enterprise revenues and gross margins before presenting the linear programming results.

4.1.0: Relative Profitability of Maize, Sorghum, Conventional rice and NERICA

4.1.1 Production Costs, Revenues and Gross margins

In determining farm income, it is important that all costs incurred be taken into account. It was however difficult to determine some of the costs with certainty since some were unique and specific to individual farmers. To reduce the influence of the indirect costs which may not be fully related to the farming activities, the study concentrated on direct costs generally incurred by most if not all the producers. These are cost directly attributable to the production process at farm level. As far as marketing costs are concerned, it was found that most farmers sell the produce at farm gate to the brokers. Such brokers then proceed to either add value through processing (milling) or sell as is to other markets or millers. Some farmers however sell part of their produce at farm gate while part is sold at the nearby markets, thus incurring additional cost such as transportation and market levies. The additional marketing costs in turn attract a better price for the produce. To standardize measurement of returns to farmers from each of the three enterprises, the study considered only the direct cost incurred up to farm gate. Farm gate prices were therefore used in the computation of revenues.

4.1.1.1 Production Costs of Conventional Rice

Nyando district is the biggest producer of rice in Western Kenya. Many farmers in this area regard rice as a cash crop and their biggest income earner. In the production of rice, a number of activities contribute to the cost of production as summarized in table 4.01 below:

TABLE 4.01: DESCRIPTIVE STATISTICS OF THE CONVENTIONAL RICE PRODUCTION COSTS

Descriptive Statistics

	N	Minimum	Maximum	**Mean**	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	**Statistic**	Statistic	Statistic	Std. Error
Crop Acreage	80	.50	5.00	**2.3062**	1.1258	.410	.269
Ploughing	80	3500.00	7000.00	**4918.7500**	758.7621	.608	.269
Seeds	80	800.00	1600.00	**1169.9375**	169.9227	.525	.269
Fertilizer	80	2000.00	4000.00	**3176.2500**	359.4101	-.166	.269
Pesticides	80	240.00	400.00	**296.8750**	34.4429	.720	.269
Nursery Prep	80	150.00	450.00	**278.5000**	70.1012	.532	.269
Irrigation	80	2000.00	3600.00	**3042.5000**	412.0879	-.585	.269
Transplanting	80	1000.00	3500.00	**2073.7500**	789.5671	.090	.269
Weeding	80	1000.00	4000.00	**2372.5000**	885.8915	.014	.269
Bird_Scaring	80	500.00	3000.00	**1687.5000**	594.7822	.522	.269
harvesting	80	2000.00	3500.00	**2857.5000**	368.2923	-.159	.269
Total P.A Cost	80	17050.00	27050.00	**(21874.06)**	2013.8656	.109	.269

TABLE 4.02: CONVENTIONAL RICE COST ITEMS BY PERCENTAGE

Expense	**Percentage (%)**
Ploughing	22
Seeds	5
Fertilizer	15
Pesticides (Bulldock)	1
Nursery Preparation	1
Irrigation	14
Planting	9
Weeding	11
Bird Scaring	8
Harvesting	13

Source: Field data

From the results, ploughing is the most costly rice production expense. Ploughing is mainly done by hired tractors but a few farmers use ox-ploughs. According to farmers, the cost of hiring a tractor is partly determined by the accessibility of the farm relative to nearest road. For better results, ploughing is usually followed by harrowing at a total cost averaging to Ksh 4918. The heavy and sometimes water logged soils make ploughing / rotavation a fairly difficulty activity, thus the farmers' preference of tractors over ox-ploughs. Second in cost was found to be fertilizer followed by Irrigation, harvesting, weeding, planting, bird scaring and seeds in that order. Pesticides and nursery preparation are the least in cost. Fertilizer is mainly bought from retailers either in 50Kg bags or two kg tins for farmers who do not need or cannot afford the 50kg bag. Planting is done by hand and as pointed out by the National Irrigation Board officer, one acre may be planted by approximately 13 people for one day. Like planting, weeding is the other demanding exercise also done by hand. This basically involves uprooting the weeds by hand because use of any sharp farm implements like a hoe would damage the closely grown grassy-like stems of rice. Harvesting on the other hand involves three basic steps; cutting of the rice stems, stacking the cut stems and beating/shaking such stems to separate grains from the rest of the biomass. Unshelled rice is obtained which is then dried and sold to brokers. Farmers are also free to take the unshelled rice for milling which is done at the rate of KSh 2.00 per kg. Many farmers however do not take that option since there is a ready market for their unshelled rice. Though less strenuous compared to weeding, harvesting is more expensive due to the many processes involved.

4.1.1.2 Production Costs of Maize:

Going by the amount of resource allocated to the various crop enterprises, maize is the second in importance in the area. It is mainly used for food but sometimes sold as an alternative source of income. Below is a tabular presentation of the various costs involved in maize production.

TABLE 4.03: DESCRIPTIVE STATISTICS OF MAIZE PRODUCTION COST

	N	Range	Minimum	Maximum	Mean	Std. Dev.	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
CROP_ACR	80	2.75	.25	3.00	1.4563	.6460	.586	.269
PLOUGHIN	80	3200.00	400.00	3600.00	2746.2500	861.2537	-.946	.269
SEEDS	80	580.00	120.00	700.00	414.7500	137.2974	-.495	.269
FERTILIZ	80	3500.00	.00	3500.00	1634.7500	770.3492	-.178	.269
PLANTING	80	1400.00	600.00	2000.00	1077.5000	281.9350	.635	.269
WEEDING	80	1240.00	560.00	1800.00	1173.2500	305.2775	-.018	.269
HARVESTI	80	1600.00	400.00	2000.00	967.1250	334.3847	.569	.269
T.C.P.A	80	6600.00	4540.00	11140.00	8013.6250	1426.8007	-.420	.269
Valid N (listwise)	80							

Unlike rice, maize has fewer expenses since a number of activities such as irrigation, nursery preparation and bird scaring are not necessary. Results in table 4.03 above however show that just like in the case of rice, ploughing had the highest contribution to production costs. This is despite the fact that most maize farmers plough only once and do not practice harrowing. The other similarity between maize and rice is that fertilizer came second in contributing to production costs. Other costs were weeding, planting and harvesting. As can be noted, weeding was the fifth most expensive activity in rice production while the same takes third position in maize. The actual monetary cost of weeding rice is however about twice that of weeding an acre of maize. This is because of the difference in the manner in which the two crops are weeded. Whereas rice weeding involves hand-picking of the weeds, a hoe is used in weeding maize. This makes weeding maize faster and less strenuous compared to weeding rice, thus the lower cost of weeding the former.

Table 4.04 below shows percentage shares taken by the various expenses mentioned above.

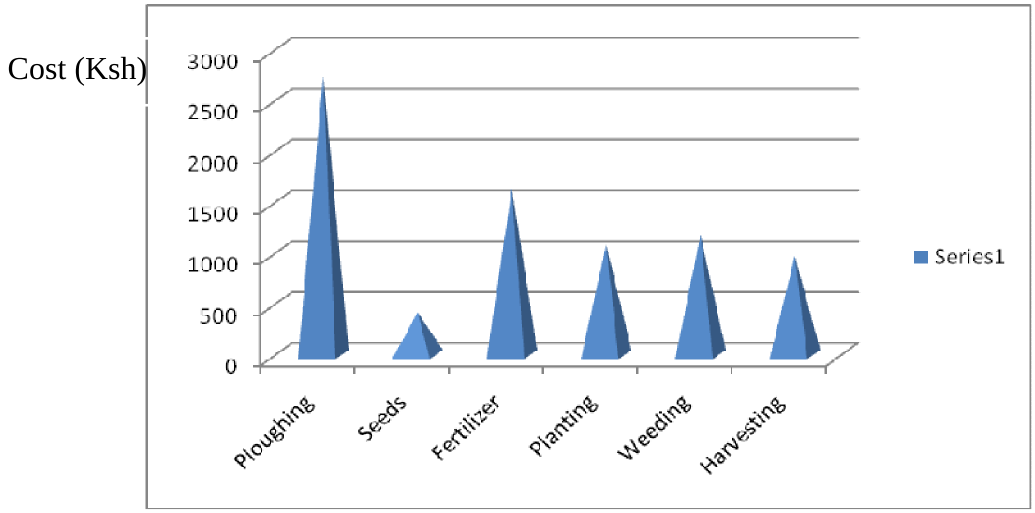
TABLE 4.04: MAIZE PRODUCTION COSTS BY PROPORTION (%)

Expense	Percentage
Ploughing	34%
Seeds	5%
Fertilizer	20%
Planting	13%
Weeding	15%
Harvesting	12%

Source: Field Data.

As can be seen from the diagram below, ploughing is the most costly activity followed by fertilizer and weeding respectively.

FIG. 4.03: MAIZE PRODUCTION COSTS BY RELATIVE SIZE



Source: *Field Data.*

4.1.1.3: Production Costs of Sorghum

Sorghum is regarded as a hardy crop able to tolerate many of the agronomic stresses especially drought and low soil fertility. It is mainly grown for home consumption and with no profit orientation, but as is the case with other crops, some of it is sold for cash. The limited profit motive and the assumption that sorghum is hardy has lead to less attention being paid to use of inputs and as such most farmers ignore some of the important agronomic practices that may improve productivity . It was, for example, evident that most farmers do not use fertilizer on sorghum. It was also observed that majority of farmers do not buy improved sorghum seeds from certified agro-input stockists. Most of the sorghum seed is bought from the open air market, just the same way consumers buy grains for consumption. The following is the analysis of the various costs incurred in sorghum production.

TABLE 4.05: DESCRIPTIVE STATISTICS FOR SORGHUM PRODUCTION

	N	Minimum	Maximum	Mean	Std.Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
CROP ACREAGE	68	.25	4.00	.9559	.4404	4.751	.291
PLOUGHING	68	800.00	3000.00	1941.1765	447.6257	.016	.291
SEEDS	68	.00	600.00	306.0294	105.9448	-.060	.291
PLANTING	68	400.00	1500.00	943.3824	265.5471	-.232	.291
WEEDING	68	500.00	1600.00	1152.5000	280.0393	.014	.291
HARVESTING	68	500.00	1600.00	870.2941	263.1836	.802	.291
T.C.P.A	68	3700.00	6800.00	5213.3824	568.9965	.164	.291
YIELD-BAGS/ACRE	68	2.00	5.00	3.4485	.8514	-.003	.291
UNIT PRICE	68	700.00	1500.00	1017.6471	172.5067	.817	.291
REV. /ACRE	68	1600.00	6000.00	3491.9118	1011.1177	.670	.291
GROSS MARGIN	68	-4100.00	850.00	-1721.47	1133.9737	.124	.291
TOTAL_EN	68	-4100.00	850.00	-1556.62	1095.2348	.004	.291
Valid N (listwise)	68						

A summary of the various activities and associated costs incurred in the production of sorghum in the area of study is given below. The table gives the average percentage costs of the various expense items.

TABLE 4.06: SORGHUM PRODUCTION COSTS

Expense	Percentage
Ploughing	37%
Seeds	6%
Planting	18%
Weeding	22%
Harvesting	17%

As can be seen from both the analysis and summarized table above, ploughing accounts for the highest proportion of farm level production cost. This could be due to the limited tractors and ox-ploughs coupled with the fact that most farmers start ploughing at the same time, thus exerting more pressure on the available ploughing facilities. Weeding which is normally done once and by use of hoes comes second in cost. This is in line with the expectation since compared to planting and harvesting, weeding requires more attention, thus take more time per unit area.

4.1.1.4 NERICA production costs of NERICA

Table 4.07 below shows the different costs incurred in the production of NERICA

TABLE 4.07: PRODUCTION COSTS FOR THE NERICA

Rice Production Costing Per acre	
ITEM	**COST (KSH)**
Land preparation	
Ploughing	1875
2nd ploughing	1355
Harrowing	1250
Sub total	**4480**
Planting and disease control	
Drilling	670
Seed 75kg	750
Fertilizer	1500
Insecticide	405
Sub-total	**3325**
Weeds and Bird Control	
Weed Control 90 MDS	7235
Bird Control	3000
Sub- Total	**10235**
Harvesting	
Cutting & stacking 25MDs	2125
Total	**20160**

Source: Field trial data (Lake Basin Development Authority, 2007).

Important to note here is the absence of the cost of irrigation in production of NERICA. This however does not mean that irrigating NERICA will necessarily cause damage. Incase NERICA is to be grown where rainfall is not sufficient to produce a good crop of maize, then irrigation may be advisable depending on the level of moisture available. In terms of relative magnitude, the various costs incurred in production of NERICA are presented in figure 4.05 below.

FIG. 4.05: NERICA PRODUCTION COSTS

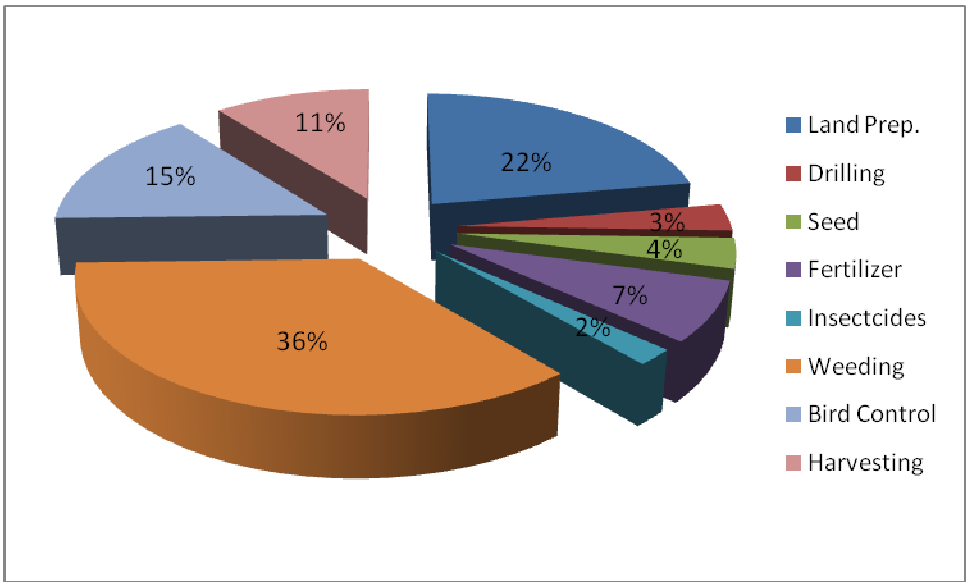


TABLE 4.08: DESCRIPTIVE STATISTICS FOR NERICA PRODUCTION COSTS AND REVENUE

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
T.C.P.A	22	20160.00	20160.00	20160.00	.0000	.	.
YIELD/ACRE	22	14.22	27.26	21.6566	3.1289	-.650	.491
UNIT PRICE	22	2120.00	2120.00	2120.0000	.0000	.	.
REVENUE/ACRE	22	30151.11	57789.63	45911.92	6633.2906	-.650	.491
G.MARGIN/ACRE	22	9991.11	37629.63	25751.92	6633.2906	-.650	.491
Valid N (listwise)	22						

From figure 4.05 above, weeding constitutes the highest cost. This shows some dissimilarity in agronomic practices between NERICA and the conventional rice. Whereas farmers weed conventional rice once, NERICA requires two hand weedings. Land preparation still features among the most costly activities as it come second in the production of NERICA. One of the reasons NERICA is being promotes is that it is more suitable to the poor soils and the low fertilizer use characterizing farming in Sub-Saharan Africa. True to this claim, field trial data in table 4.08 whose relative percentages are presented in figure 4.05 show that the cost of fertilizer comes fifth in production of NERICA and it accounts for only 7% of the total cost. The crop therefore fairs well in fertilizer requirement compared to conventional rice and maize whose fertilizer requirement accounts for 15 and 20% of the total costs respectively. At 22% of the total cost of producing an acre of NERICA, land preparation (ploughing and harrowing) has consistently ranked high in all the crops. This could be an indication of the limited availability of farm machinery in the area. It may also be due to the *difficult-to-plough* soils that characterize most parts of Nyando district.

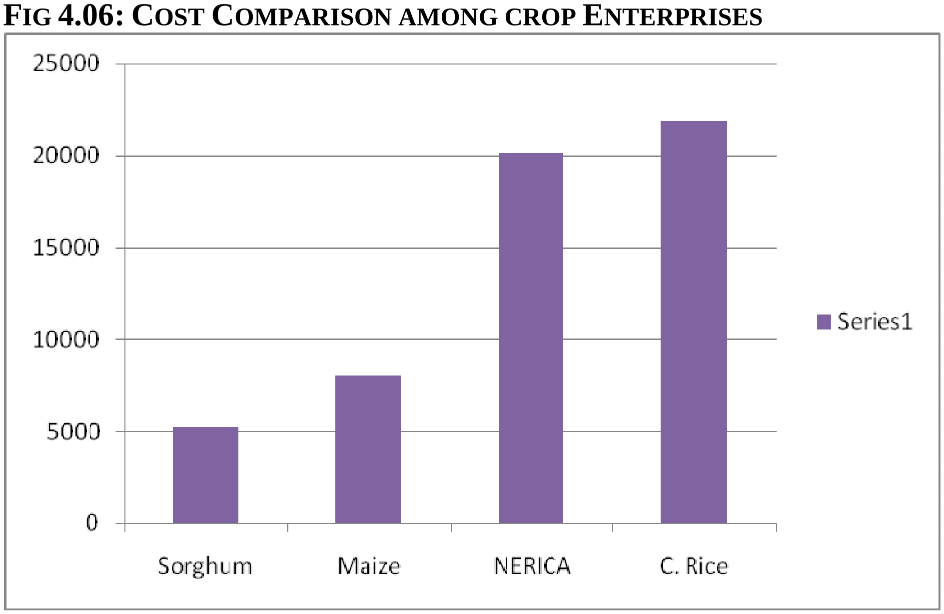
Some farmers participating in the NERICA field trials pointed out that birds seem to like the crop more than any other rice variety. Such a statement also appeared on SACRED Africa's website (www.sacredafrica.org. Accessed October 11th 2007) where one farmer, asked to comment on the quality of NERICA, reported that NERICA was so sweet that even birds had liked it more than other types of rice thereby causing serious damage to the crop. The birds' damage was found to be of economic significance in production of NERICA with 15% of the total cost going to bird control which is done through physically scaring ways the birds by casual labour.

Comparison of production costs for the four crops

The cost of production is an important determinant of enterprise choice, especially in a community with low resource base such as farmers in Nyando district. High cost of production may make a given enterprise unaffordable hence lock out interested farmers.

FIG 4.06: COST COMPARISON AMONG CROP ENTERPRISES

Ksh



It is important to note here that though most costly to produce, conventional rice still receives more attention than most of the crops grown in the area. Taking land for example, conventional rice takes up to 52% of the land available for cereal growing in this area. This represents more land than both maize and sorghum combined. Favourable attention enjoyed by rice is therefore mainly due to its superiority in income generation rather than affordability in terms of resource requirement.

4.1.2.0: Enterprise Revenues and Gross Margins

In every enterprise, the gross margin realized by the farmers is directly dependent on costs and revenue from sales. Revenue is, on the other hand dependent on yield and the price at which the commodity is sold. The interactions in yield, price and gross margins for each of the four crops covered in the study crop are presented and discussed in the following subsection.

4.1.2:1: Revenues and Gross Margins for Conventional Rice

Conventional rice was found to generate an average gross margin of Ksh 29,700 against revenue and cost of KSh 51,574 and KSh 21,874 per acre respectively.

TABLE 4.09: GM, TCPA, YIELD AND PRICE CORRELATION ANALYSIS FOR THE CONVENTIONAL RICE

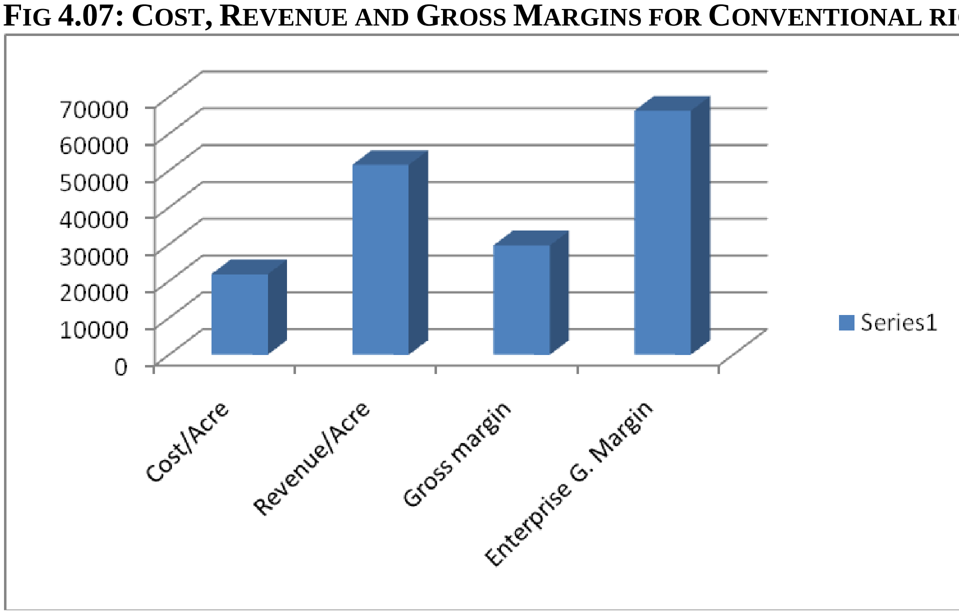
		G.M	TCPA	YIELD	UNIT PRICE
Pearson Correlation	G.M	1.000	-.282	.834	.453
	TCPA	-.282	1.000	-.022	-.277
	YIELD	.834	-.022	1.000	-.086
	UNIT PRICE	.453	-.277	-.086	1.000
Sig. (1-tailed)	G.M	.	.006	.000	.000
	T.C.P.A	.006	.	.424	.006
	YIELD	.000	.424	.	.225
	UNIT PRICE	.000	.006	.225	.
N	G.M	80	80	80	80
	T.C.PA	80	80	80	80
	YIELD	80	80	80	80
	UNIT PRICE	80	80	80	80

G.M = Gross Margin, TCPA= Total Cost of Production per Acre

The high gross margin is mainly due to its superiority in yields compared to the other three crops. The importance of yield on gross margins can be seen from the correlation analysis presented above (Table 4.09) which indicates a strong positive correlation between yield and gross margins. Another variable that showed a positive correlation with gross margin was price per unit (75kg bag) of rice. The correlation between price and gross margin is however weaker than that of yield and gross margins. Improving yield may therefore have a higher income enhancing capacity than would an equivalent increase price.

The analysis however, revealed some unexpected results where the cost of producing an acre of rice is negatively correlated with both yields and Price at which the crop is sold. Ordinarily, it would be expected that the higher costs imply more inputs and higher yields in return. The apparent anormally could point to some form of inefficiency both at farm level activities and in marketing. It is possible that some farmers are not adequately informed about the most efficient and economical ways to acquire inputs and sell their produce. This may lead to higher input costs and lower prices for the produce. Another possible cause could less personal involvement of the farmer in both production and marketing of the crop. The casual employees may sometimes take advantage of the absence of the farmer and engage in less efficient ways of production such as over pricing of the inputs or generally not bargaining for better farm gate prices. The low yield on the other hand may have resulted from misappropriation of some of the purchased inputs by reselling or using on other crops, but recording them as having been used in rice production. This could deny crops the necessary levels of nutrients leading to lower yields. Though the above scenarios could occur in a farming system characterized by high levels of hired labour as is the case in rice farming, the study did not focus on such issues; hence no authority is attached to the suggestions. The phenomenon however warrants further and more targeted investigations to uncover the underlying problems. Below is a graphical presentation of the relative magnitudes of Cost, Revenue and gross margin per acre and the average gross margins from the whole rice enterprise. This last component captures the average size of rice farms in the area and its importance lies in the fact that it gives an indication of the income generation capacity of conventional rice in the area.

FIG 4.07: COST, REVENUE AND GROSS MARGINS FOR CONVENTIONAL RICE



Note:
Gross margin (2nd last bar) refers to Gross Margin per acre while Enterprise G. Margin refers to the gross margin for the whole rice farm

The above figure is a diagrammatic presentation of the cost-benefit analysis in the production of conventional rice. The Gross margin (second last bar from left) is equal to Revenue per acre (second bar) minus Cost per acre (first bar). The enterprise gross margin (last bar from the left), on the other hand is gross margin per acre multiplied by the number of acres planted of rice. Given a per acre gross margin of Ksh 29,700, the whole enterprise gross margin of Ksh 66,261 indicate an average farm size of 2.3 acres.

4.1.2.2: Revenues and Gross Margin for Maize

Being one of the crops most grown in the country, maize plays an important role in shaping the welfare of many subsistence farmers. Information on net returns from maize production is therefore crucial in making decisions on any new enterprise. Field data indicate that revenue per acre ranged from Ksh 3,900 to Ksh 21,000, while gross margins ranged from Ksh -5,450 to Ksh 12,100 with a mean of Ksh 1,370. The high instability in both revenues and gross margins among different farmers may be due to lack of profit motives characterizing maize farming in the area. Such subsistence approach may discourage farmers from paying adequate attention to the recommended agronomic practices. With little or no attention paid to recommended practices, each farmer comes up with their own field standards hence highly varied and generally low average yields.

The following table shows the average costs, revenue and gross margin characterizing maize production in Nyando district.

TABLE 4.10: AVERAGE COSTS, G. MARGINS AND REVENUE FOR MAIZE PRODUCTION

Descriptive Statistics

	N Statistic	Minimum Statistic	Maximum Statistic	Mean Statistic	Std.Deviation Statistic
Crop acreage	80	.25	3.00	1.4563	.6460
Ploughing	80	400.00	3600.00	2746.2500	861.2537
Seeds	80	120.00	700.00	414.7500	137.2974
Fertilizer	80	.00	3500.00	1634.7500	770.3492
Planting	80	600.00	2000.00	1077.5000	281.9350
Weeding	80	560.00	1800.00	1173.2500	305.2775
Harvesting	80	400.00	2000.00	967.1250	334.3847
T.C.P.A	80	4540.00	11140.00	8013.6250	1426.8007
Yield	80	3.00	15.00	6.5875	2.2485
Av. Price per unit	80	1050.00	1750.00	1428.1250	156.2706
Amount	80	3900.00	21000.00	9383.7500	3332.8892
Gross Margin	80	-5450.00	12100.00	1370.1250	3482.1743
Valid N (listwise)	80				

The capacity of any agricultural enterprise to generate income is directly determined by the costs, yield and output price among other indirect factors. It is therefore important to understand the relative importance of each of the three factors affect the gross margins of an enterprise.

Table 4.12 below shows summary results of the correlation between the gross margin and yield, Cost and unit price in maize production.

TABLE 4.11: CORRELATION ANALYSIS FOR COSTS, YIELD, PRICE AND G. MARGINS IN MAIZE PRODUCTION

		G.MARGIN	UNIT PRICE	YIELD	COST/ACRE
Pearson Correlation	G.MARGIN	1.000	.197	.875	-.307
	UNIT PRICE	.197	1.000	-.069	.122
	YIELD	.875	-.069	1.000	.068
	COST/ACRE	-.307	.122	.068	1.000
Sig. (1-tailed)	G.MARGIN	.	.040	.000	.003
	UNIT PRICE	.040	.	.271	.141
	YIELD (BAGS)	.000	.271	.	.276
	COST/ACRE	.003	.141	.276	.
N	G.MARGIN	80	80	80	80
	UNIT PRICE	80	80	80	80
	YIELD (BAGS)	80	80	80	80
	COST/ACRE	80	80	80	80

Results show a strong positive correlation (0.875) between yield and the gross margin. It is also clear that as much as the price positively affect gross margin, it does so to a lesser extent (0.197) compared to the 0.875 index observed for yield. The effect of the high cost of production is also evidence by the negative correlation between cost and gross margin. The effect is however not as strong as that of yield. An improvement in yield may therefore cause a much more positive change in returns than would do a proportionate reduction in costs.

4.1.2.3: Revenues and Gross Margin for Sorghum

From an earlier analysis (Table 4.05), it was observed that sorghum recorded an average per acre loss of KSh 1721 against average revenue of Ksh 3492. The following table shows the correlation between costs, yield, price and gross margins for sorghum production.

TABLE 4.12: CORRELATION ANALYSIS FOR THE COSTS, YIELD, PRICE AND G. MARGINS IN SORGHUM PRODUCTION

		GROSS_MA	AV._UNIT	YIELD	TOTAL_PE
Pearson Correlation	GROSS_MA	1.000	.498	.641	-.455
	AV._UNIT	.498	1.000	-.121	-.029
	YIELD	.641	-.121	1.000	.069
	TOTAL_PE	-.455	-.029	.069	1.000
Sig. (1-tailed)	GROSS_MA	.	.000	.000	.000
	AV._UNIT	.000	.	.163	.408
	YIELD	.000	.163	.	.289
	TOTAL_PE	.000	.408	.289	.
N	GROSS_MA	68	68	68	68
	AV._UNIT	68	68	68	68
	YIELD	68	68	68	68
	TOTAL_PE	68	68	68	68

The negative gross margins recorded by most sorghum farmers show that engaging in sorghum production at the current costs and yield levels makes farmers worse of economically. This is because such farmers usually do not recover the all resources invested in sorghum production. Though better marketing strategies could add value to sorghum and attract better price, yields recorded were considerably low. Looking at the above correlation analysis (table 4.13), it is clear that yield has a stronger positive correlation with gross margin than is price. It follows, therefore, that improving marketing to raise price without considerably improving yield may not improve the profitability of sorghum in Nyando by a significant margin.

Having looked at how each crop performs in terms of gross margins, it is clear that conventional rice still tops the list with an average gross margin of Ksh 29,696, followed closely by NERICA with Ksh. 25752. The analysis showed a big difference in margins between the first two crops (conventional rice and

NERICA) and the last two crops (maize and sorghum). Maize recorded an average gross margin of Ksh 1370 while sorghum showed a negative gross margin of Ksh 1,721. These results are graphically illustrated in figure 4.09 below.

4.1.2.4: Expected Revenues and Gross Margins for NERICA

Field trial data showed that NERICA generated an average gross margin of Ksh 25,752 from average per-acre revenue and cost of Ksh 45,911 and Ksh. 20,160 respectively. It is important to point out here that unlike conventional rice where prices were given by the farmers, NERICA is yet to be commercialized and so there was no farmer-given market price for it. The constant price used was provided by one of the lead NERICA research institutions, the LBDA as the price at which they acquire the produce from the farmers participating in the field trials. The same institution also provided the average cost per hectare from which per acre costs were derived.

TABLE 4.13: DESCRIPTIVE STATISTICS OF THE COSTS AND G. MARGINS FOR NERICA

G. Margin	22	9991.11	37629.63	**25751.92**	6633.2906
Unit Price	22	2120.00	2120.00	**2120.0000**	.0000
Revenue	22	30151.11	57789.63	**45911.92**	6633.2906
Yield (bags)	22	14.22	27.26	**21.6566**	3.1289
TCPA	22	20160.00	20160.00	**20160.00**	.0000

From the above results, it can be seen that the gross margin has a wide range of KSh 27,638.52. As noted from the analysis of conventional rice, yield has a strong influence on gross margins, especially in rice. The NERICA data used was from various field trails where different varieties were tried with varying yield levels. The wide difference in NERICA yields therefore led to the wide range in expected gross margins.

The following figure illustrates the comparative values of revenues, costs and gross margins per acre of NERICA.

FIG 4.08: REVENUE, COST AND G. MARGIN COMPARISONS FOR NERICA

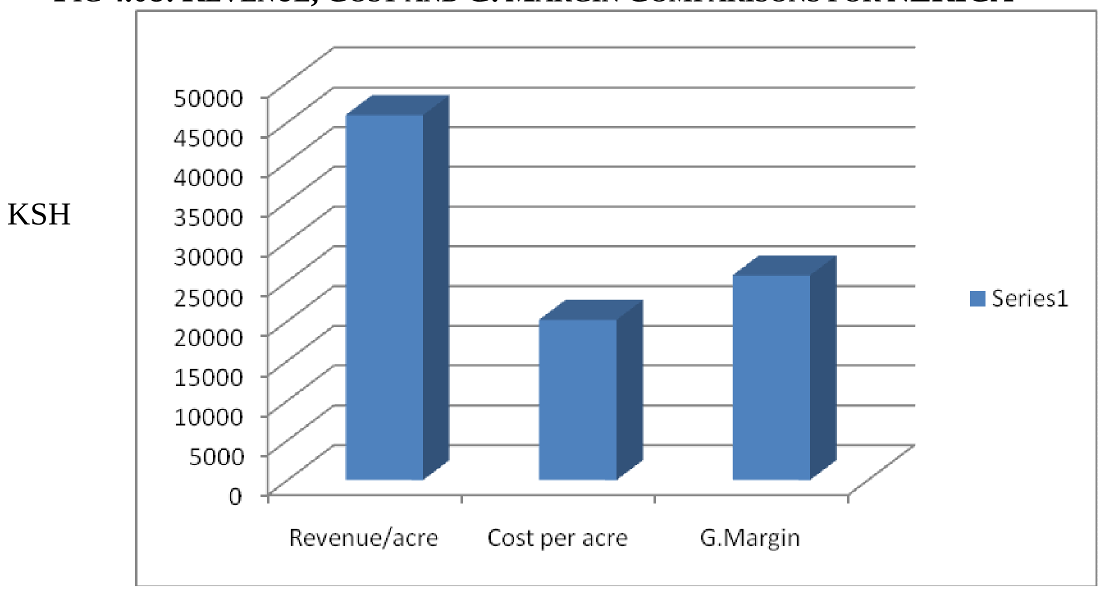
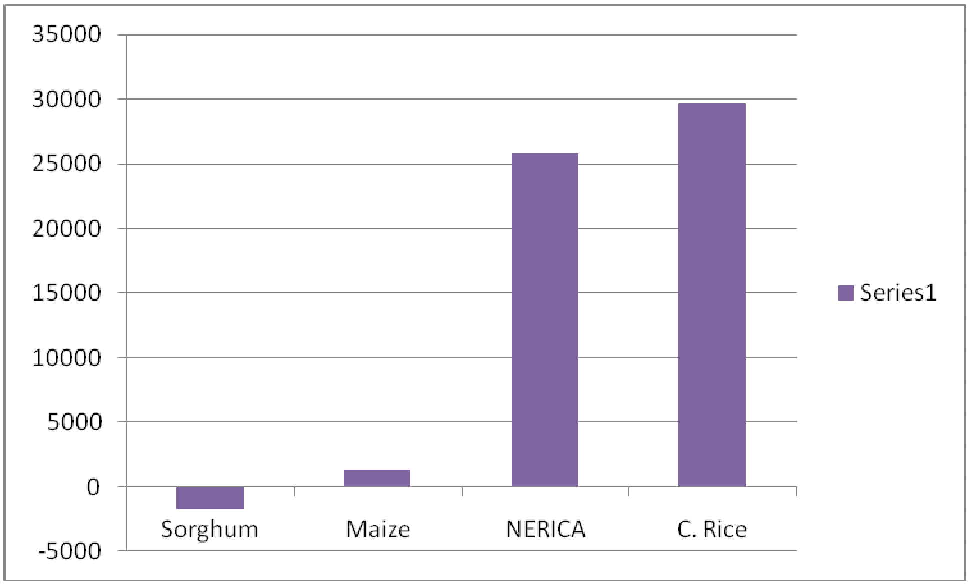


FIG 4.09: INTER CROP COMPARISON OF GROSS MARGINS

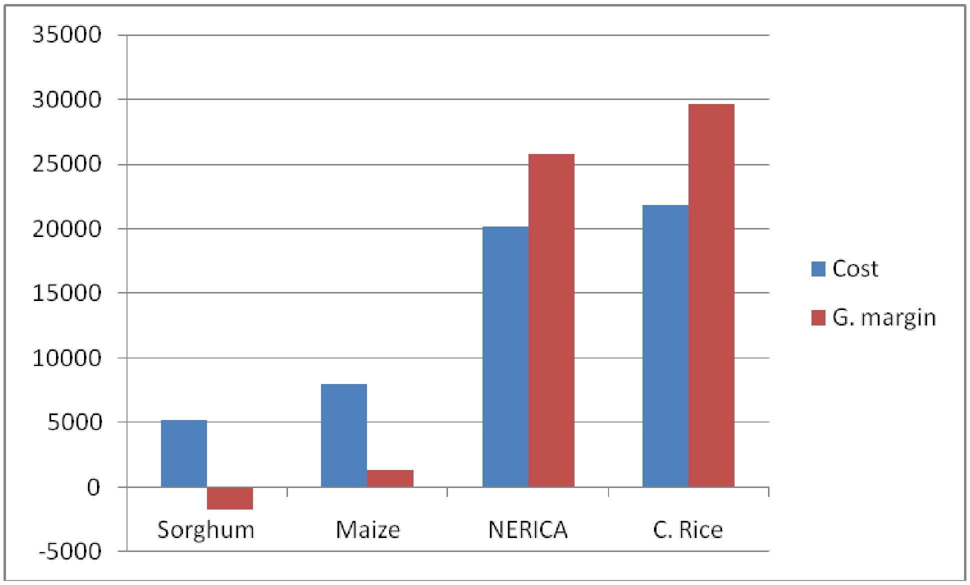


4.1.3: Comparison of Costs and Gross margins among the four enterprises (Conventional rice, NERICA, Maize and Sorghum).

Accessibility of inputs is usually an important factor in determining which enterprise a farmer will chose. There are, therefore cases where lucrative enterprises may be avoided by farmers simply because such enterprises are too demanding in terms of required resource. There are also some enterprises which may attract investment due to their low input requirement. It is therefore important that in comparing profitability of different enterprises, one should take into consideration the resource requirement/production costs for each enterprise. This is particularly important in cases where resources are very limited as is the case with many rural smallholder farmers commonly referred to as “resource poor farmers”.

Fig 4.09 gives a clear picture of both average cost and gross margins per acre for the four crops.

FIG 4.10: COST AND G. MARGIN COMPARISON FOR CONVENTIONAL RICE, NERICA, SORGHUM AND MAIZE



From the above figure, it is clear that lucrative enterprises also require higher investment. Taking production of sorghum and NERICA for example, it only requires an average of KSh 5000 to produce one acre of sorghum while one needs Ksh 20,000 to produce an acre of NERICA. Whereas farmers with limited capital may prefer sorghum because it is more affordable than NERICA, such farmers actually end up making losses. Approached from a purely financial cost-benefit assumption, sorghum, in its current production status is more of a wealth-reducing than a wealth-creating enterprise; that is, it reduces total farm incomes thereby increasing, rather than reducing poverty. In other words, it would be better for a farmer to do nothing than to engage in sorghum production at the current costs, yield and price levels.

TABLE 4.14: ANOVA FOR THE COSTS OF C. RICE, NERICA, MAIZE AND SORGHUM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.35E+10	3	4508317000	2205.242	.000
Within Groups	5.03E+08	246	2044363.722		
Total	1.40E+10	249			

Table 4.14 above shows results of ANOVA test. This was done to determine whether or not there was a significant difference in average costs of the four enterprises. The results show (as indicated the by F statistic of 2,205.242 as well as the significance level of 0.000), that there is a significant difference in average costs among the four crops. Likewise, table 4.15 below shows that there is a significant difference in the gross margins obtainable from the four enterprises.

TABLE 4.15: ANOVA IN GROSS MARGINS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.54E+10	3	2.512E+10	329.296	.000
Within Groups	1.88E+10	246	76278075.22		
Total	9.41E+10	249			

Though they show that there are significant differences in average costs and gross margins, tables 4.14 and 4.15 above do not tell how significant such differences are and which crop enterprises actually differ in costs or gross margins. The two tables only tell us that at least one of the average costs and gross margins differs significantly from the others. This necessitates a further analysis in order to find out between which crops there are significant differences in average costs or gross margins. Table 4.16 below compares average costs of each crop against the other three crops, while table 4.17 compares the gross margins in a similar manner.

TABLE 4.17: COMPARISON OF GROSS MARGINS FOR THE FOUR CROPS

Dependent Variable: G. Margin, Independent Factor: CROP

(I) CROP	(J) CROP	Mean Difference	Std Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Tukey HSD 1	2	-9445.71*	2102.54	.000	-14847.19	-4044.22
	3	25815.67*	2102.54	.000	20414.18	31217.16
	4	29362.01*	2142.18	.000	23858.68	34865.33
2	1	9445.71*	2102.54	.000	4044.22	14847.19
	3	35261.38*	1380.92	.000	31713.73	38809.02
	4	38807.71*	1440.56	.000	35106.87	42508.56
3	1	-25815.67*	2102.54	.000	-31217.16	-20414.18
	2	-35261.38*	1380.92	.000	-38809.02	-31713.73
	4	3546.34	1440.56	.066	-154.51	7247.19
4	1	-29362.01*	2142.18	.000	-34865.33	-23858.68
	2	-38807.71*	1440.56	.000	-42508.56	-35106.87
	3	-3546.34	1440.56	.066	7247.19	154.51

The mean difference is significant at the .05 level.

Table 4.16 compares the average costs of producing one acre of each crop. Each of the crops is taken at a time (show in column I) and compared with the other three crops listed in column J. To verify the results two tests (Tukey HSD and Scheffe) are conducted for each crop. Any pair that has a significant difference is indicated by an asterix (*) against the mean difference, (I-J). For purposes of analysis, crops were assigned numbers ranging from 1through 4. Conventional rice is represented by the digit 1, NERICA by 2, 3 represents maize while sorghum is represented by 4. From table 4.16 and under the Tuskey HSD, crop number 1 which is conventional rice has its costs compared to that of 2, 3 and 4. In all cases, there are * against 2, 3 and 4, meaning the cost of 1 significantly differs from that of 2, 3 and 4. A different scenario is found in the next table (table 4.17) which has comparisons for the gross margins. Under the same Tuskey HSD, there is a column named (I) CROP. Down that column, a comparison between crop 3 margins and crop 4 margins indicate no significant difference. There is no asterix (*) against 3546.34 which is the measure of the difference in average gross margins between crop 3 and crop 4.

From the foregoing analyses of costs and gross margins, it is clear that contrary to the traditional view that small scale farming is non profitable, the profitability or otherwise may much depend on the type of enterprise one is engaged in.

To assess the competitiveness of NERICA over the other crop enterprises, it is necessary that a further analysis be done to determine which enterprises are less or more competitive than NERICA. A two tailed t-test was used to evaluate the competitiveness of the various crop enterprises with gross margins as the indicator of competitiveness. Table 4.18 presents the results of the t-test where the gross margin per acre of NERICA is tested against the average gross margins of the maize, sorghum and conventional rice.

TABLE 4.18: MAIZE, SORGHUM AND CONVENTIONAL RICE GROSS MARGINS AS COMPARED TO EXPECTED NERICA GROSS MARGIN (ONE-SAMPLE TEST)

	Test Value = 25,751					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Maize	-40.673	79	.000	-24381.00	-25574.16	-23187.84
Sorghum	-105.301	79	.000	-27472.08	-27991.36	-26952.79
Conventional Rice	4.692	79	.000	3949.13	2273.95	5624.30

Source: Field data

The above results indicate which crops have gross margins greater than or lower than that of NERICA. This can be pointed out from the positive or negative mean difference which is obtained by subtracting the test value (Ksh 25,751) which is the NERICA gross margins from the gross margins of each of the other three crops shown on the far left of the table. As can be seen the table shows negative mean differences for maize and sorghum while conventional rice has a positive mean difference. This implies that by way of gross margins, NERICA is more profitable than maize and sorghum but less profitable than the conventional rice.

Though conventional rice is the most profitable, choice of a given enterprise not only depends on the profitability but on its overall competitiveness that captures its resource requirement and availability of such resources as well.

4.2.0 Competitiveness of NERICA relative to Maize, Sorghum and Conventional Rice

4.2.1.0: Resource Availability and Usage:

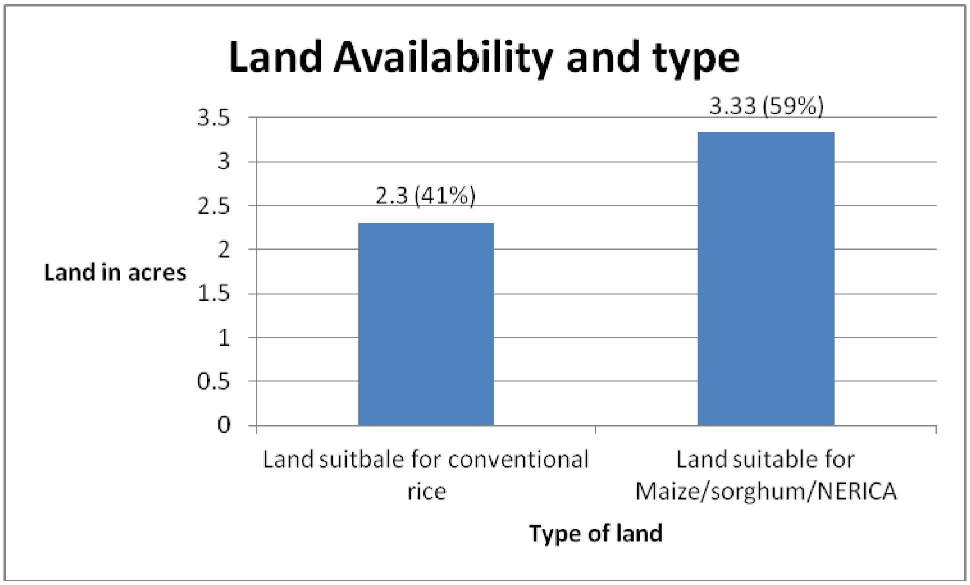
The three basic resources that were considered for the purpose of the four crop enterprises (Conventional rice, NERICA rice, Maize and Sorghum) were land, labour and capital.

4.2.1.1 Availability of Land

Nyando district is characterized by seasonal flooding especially along river Nyando which cuts across the region where this study was conducted. The almost regular and predictable flooding has made it necessary for the land in this area to be informally categorized as either flood-prone or non flood-prone. Flood prone land consists of parts of land that usually remain flooded for a time long enough to destroy other crops like maize and sorghum. The flood-prone land is suitable for conventional rice while the non flood-prone parts of the land are suitable for other crops like maize, sorghum and NERICA rice. Flood prone land which in most cases borders the river is therefore usually allocated to the growing of conventional rice since the nearness to the river allows irrigation. It is important to note here that natural flooding is insufficient to produce a good rice crop and so farmers engage in flood irrigation. This is achieved by blocking the river and directing the water into communally dug tunnels which then lead water into the fields. The blocking of the river is done at intervals depending on the stage of rice and the moisture needs.

Figure 4.11 below shows the average size and types of land available to farmers in Nyando district.

FIG. 4.11 AVERAGE LAND SIZES



In summary, land at the disposal of farmers was found to range from 1 acre to 14 acres. The average land holding was however found to be 5.63 acres while the mode was 5 acres. The average size of the seasonally flooded land was 2.3 acres while the non-flood prone land average 3.33 acres. As a percentage, the flood prone land accounted for 41% while the rest of the land available for other crops accounted for 59% net of the homestead.

Whereas most of the flood prone was fully utilized in the production of conventional rice, the study found that the community only utilized about 50% of the available non flood prone land. Some of the reasons advanced for the underutilization were lack of enough capital and the high production costs. It was however evident that the community put a lot of focus on the production of the cash fetching conventional rice and did not give much attention to food crops.

4.2.1.2 Labour Availability

It was established that most of the labour used in the area is hired. There are however, some farmers who complement hired labour with family labour. On average available family labour totaled to 60 man days per production season lasting five months. The high level of unemployment and seasonality of the labour requirement make casual labour (paid per day) a better option to the farmers compared to salaried, long term employment where the farmer is required to pay every month. Though labour is a distinct factor of production usually treated as an input separate from capital and land, the study found it appropriate to combine labour with other non land expense. The cost of labour was therefore considered as a component of monetary capital required just like the cost of seed or fertilizer. This was so because what determined whether one will have sufficient labor or not was the availability of money/capital to pay for labour rather than the available family labour. It is important to note here that rice production in the study area is fairly labour intensive and so it attracts many labourers in the rural areas throughout the production period which lasts for about five to six months. In the course of data collection, it was common to find labourers moving from one farm to the other seeking for casual employment. The applicable rate per day as at the time of study was KSh. 150 regardless of the type of activity performed. Labour is however required in three major activities namely planting, weeding and harvesting. To get the casual labourers, farmers place requests to fellow farmers stating the type of activities they need the labour for. It is also worth noting here that most of the people who provide labour are actually farmers who have either completed attending to their crops or are waiting for their crop to reach a stage at which it should be attended to. Farm labourers (employees) in one week may therefore be hirers (employers) of labour in the following week. This has provided adequate supply of labour throughout the production period.

4.2.1.3 Capital Availability

Capital was ranked as the scarcest resource limiting agricultural production in the area. Farmers complained of insufficient credit facilities in the area and the stringent requirement demanded by commercial banks before they (banks) can avail credit. The most important source of agricultural finance was proceeds from the sale of produce. Some farmers however do access some finance from self-help groups to which they make savings. The two active self-help groups in the area are Sagga and Adok Timo. It was also found out that brokers/middlemen do give some credit but on forward contract agreement where the farmer agrees to sale all or part of his/her produce to the lending middleman at harvest.

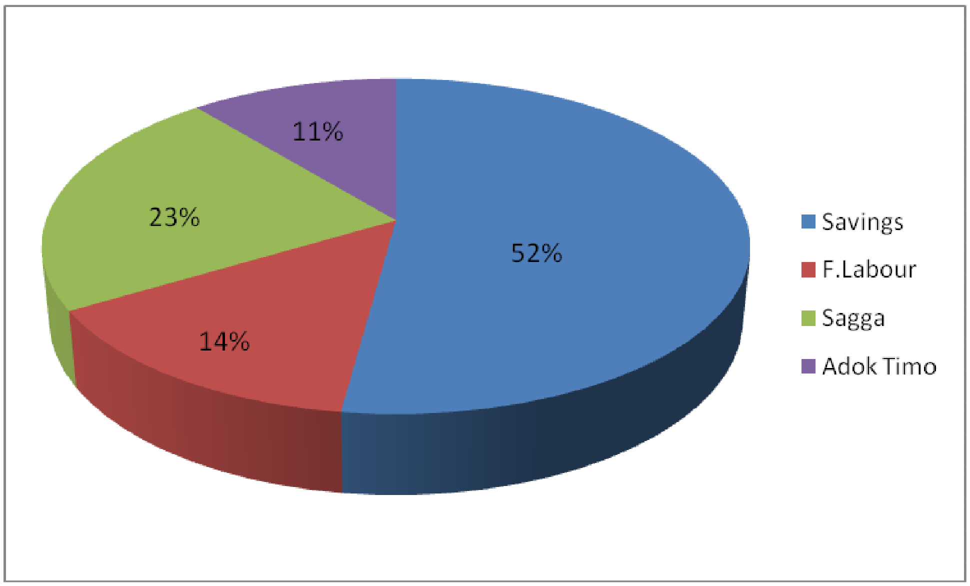
For the purpose of this study, farmers' own inputs such as own labour were valued at the market rates and added to the capital obtainable from other sources. In summary, the available capital being the sum of savings from sale of produce, loan from self-help groups, advance payments made by brokers and the value of available family labour averaged to KSh 62,350.

The table below shows the average contribution to capital from the various sources.

TABLE 4.19: SOURCES OF FINANCE

Source of Finance	**Average amount obtainable KSh**
Own savings from sale of produce plus advances	32,500
Family labour Valued at KSh 150 per man day	8,943.75
Sagga Self-Help group	14,050
Adok Timo Self Help Group	6,856.25
Total	**62,350**

FIG 4.12: SOURCES OF FINANCE BY RELATIVE SHARE



As noted earlier, there are only two credit institutions in the area, a fact that has made access to credit rather difficult to most small scale farmers. Dependence on farm proceeds for both farming inputs and other household needs has also limited the amount of resources available for farming in the area. This may create a cyclic phenomenon of capital insufficiency since most of the profit made from farming is spent on nonfarm activities resulting in capital deficits year after year.

TABLE 4.20: SUMMARY OF RESOURCE AVAILABILITY

Type of Resource	Land for conventional rice (Acres)	Land suitable for maize/sorghum/NERICA (Acres)	Capital (KSh)
Amount	2.3	3.33	62,350
Current utilization	Full	50%	Full

4.2.2: Linear Programming

Having estimated both profitability and resources at the disposal of farmers, the study determined the competitiveness of the various enterprises. The four crops (conventional rice, maize, sorghum and NERICA) were all jointly subjected to a linear programming analysis to determine their relative positions under optimal resource allocation scenario in which maximizing the total gross margins is the objective of the typical farmer. Results of the linear programming are presented in table 4.20 below.

TABLE 4.21: SUMMARIZED LP FOR THE FOUR CROPS

Number	Variable	Solution	Opportunity Cost	Objective Coefficient	Minimum Obj. Coeff.	Maximum Obj. Coeff.
1	X1	**+2.3000000**	+ 1759.2087	+29697.000	-Infinity	-27937.791
2	X2	**+.59744054**	0	+25751.000	+3446.798	+27372.510
3	X3	0	+ 8865.2559	+1370.0000	-Infinity	+10235.256
4	X4	0	+ 8379.7285	- 1721.0000	-Infinity	+6658.7285

Maximized OBJ = **Ksh. 83,687.8,** Iteration = 2

Note:

X1=> Conventional rice

X2=> Nerica rice

X3=> Maize

X4=> Sorghum

Linear programming is applied in such a way that it allocates more units of the most limiting resource to the enterprise that generates the highest profit per unit of such limiting input. In this analysis, four crops (Conventional rice, NERICA, Maize and Sorghum) and three inputs (capital, flood prone land and non flood prone land) were considered.

All the respondents stated capital as the most limiting factor of production, while conventional rice showed highest level of profitability from the partial budgeting carried out in cost and gross margin comparisons in the preceding sections. More capital was therefore allocated to the most profitable enterprise (conventional rice) until the land available for the conventional rice (2.3 acres) was exhausted. The solution for the profit (gross margin) maximization problem tackled by the above linear programming is that a farmer with average capital of Ksh 62,350 should produce 2.3 acres of conventional rice and 0.59 acres of NERICA rice. With this type of plan, a typical farmer with capital of Ksh 62,350, flood prone land of 2.3 acres and non flood prone land of 3.33 acres would realize a total gross margin of Ksh 83,687.80 from farming. Though conventional rice is more profitable and should receive all the capital, land for growing the conventional rice is insufficient. From the partial budgeting results, NERICA is second in profitability after conventional rice. This is why according to the solution obtained; some capital was allocated to the production of 0.59 acres of NERICA. In terms of capital consumption, conventional rice would take most of the available capital estimated at Ksh 50,310 out of the total Ksh 62,350 leaving only Ksh 12,040. This “residual” capital of Ksh 12,040 could either grow approximately 1.5 acres of maize or about 2.5 acres of sorghum. The analysis however indicates that using all this residual capital to grow only 0.59 acres of NERICA will be a better option in terms of revenue generation. Maize and sorghum will therefore be eliminated from the farming system. It is therefore clear that due to capital constraint, most of the non flood prone land suitable for NERICA and other crops will remain highly underutilized with only 0.59 acres out of 3.33 acres being put under production.

4.3.0To evaluate the potential impact of NERICA rice on farm incomes in Nyando District

4.3.1: Simulation of Gross margins

To determine whether introducing NERICA will have any impact of farm incomes in Nyando district, the study simulated and compared two farming systems using linear programming. The first system was with four crops (conventional rice, maize, sorghum and NERICA), see table 4.20 above. This represents how farm incomes would be like when NERICA is introduced. The second system simulated was the current situation, that is, before NERICA is introduced. This means only three crops (conventional rice, maize and sorghum) are considered. The results of this second linear programming are shown in table 4.22 below

TABLE 4.22: THE LP SOLUTION FOR FARMING WITHOUT NERICA

Basis	C<J>	X1	X2	X3	S1	S2	S3	B<i>	B<i> / A<I,j>
		29700	1370	-1721	0	0	0		
S1	0	-.0000	0	0.349	1.000	2.73	-.000	1.275	0
X1	29700	1.000	0	0	0	1.000	0	**2.3**	0
X2	1370	6E-17	1.000	0.651	0	-2.73	1E-04	**1.995**	0
C<J>-Z<J>		0	0	-2612	0	-xxx-	-o.171	**70368**	
* Big M		0	0	0	0	0	0	0	

<Max.> Optimal Objective Value = 70,368

Table 4.23 below compliments table 4.22 above by presenting a summarized report for the linear programming without NERICA

TABLE 4.23: SUMMARY RESULTS OF THE LP WITHOUT NERICA

Number	Variable	Solution	Opportunity Cost	Objective Co-efficient	Minimum Obj. Coeff	Max. Objective Coefficients
1	X1	+2.30000	0	+29700	+3739.845	+Inifinity
2	X2	+1.50255	0	+1370	+0.000122	+10235.256
3	X3	0	+2612.2778	- 1721	-Infinity	+891.2778

Max. Objective KSh 70,368

From this second system and guided by the above linear programming results, a typical farmer having capital of KSh 62,350, 2.3 acres of land suitable for conventional rice and 3.33 acres of land suitable for maize and sorghum should produce 2.3 acres of conventional rice and 1.503 of maize. Sorghum gets eliminated from the farming system. With such a plan, the typical farmer would earn a total gross margin of KSh 70,368.

The study however recognized the fact that simulated results may be different from the actual results that may be observed by farmers when they finally adopt NERICA. It was therefore important that total gross margins obtained from simulation of the four crops be moderated to reflect what would realistically be achieved by farmers. To get the moderation factor, the actual results from the immediate previous season involving three crops, conventional rice, maize and sorghum were compared to what simulation of the three crops obtained. It was realized that simulation of the actual previous season incomes were about 93.6 % of simulated results involving the same three crops.

Given that introduction of NERICA may not in itself induce smallholder farmers to optimally allocate their resources in scientific, linear programming-like manner, it was important to moderate the results of linear programming to reflect the inequality that exists between observed and scientifically simulated income levels. To achieve the moderation, the gross margin estimates obtained from the with-NERICA linear programming were lowered by 6.4%. The 6.4% used in the adjustment was obtained after comparing the observed gross margins which were 6.4% lower than the gross margins estimated by the LP for the same resource base and enterprise profitability. This put the with-NERICA gross margin estimates at Ksh 78,386 down from Ksh 83,687.80.

4.3.2: Comparison of differences in gross margins

To determine whether the introduction of NERICA into the farming system is likely to significantly change farm incomes a t-test was carried out to compare the difference in actual mean gross margin of KSh 65,910 observed by a typical farmer in the previous season to the expected with-NERICA gross margins of KSh 78,386 that a typical farmer is likely to observe if he/she produces conventional rice and NERICA but drops maize and sorghum. Results of the t-test are as shown below.

TABLE 4.24: ONE-SAMPLE STATISTICS (WITH NERICA)

	N	Mean	Std. Deviation	Std. Error Mean
GMARGIN	79	65910.2722	51603.28762	5805.82346

TABLE 4.25: ONE -SAMPLE T-TEST (WITH NERICA)

	Test Value = 78386					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
G. Margin	-2.149	78	.035	-12475.7278	-24034.2345	-917.2212

The results of the second t-test show significant difference between the observed gross margin and the estimated gross margins.

To verify whether the obtained difference in gross margins was due to introduction of NERICA into the analysis and merely because of the improved resource allocation that may come with linear programming, a second t-test was carried out. This was to compare the difference in means between the actual gross margins with the simulated without-NERICA gross margins. Results of the second t-test are shown in tables 4.24 and 4.25 below.

TABLE 4.26: ONE SAMPLE STATISTICS (WITHOUT NERICA)

	N	Mean	Std. Deviation	Std. Error Mean
G. Margin	79	65910.2722	51603.28762	5805.82346

TABLE 4.27: ONE-SAMPLE T-TEST (WITHOUT NERICA)

	Test Value = 70,368					
	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
G. Margin	-.768	78	.445	-4457.7278	-16016.2345	7100.7788

The t-test in table 4.25 above which sought to test the null hypothesis that two gross margins are not significantly different shows a significance level of 0.445 against the rejection thresh hold of 0.05. We therefore fail to reject the null hypothesis, which in turn implies that there is no significant difference between the actual gross margins obtained by farmers in the previous season and what would be obtained if resources were to be allocated more optimally among the current three crops. In other words, the test results seem to imply that farmers are currently allocating their resources optimally. From the results, it seems like the income-generating capacity of the three crops is nearly exhausted, and that for any substantial increment in farm incomes to be realized, farmers may have to consider different enterprises.

Though the two t-tests give different results, the only change that was made to the first linear programming is the inclusion of NERICA as an additional enterprise. It is therefore likely that the change in significance of the difference in gross margins was caused by inclusion of NERICA in the LP analysis as one of the possible enterprise. In other words, introducing NERICA will have a positive impact of farm incomes.

4.4.0: Opportunities and/or constraints facing farmers in Nyando district

In determining the prevailing opportunities and constraints, the study used direct questions to farmers asking them to name constraints. Constraints were also inferred from other parameters such as production costs and resource availability.

Table 4.28: Level of awareness about NERICA

Level of Awareness	Number of Farmers	% no of farmers
Heard of Advantages of NERICA	6	7.5
Ever heard of NERICA	16	20
Never Heard of NERICA	58	72.5

Of all the respondents interviewed, it was found that only 20% had heard about NERICA.

The level of knowledge held by farmers about NERICA was, however, very scanty. This was evidenced by the fact that most respondents did not understand the basic advantages or disadvantages of NERICA over the conventional rice. Only 7.5% of the respondents were able to mention at least one advantage NERICA rice has over the conventional rice varieties. It was further found that the only advantage of NERICA which farmers know of is its drought tolerance. An interview with the Lake Basin Development Authority (LBDA) revealed that Nyando was yet to receive targeted promotion of the crop due to scarcity of NERICA seeds. The LBDA however indicated that it was fast tracking seed multiplication and commercial NERICA production was expected in the near future. Indrit *et al* (2005) holds awareness as a pre-requisite for effective technology adoption. The low level of awareness therefore presents an uphill task and challenge for extension officers tasked with transferring NERICA to farmers.

Despite the apparent ignorance, most farmers were interested in knowing more about the new rice. Below are the responses from farmers on their willingness to grow NERICA.

TABLE 4.29 FARMERS WILLINGNESS TO GROW NERICA

Attitude About NERICA	No of farmers	% no of farmers
Willing to grow NERCA	57	71.25
Not Willing	6	7.5
Undecided	17	21.25

The high willingness of the farmers to grow the NERICA is likely to create conducive environment for adoption of NERICA. The willingness will however need to be coupled with the ability to grow the new rice. Farmers' ability encompasses both production costs as well as resource availability at farm/household level. Given the nature of resource availability summarized in table 4.20 above, it is clear that capital is a limiting factor. Although Nyando farmers have more land to put under production of NERICA and replace the less profitable maize and sorghum, lack of adequate capital has made such a shift impossible because after allocating capital to the most profitable conventional rice, very little of it is left for investment in NERICA.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.2: Profitability of the four crops

It was established that the four crops have different resource requirements as well as income generating capacities as measured by gross margins. Calculated per acre, and one enterprise taken at a time, results indicated that conventional rice is the most profitable crop enterprise in the area with a gross margin of approximately KSh 29700. Second in profitability was found to be NERICA rice at KSh 25,750, followed by maize but with a very low gross margin of KSh 1,370 per acre. Sorghum was found to generate looses as indicated by negative gross margin of KSh -1,721 per acre.

5.3: Competitiveness of NERICA in the area

The evaluation of the farming system in the area using gross margin as the indicator of profitability placed NERICA in the second place. The most competitive crop as at the time of study was conventional rice. Conventional rice was found to enjoy yield advantage hence a better capacity to absorb costs compared to NERICA. Maize and sorghum would be eliminated from production system due to the less gross margin they generate per acre of land.

5.4: Potential of NERICA on Farm incomes:

Results showed that an acre of NERICA has the potential of contributing KSh 25,751in gross margin to the farmers' income. Using profit (gross margin) maximization as the objective of engaging in farming, conventional rice would take up most of the capital and fully utilize the flood prone land that is suitable production of conventional rice. The balance of the capital would be put into production of NERICA but given the inadequacy of capital, only a small fraction of the non flood prone land would be exploited. From the analysis, it was found that currently, total farm incomes as measured by gross margins from the three common crops (Maize, Sorghum and Conventional rice) averages KSh 66,778. As a form of sensitivity analysis, the study evaluated the likely results of rearranging production resources (Using Linear Programming) by eliminating both sorghum and maize from the farming system. This would mean that farmers put to full use the land available for conventional rice then use the balance of capital to grow some 0.5974 acres of NERICA rice. With that kind of resource reallocation, our representative farmers would generate farm incomes averaging to KSh 83,687, giving a net gain in whole farm gross margins of KSh 16,908. This net increment in whole farm gross margins may therefore be realized by simply terminating the production of maize and sorghum to eliminate the losses/inefficiencies suffered in the production of the two crops. In the ideal situation where affordable credit is provided in adequate amounts such that all the land that is suitable for NERICA is also put under production, farmers would improve their farm income from the current KSh 66,778 with three crop to KSh 167,854 with two crops, representing a nearly 300% increase in farm incomes. Realization of this potential is however pegged on exploitation of opportunities and mitigation of constraints prevailing in the agricultural sector and particularly in the rice sub-sector.

5.5: The prospects and Constraints of NERICA in Nyando

It has been argued that some farmers may grow certain crops not for profit but for subsistence or cultural reasons. The current globalization is, however, rapidly changing food systems such that many farmers are now acknowledging the importance of the market economy. It is now much easier and sometimes a lot cheaper to buy than to grow certain types of food. The current very low and sometimes negative profit realized by most of the farmers from maize and sorghum in Nyando is a clear indication of the disadvantage they have in producing these two crops. It therefore makes sufficient economic sense for farmers in this area to concentrate on rice farming and buy both maize and sorghum from the market, which inescapably awaits them for acquisition of many other goods and services that they cannot produce in their own farms.

The fact that most, if not all the farmers tend to produce less of both maize and sorghum than they actually consume, and that they go to the market for supplementation is an indication of the willingness by the community to go to the market for what they do not have. This market-dependency culture may be advanced, much to the benefit of farmers by encouraging them to concentrate on rice, get more income and depend on the market for maize and sorghum produced from other regions that have a comparative advantage in the production of the two cereals. In this regard, a number of strengths and opportunities do exist for using NERICA to enhance income generation and possibly poverty reduction in the area.

5.5.1 NERICA Prospects

Availability of more land suitable for growing NERICA rice: It was established from the study that most of the land currently under maize and/or sorghum could best be put under the increasingly popular NERICA rice that has shown good prospects both in Kenya and the rest of Africa. NERICA rice is therefore likely to attract farmers who were previously locked out of the rice subsector due to their geographical location, say in areas that do not have wet lands or other forms of irrigation facilities. Such farmers may now diversify into rice production instead of confining all their resources in the less profitable maize and sorghum.

Abundance of labour: In general terms, rice farming is a labour intensive activity and NERICA is not an exception. Kenya has surplus labour as evidenced by the high rate of unemployment in the country. Appropriate adoption of NERICA as an economic activity has the potential to provide at least three major benefits to the country namely, employment creation to the farm labourers, income generation to the farmers and increased supply of rice to counter the high and fast growing deficit in rice production in the country.

Willingness to grow rice: It is clear that farmers in the study area appreciate the importance of rice farming as an economic activity. This is evidenced by the relatively more resources allocated to it as compared to maize and sorghum. NERICA rice will therefore not be a very foreign enterprise in the area and this is likely to enhance its acceptance and fast adoption.

Ready market for rice in the country: Unlike other cereals which have disappointed farmers due to lack of attractive markets, rice is on high demand in the country. During the study, no farmer complained of lack of market for the rice as opposed to maize and sorghum which were said to present marketing problems especially during and shortly after harvesting.

The changing food systems: The last few years have witnessed a radical shift in food production paradigms. Patterns of food consumption have become more diversified than domestic agricultural production, thanks to rising international trade, Timmer, (2004). The period has also seen a significant change in the eating habits of people around the globe. Kenya has not been left out and now communities that used to regard rice as a poor source of nutrients are accepting it as an important component of their diet. Rapid urbanization is also increasing the population of busy people who prefer rice because it is easier to cook. These changes have a net effect of increased demand and expanded market for rice in the country.

Renewed interest in rice by both governmental and non-governmental organizations: Several agencies such as the Alliance for the Green Revolution in Africa (AGRA) and the Japanese government have publicly expressed interest in promoting rice production in the country. The government of Kenya has also reassured the public of its commitment to increase budgetary allocation to agriculture. This is likely to avail the necessary resources needed for the commercialization of NERICA in Kenya as a whole and Nyando in particular.

Despite the apparent opportunities and potential benefits which farmers may get from the production of NERICA, there are several constraints that may hamper exploitation of such opportunities.

5.5.2 Potential Constraints in NERICA production

Limited capital: Inadequacy of capital is a familiar song that has remained on fashion, transcending both geographical and inter-temporal boundaries in most agriculture-dependent countries. Kenya has long recognized the importance of capital in agricultural production as indicated by the formation of institutions such as the Agricultural Finance Corporation (AFC) with the aim of providing capital to farmers. It was however clear, both from the linear programming analysis and the direct responses from farmers, that capital is still a major constraint to farming in the country.

Low awareness among the potential beneficiaries: Despite years of trials of NERICA in the country, results indicate that not many farmers understand the potential costs and benefits of the new rice. Realization of the benefits of this technology will therefore remain pegged on how effective awareness creation strategies will be.

Low profit motive in farming Practices: Like most of the smallholder farmers in rural areas, farmers in Nyando still produce certain crops as a show of consistency with the norms. Maize and sorghum are considered to be “foods” which one has to produce whether he/she makes a profit or loss.

Lower Yield: The NERICA yield is still lower than that of the conventional rice. Though this may discourage farmers from adopting the new rice, it is worth mentioning that compared to the conventional rice; NERICA is lower in production costs. NERICA is also more suited for areas that are drier and which may not be the best for the conventional rice. Therefore as far as land is concerned, NERICA is more in competition with maize than it is with conventional rice.

5.6 Policy Recommendations

Results indicate a high potential for enhancement of farm incomes by adoption of the NERICA rice. Though NERICA yields are lower than those of conventional rice, the study shows that gross margins from NERICA are much higher than those of maize and sorghum. Farmers who have land that is suitable for both conventional rice and maize/NERICA are therefore strongly encouraged to embrace NERICA rice as a pathway out of poverty, food insecurity and persistently worsening rice deficit in the country. Such a move will avail better living standards to the farmers and also save the foreign exchange the country is spending on rice imports, thereby positively contributing to the wider goals of economic development in Kenya. However, for the farmers and the nation as a whole to tap in the potential benefits held by the NERICA rice, specific measures need to be taken to achieve the twin objective of addressing the constraints and exploiting the opportunities identified in this study. To achieve this and ensure that Kenya does not miss out on gene revolution as happened with the green revolution, the following specific interventions are recommended:

Create awareness on the existence, prospects and constraints of NERICA farming. Farmers, extension officers and policy makers should be adequately educated on the benefits of NERICA (highlighted in the justification of this study), its growth requirements and the prevailing constraints so that all the stakeholders may, through inclusive participation jointly forge the way forward.

Enhance multiplication and distribution of NERICA seeds. The role of well organized seed system cannot be overemphasized in any agricultural production system. The best indicator of acceptance or otherwise of a given technology will, in most cases be the willingness to buy that technology, which may be best signaled by the quantity of seed purchased. Any promoter of a technology should, as much as possible, reduce barriers to accessing the technology. Timely delivery of good seed at the right price and place would be a significant step towards enhancing adoption.

Yield improvement: Results show that there is a strong positive correlation between yield and gross margin. Though yield may be improved through additional inputs such as fertilizers, the extra cost associated with additional inputs may easily reverse the intended benefits by raising total costs which in turn reduces farmers' profits. It is therefore important that researchers working on NERICA pay particular attention to yield improvement through crop breeding.

Such inbuilt yield enhancement is likely to be more affordable and accessible by more resource poor farmers.

Enlighten farmers on the changing food systems and the rice deficit facing the country. Knowledge on the nutritional value of rice is likely to enhance the value of rice to the local people thus stimulating production of more rice. On the other hand, education on the economic relevance of concentrating on areas of comparative advantage in substitution of areas of comparative disadvantage is likely to enhance the displacement effect that will release more resources from maize and sorghum to the more lucrative NERICA. Given the market access constraints facing many maize and sorghum farmers in the country, knowledge of the availability of a ready market for rice should make NERICA a crop of choice for such farmers.

Enhance access to credit: Given the acute inadequacy of finance depicted by the study, the government and the private sector should join hands in the provision of affordable credit to existing and potential rice farmers. This will facilitate full utilization of other production resources such as land that is left fallow due to lack of capital.

Improve supply of farm machinery, especially ploughing machines. Though labour is readily available, some farm activities such as ploughing are usually done by tractors. The cost of hiring a tractor was found to be very high leading to high cost of production. Increased availability of tractors may reduce pressure on the existing ones thereby lowering cost of hiring such machines. Adequate farm machinery will also allow timely preparation of land and better utilization of natural resources such as seasonal rains on which NERICA is highly dependent. This will go a long way in improving yields, reducing exposure to some pests and eventually improving returns to farmers. The government and/or private investors should therefore be encouraged to invest in such important machinery.

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APPENDICES

Appendix 1: The Questionnaire

The University of Nairobi

Determination of the Impact of Biotechnology on Farm Income

A Case of NERICA in Nyando district, Kenya

Name of Enumerator...

Date..

Place of Interview: (Home, Farm, Market, Roadside). Other place (state where)..........................

SECTION A: Farmer's/Respondent's details:

Name..

Division..

Location..

Sub- Location...

Telephone number...

Gender:

Male/Female...

Relationship with household head..

Occupation...

SECTION B: Constraints, Awareness and Perception on the NERICA rice:

1) Have you ever heard of the New Rice for Africa (NERICA)? Yes /No.............................

2) If yes, from where did you hear it first? ....

3) Have you ever grown it? Yes /No...

4) What could be its advantages over the conventional rice? ....
....

5) What could be its disadvantages compared to the conventional rice?
....
....

6) If No in 3 above, would you be willing to grow it?

   a.) Yes/No...

   b.)Why...

7) If yes in question 6 above do you think you have adequate resources needed to grow NERICA? Yes/ No...

8) If no, what assistance would you need to profitably grow the NERICA rice?

....

9) What constraints do you face in rice production and which you would like the new rice to solve?

1).. 2)...

3)... 4)..

SECTION C: **Farming Enterprises**

12. How much land do you use for livestock production (if any)? ....acres

14. How much land do you use for crops? Please list the various crop enterprises engaged in and acreage usually planted in the table below (Start with the largest field).

Crop Enterprise	Acreage
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

15. Of the crops listed above, which one do you consider to be the most important for you?

a.) Please rank the crops starting with 1 as the most important one.

1. ....
2. ....
3. ....
4. ....

b.) Why do you consider the crop number 1 in 15 above as the most important?

....

17. Would you like to specialize fully in the number one crop stated above? Yes /No. ....

18. If yes, why are you not specializing?

....

19. If no why would you want to continue growing the other crops?

....

....

20. Is it possible for you to change you acreage allocation to the various enterprises? (Yes/ No)...

21. If yes, on what basis do you allocate your land to the various enterprises?

a) ....
b) ....
c) ....
d) ....

22. If No in 20 above, what are the reasons for inflexibility in land allocation?

a) ....

b) ....

c) ....

d) ....

e) ....

SECTION D: **Resource Requirement and Production Cost Estimates**

23. What type of expenses do you incur in production of the various crops?

Expense Item per acre	The per Acre Resource requirement for the various Crop Enterprises (*please state total acreage planted below each crop if not able to directly get the per acre cost)*																	
	Maize			Sorghum			Conventional rice			NERICA rice								
	Quantity	Unit cost	Amount	Quantity	Unit cost	Amount	Quantity	Unit cost	Amount	Quantity	Unit cost	Amount	Quantity	Unit cost	Amount	Quantity	Unit cost	Amount

SECTION E: Resource Availability and Potential Access

Land Availability:

24. What is the size of your arable land in acres? .... Acres.

25. How much of this land is suitable for rice? .... acres

26. How much of your arable land is suitable for maize/sorghum................acres

Labour Availability:

27. How do you get your labour? (1). Family (2). Hired labourers (3). Others.............................

28. How many members of the family provide farm labour and for how long in a season?

Family members	Full Days Available	Half Days Available
Adult		
Non Adults		

29. Do you experience labour shortages? Yes/No

30. If yes, for which crops and during which months? ....

31. How do you usually counter such labour shortages? ....

32. What is the labour usage among the different crop enterprises? Please fill the table below.

Crop	Number of Acres	Activities (e.g ploughing, planting, weeding, harvesting, etc)													
		No of workers	No of days	No of workers	No of days	No of workers	No of days	No of workers	No of days	No of workers	No of days	No of workers	No of days	No of workers	No of days
Maize															
Sorghum															
Conventional Rice															
NERICA Rice															

Capital Availability:

33. How do you finance your farming (Your source of capital)? ....

34. Do you have access to credit finance for your farming from any credit institution? (Yes/No).

35. If yes, what are the potential credit institutions in your reach and what is the maximum credit you are likely to get from such institutions? Please fill in the table below.

Name of credit Institution	**Maximum Amount of Credit Accessible Ksh**
1.	
2.	
3.	
Total	

36. What percentage of such credit would you spent on farming?

(1). 0 -25% (2). 25-50% (3) 50-75%

(4) 75-100%

37. Approximately how much capital do you hope to put in farming this or next season?...(KSh).

38. Do you usually save any income from farm revenues and use it for purchasing inputs in the next season? Yes /No.

39. If yes, how do you save?

(1).Bank (2).Co-operatives (3).Others (please state).

....

40. Of the three main factors of production; land, labour and capital, which one do you find more constraining in your farming? Please rank them on a scale of

1to 3, where 1 is the most constraining and 3 the least constraining of the three.

(1)...

(2)..

(3)..

41. What do you think could be done to counter such constraints in the region?

....

SECTION F: Farm Productivity and Marketing

42. How much do you harvest from the various crops and what prices do the crops usually fetch in the regional/area markets? Please fill the table below.

Crop	Yields (B) (90kg Bags)	Price per 90 kg bag(C) (Ksh)	
		During Surplus	During Scarcity
1. Maize			
2. Sorghum			
3. Conventional rice			
4. NERICA rice			
5.			

43. Do you produce any of the above listed crops with intention to sale for profit? Yes /No.

44. If yes, which ones and what proportion of the total harvest do you usually sale?

Please fill in the table below.

Crop	Percentage Sold: (0-25%, 25-50%, 50-75%, 75-100%)			
	0-25%	25-50%	50-75%	75-100%

45. How do you sell your produce? (Cooperative, farmers group, individually,) other marketing

Channels please state...

46. Where do you majorly sell your produce (local market, farm-gate brokers, factory, etc), ...

47. Has market access, price regimes and/or quality requirements affected your production in any way? If so, please briefly explain how such market dynamics have affected:

a). the type of crop you grow...

....

b). the quantity of crop you produce...

....

48. What would you say are the major challenges faced in your farming?

....

49. What would you recommend as solutions to the problems faced by farmers in this region?

....

....

SECTION G: RESEARCHERS (KARI & COLLABORATORS).

Details of the Researcher/Respondent:

Prof/Dr/Mr/Mrs/Miss...

Contact (Tel. No.)..

1. What would you say is/are the main reason(s) why Kenya needs NERICA?

....

....

2. Is there any strength(s) the conventional rice has over NERICA?

....

....

3. What are the average production costs for maize, sorghum, conventional rice and NERICA? Please fill the in the table below.

	Maize			Sorghum			Conventional rice			NERICA rice		
Type of input (Expense items)	Unit cost	Units	Amount	Unit cost	Units	Amount	Unit cost	Quantity	Amount	Unit cost	Quantity	Amount

5. How available are the inputs for NERICA, especially the planting material/seeds?..
....

6. Do farmers have the capacity to manage NERICA rice as to enable them reap the potential benefits?
....

....

7. What should be to be done to enable farmers to improve on their field management abilities especially as regards production of NERICA?

8. Given farmers' abilities and Kenyan agro-ecological conditions, what would be the average yields for NERICA at farm level?
....

9. Are there any key quality differences between NERICA and the conventional rice that could significantly affect consumer tastes and preference?
....

In your opinion, how would NERICA prices compare with the conventional rice prices?...
....