Optimum crop enterprise combination in sugarcane based farming systems: A case of sugarcane and maize in busedde sub-county, Jinja District, Uganda

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Abstract

The present study titled "Optimum crop enterprise combination in sugarcane based farming system: a case of sugarcane and maize in the vicinity of Kakira sugar estate specifically Busedde sub-county, in Jinja District", it was undertaken to find a way how sugar cane and maize enterprises can be combined using the available limited resources in order to maximize profits and solve the problem of food security, as well as ensuring sustainable land management. Simple random sampling was used in selecting sample farmers, were by three parishes were selected, and two villages from each parish were considered for detailed study. From each village, 10 small scale sugarcane famers were selected randomly and all together 60 famers were considered in the study. The required data was collected using check lists and personal interviews. Linear programming was used in developing optimum plans for maximization of profits.

Findings of the study indicated that 83.3% of the people in the study area depend on maize as the main source of food. Also the farmers should use 25% for maize and 74% for sugarcane of the total land utilized for agriculture. In addition sugarcane contributed an average net return of 13,360,354 Uganda shs, and maize 526,960 Uganda shs per hectare to farmer's income with in a period of five years. The net present value analysis indicated that sugarcane growing Project is a profitable enterprise however its not advisable to carry it out as a single project because the out comes can not cater for all requirements for the house hold.

In conclusion in order to solve food security issues in the area the small scale sugarcane out grower should produce 1units of sugarcane and 1 unit for maize, for a period of five years using 1.8 ha of land for sugarcane and 0.6 ha for maize and full utilization of the available labor and seeds, of the total resources available, in order to maximize profits that can enable them to avail their families with enough food for a period of five years in the sub county of Busedde in the vicinity of Kakira sugar estate.

Introduction

Background

Africa's socio economic development is mainly agrarian and about 70 percent of the labor force and 80 percent of its poor people are directly or indirectly engaged in agriculture, live in rural area and depend on agriculture for livelihood (New partnership for African development-NEPAD, 2004).

According to the state of environmental report (2010), agricultural sector in Uganda is composed of crop and animal production, forestry and fisheries and the associated trade and processing industries. Agriculture continues to dominate the Ugandan economy albeit at a continually a declining level. Agricultural production contributed approximately 15.1 of the total GDP in 2009 down from 15.7 percent of GDP in 2007/2008. At current market prices, agriculture contributed 22.5 percent of GDP in 2010 compared to 23.7 percent in 2008/09 and 21.2 percent in 2007/08. The sectors share of exports and employment however remained at 90 and 80 percent respectively in 2009. The sector also constitute about 40 percent of manufacturing sector through food processing. The sector supports 24.6 million people of the estimated total Ugandan population of 30.7 million people. In addition agriculture is important in simulating economic growth through the supply of raw materials to agro industries,
supporting the development of food security system, income enhancement and employment. (Kitutu et al., 2010).

Agriculture is the most important sector of the economy, employing over 80% of the work force (Uganda economy profile, 2012). Over 70% of the population of Uganda is engaged in agriculture, most of the farmers cultivate <5.0 Ha of land (Misango, 2008).

The agricultural system in the Busoga region is majorly occupied by the sugar cane farming system which is practiced in most of the areas of Jinja district and Mayuge district. A good % of the farmers in South Busoga region do grow sugarcane while others are picking up (Misango, 2008).

**Crop combination and food security issue.**

Crop combination analysis technique was evolved by weaver to delimit agricultural regions which, he argued, are not regions of simple monoculture as suggested by the names Corn Belt, or spring wheat belt, but are areas of combinations of crops. (http://www.answers.com/topic/crop-combination-analysis)

In the region sugar cane is being grown with other crop, such as maize, banana, coffee, sweet potatoes and cassava, and about 15 years ago, Busoga region was well known for its production of a wide variety of food crops especially maize, sweet potatoes and fruits like oranges. The people also used to intercrop their farms with Coffee and cotton that served as cash crops (http://www.sunrise.ug/news/national-news/4386-plan-to-limit-sugarcane-growing-in-busoga.html)

The increased growth of sugar cane in the region especially in the sub county of Busede has contributed to the increased food insecurity in the region, and best combinations to give the farmer desired result is a decision they often take by trial and error method, therefore the outcome of this study is to provide answers to which enterprise combinations between sugar cane and maize would be the most profitable venture in order to solve the problem of food insecurity in the region.

In agriculture, as in any other business, the efficiency is achieved by an optimum utilization of resources. Resources include land, labor, capital, irrigation facilities etc. Optimum allocation of land and other resources is defined as what crops to undertake, how much land to allocate to each crop activity and what method and combination of inputs to use for each crop so that the farm returns are maximum (Varalakshmi, 2007)

This study attempts to analyze the possibilities and prospects of increasing the net farm income and reducing the increasing food insecurity problem by rational resource allocation through optimum crop enterprise combination for the case of sugar cane and maize in the vicinity of kakira sugar estate.

**Problem statement.**

The sugar industry in Uganda provides employment to the population, an estimate of 20,000 people provide work force on the estates alone and it provides livelihood for many more in jarggery estates and those involve the out growers (Mukiibi, 2001).

The increasing number of farmers in the vicinity of Kakira sugar estate is concentrating on sugar cone growing were by most of the land in this area is used for sugar cane growing, which is grown in isolation which is done in the disguise of it being profitable as the different reports indicate it that is according to Mukiibi , (2001). This has lead to the increasing food crisis in the areas of Eastern Uganda because sugar cane growing is not a sustainable farming system since its associated with monoculture which reduces the productivity of the soil for planting of other crops like maize ,cassava, banana, beans and sweet potatoes for the purpose of food security.

There is an ever increasing concern about the ever-worsening food crisis and the capability of agriculture to satisfy the food requirements of a fast-growing population with in the vicinity of Kakira sugar estate; this has been majorly due to the increased expansion of sugar cane growing by the farmers in this area.
The above problem is because it’s not known by the farmers how best they can combine the sugarcane growing with other food crops such as Maize using the available resources in order to reduce the problem of food security with in the vicinity of Kakira sugar estate. This research provides critical information about the relationship between food security and profitability, by determining the best combination of sugarcane growing and maize in a sugar cane based farming system in the vicinity of Kakira Sugar Estate.

Significance of the study

This study is important to different stakeholder that is through use of its findings. It provides critical information about the contribution of sugar cane and maize to farmer’s income in the vicinity of Kakira sugar estate and also how best maize as the main food crop within the area can be optimally combined with sugarcane growing. This optimal combination improves the farmer’s well being in terms of food security and income and also to benefit the company of Kakira Sugar Estate and the sub county plus the country as a whole in decision making and Land use planning for sustainable food security and climate change adaptation in Africa.

Objectives of the study

General objective

To determine the optimal crop enterprise combination in a sugar cane based agricultural system in the vicinity of kakira sugar estate specifically Bussede sub county. (For the case of maize and sugarcane)

Specific objectives of the study.

a). To identify the main food crop and its contribution to farmer’s income in the vicinity of Kakira sugar estate
b). To find out the contribution of sugar cane growing to farmer’s income in a sugar cane based farming system.
c). To determine the optimal crop enterprise combination in the vicinity of Kakira sugar estate.
d). To identify recommendations about the best crop combination in a sugar cane based farming system in busedde sub county, Jinja district

Objective questions.

a). What is the major food crop in the vicinity of Kakira sugar estate?
b). How much land is used for sugar cane growing in the vicinity of Kakira sugar estate?
c). How much land is used for the main food crop in the vicinity of Kakira sugar cane estate?
d). What is the contribution of sugar cane growing to farmer’s incomes?
e). What are the returns of both sugar cane and the main food crop?
f). What and how much requirements are needed for sugar cane growing?
g). What and how much requirements are needed for the main food crop?

Methodology and materials used

Description of the study area.

The research was carried out in the sub county of Busedde, the sub county is made up of five parishes which include Bugobya, Kisasi, Nalinaibi, Itakaibolu and Nabiambala .The study covered three parishes of the sub county that is Kisasi, Bugobya and Nalinaibi ,and the study area is located in Jinja district (Eastern part of Uganda) and it is with in the vicinity of Kakira sugar estate. The estate is located in jinja District, approximately 10 miles(16km) east down town Jinja on the highway to Iganga .The coordinates of the town 00 30 00N , 33 16 48E(Latitude:0.5000; Longitude:33.2800) , and occupies a land.
area of about 37 square kilometres. The agricultural system in the study area is majorly sugar cane based farming system.
**Stakeholder assessment**

**Table 1: Stakeholders’ analysis**

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Interest, influence, type and adoption</th>
<th>Government (NEMA)</th>
<th>Kakira sugar estate (KSWL)</th>
<th>Farmers (out growers)</th>
<th>Sub county (CBOs and NGOs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Influence</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Secondary</td>
<td>Primary</td>
<td>Primary</td>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Adoption capacity</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

1-high, 2-medium, and 3-low

**Research design**

The study was conducted using a combination of approaches to obtain primary and secondary data as follows:

Check lists and key informant interviews targeting relevant farmers and leaders of farmers and other farmers in Busedde Sub County.

Document reviews of publications and reports of key actors in the agricultural sector. These included reports from the district and other agricultural research reports and books from Kakira sugar estates library and public libraries. This helped to obtain the secondary data.

Case Studies were taken from particular out growers of Kakira sugar estates in different parishes of Busedde Sub County.

**Sampling design**

**Selection of the area**

Busedde Sub County was selected purposively for the present study as it is one of the sub counties with most of the out growers of sugarcane in the vicinity of Kakira sugar estate, and it’s claimed to have had rampant effect of food insecurity from the findings.

**Selection of parishes and villages**

Among the six parishes in Busedde sub county three parishes are going to be selected and from each parish two villages were selected for a detailed study. The selected parishes were Nalinaibi, Bugobya and Kisasi and the villages were Kakuba, Kisasi, Bugobya, Kiko, Nalinaibi and Nabitambala.

**Selection of farmers**

The list of farmers or out growers from the selected villages was obtained from the list of farmers at Kakira sugar estate. The study concentrated on small scale farmers, and ten farmers were selected randomly from each village and all together 60 respondents were considered in the study.

**Data collection method**

Representative farm households were selected using simple random sampling from the list of small scale sugar cane out growers of Kakira sugar estate in parishes of Bugoby, Kisasi and Nalinaibi in Busedde Sub County from the factory library.

Information on household characteristics, farm size, and management, input costs, farm gate prices and yield was solicited using a check list which included the questions about the farm and interviews were
individuals are asked a series of questions with the hope that they will supply use full information to the decision maker. (Shannon 1993).

Also in addition the observation method of data collection was also used and it involves the use of eyes to observe different aspects during the study, and in this study it was used to observe the main food crop in the study area that is in terms of its area coverage in comparison to other food crops.

**Data processing and analysis tools**

*Tabular analysis*

This involved the computation or the calculation of the means, percentages and other measures, and this was used to determine the social economic characteristics of the respondents with in the vicinity of the study for example the level of education, period of in the field of agriculture and others.

*Average gross returns and average net returns*

It involves the calculation of the average gross profit and average net profits of different enterprises and its and under this, profit returns of each crop were calculated by multiplying the average price of that crop with the average out put per hectare to obtain the gross returns. The average net return was calculated through subtraction of the average expenditure from the average gross returns of the enterprises. The average gross return and the average net returns were used to indicate the contribution of the different enterprises to farmer’s income, and also were used in the model linear programming model.

That is, 

\[ \text{Max} = \text{average price} \times \text{average yield} \]  

For average gross return

Average Net returns =Gross returns–Expenditure.

According to Hans Ruthenberg (1976) Net return (NR) is the most appropriate measure if the purpose is an accounting evaluation of past or future projected performance. It is obtained as:

\[ \text{NR} = \text{TGR} - \text{TC} \]

Where TGR, total gross return of the enterprise, is the sum of all outputs times their prices, real or imputed, and TC is total enterprise cost, again real or imputed.

*Net present value analysis.*

It is defined as the sum of the present values (PVs) of the individual cash flows of the same entity. NPV is an indicator of how much value an investment or project adds to the firm, and when the NPV is greater than 0 then the investment would add value to the firm, when it is less than 0 the investment would subtract value from the firm and when it is 0 the investment would neither gain nor lose value for the firm (http://en.wikipedia.org/wiki/Net_present_)

The net present value in this study was used to determine the profitability of the sugar cane enterprise as it take along period of time and to also find out whether it adds value to the farms of the house holds, it was calculated using a discount rate of 15% for each period and the average net returns from the different life cycles of sugar cane project that is the plant, raton 1 raton 2; and raton 3. It is given by the formula below,

\[ NPV = \sum_{i=0}^{n} \frac{\text{present values}}{(1 + \text{rate})^i} \]

Were i is the time period of the project..

*Linear programming analysis.*

It is a mathematical technique used in computer modelling (simulation) to find the best possible solution in allocating limited resources (energy, machines, material, money, personnel, space, time and others) to achieve maximum profits or minimise costs. (http://www.businessdictionary.com/definition/linear-programming.html).
Linear programming (LP) was used to determine the optimal crop combination in a sugarcane based agriculture based farming system, and the maximum profits obtained is going to be compared with the calculated requirement for food security in monetary terms to determine the level of food security in the area. It was also used to determine the way how the resources available in the region can be combined in order to maximize profits through use of the optimal decisions that was obtained by linear programming.

Mathematical specification of the linear programming model

Max \( Z = W_1X_1 + W_2X_2 + \ldots + W_jX_n \) \hspace{1cm} (1)

Subject to.

\[ B_1X_1 + B_2X_2 + \ldots + B_iX_n < M_0 \] \hspace{1cm} (2)

\[ X_n \geq 0 \text{ for } j = 1 \ldots n \] \hspace{1cm} (3)

Where

\( (Z) \) = objective function.

\( W_j \) = per unit cash return of jth activity \( \text{were j = 1, 2, 3 \ldots} \)

\( X_n \) = enterprises \( \text{were n = 1, 2, 3 \ldots} \)

\( M_0 \) = level of resources available

\( B_i \) = amount of ith resource consumed by each activity per hectare.

Equation (1) is the objective function.

Equation (2) is the constraint inequality.

Equation (3) is the non negativity inequality.

The objective function

The objective function for the model in this study was to maximize the annual net returns on the farm (from maize and sugar cane crop enterprises) subject to the resource constraints specified in the model. The total average net returns were calculated by deducting variable expenses from total average gross returns. The various items of variable costs were cost of seeds, human labor (weeding, ploughing, planting, harvesting), transport costs, and land rent. In this model the value of objective function (the optimum solution) which was to be maximized included the sum of the year’s average total net returns.

The maximized average net returns was compared to the monetary value of yearly household food requirement calculated for the case of Mayuge by Isabirye (2005) in order to assess the level of food security in the area.

Resource constraints in the model.

In this model the resources which seemed to be so important to the farmers and they were in limited supply were considered that is the type of constraints included in the model were physical resource constraints, and among these included labor constraint inters of the average number of workers used on the farm in the different activities, seeds constraint in terms of kilograms used, land constraint in terms of acres and the non negativity production constraint.

Degree of utilization of the constraints at the maximum profits.

The degree of utilization of the resources indicated the percentage of the resources used when the firm has maximized the average net returns with in a given period of time and this was used in determining the percentage of the resources which should be used of the available resources scarce resources to the small scale farmer in a period of five years in order to maximize profits.
This formula was used $b_i = (d/g)\times 100$

Where $b_i$ is the percentage value of the resource utilization, $d$ is the average amount of the resources utilized and $b$ is the average total amount of the resource available in the period of five years.

**Assumptions based on the study**

It was assumed that the farmer entirely depends on agriculture for his or her living by it’s the only source of income to the farmer and the net returns gained by the farmer are used to purchase food in the home.

A period of stable economic condition was also assumed over a period of five years.

It was also assumed that sugar cane project takes approximately five year consisting of the plant and three ratons, and for the case of maize there are two seasons with in a period of one year that is 10 seasons in five years with a stable bimodal type of rain fall.

All the assumptions of linear programming were considered that is, linearity, divisibility, limitedness, non negativity, additivity and fixed proportionality.

It was also assumed that the physical condition of the soil favors the growth of crops for a period of five years.

**Results and discussion**

*Socio-economic characteristics of the sample farmers.*

**Family size.**

For the case of the family size the study considered the number of people at home of an individual irrespective of the gender disparities, and in the family of a small scale individual it was found out that they consist of an average number of 6-8 people as indicated in Table 3.1 below.

**Line of employment.**

In the study most of the sample farmers are employed in agriculture that is 80 percent of the sample farmers depend on agriculture as the source of income as indicated in the Table 3.1 below and a few of the people are employed in other economic activities such as Boda boda riding, teaching and trade. This indicated that the dominant activity in the vicinity of Kakira sugar estates especially in the sub county of Busede depend on agriculture as the major source of income and this is in line with the view that, Most of the Uganda population live in rural areas and directly depend on agriculture and related activities for their livelihood (Uganda Bureau of statistics, 2002). Also that agriculture is the most important sector of the economy, employing over 80% of the work force. (Uganda economy profile 2012), and in addition also from the findings of Misango (2008) 70% of the people in Busoga region solely engaged in agriculture as their business, growing sugarcane as their major cash crop.

**Gender**

From the analysis most of the sample famers in the study area were male that is 85 percent of the respondents were males as indicated in Table 3.1 below and this indicated that most of the people who own the farms in the study area males.

**Period in the agriculture sector**

The period spent in agriculture was indicated by the amount of years spent in the agriculture sector and this was handled in different categories as indicated in Table 3.1 below, and from the analysis it was found out that most of the sample famer fall into the category of 10-19 years that is 40 percent of the respondents were with in that category. Their period in agriculture account for their being small scale farmers.
**Level of education**
Most of the sample farmers in the study area reached at least the secondary level of education that is 58.3 percent of the farmers fall in the category of the secondary level of education as indicated in the Table 4.1 below.

**Level of fertilizer use.**
From the findings of the study most of the sample respondents do not apply fertilizers, were by nearly zero percent of the respondent were using fertilizers and 100 percent of the respondents were no using fertilizer and this accounts for their low yield as indicated in the Table 1 below. And from the findings of the study the farmers claim that “the fertilizers are very expensive yet they have no enough capital and so they decide to abandon them” (per-Sekibungo).

<table>
<thead>
<tr>
<th>Parameter number</th>
<th>Parameter</th>
<th>Unit</th>
<th>Average values</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Family size</td>
<td>No. people(average)</td>
<td>6-8</td>
</tr>
<tr>
<td>B</td>
<td>Employment opportunity</td>
<td>No. Percentages</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Agriculture</td>
<td></td>
<td>48 (80)</td>
</tr>
<tr>
<td>1</td>
<td>Other fields</td>
<td></td>
<td>12 (20)</td>
</tr>
<tr>
<td>C</td>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Male</td>
<td></td>
<td>51 (85)</td>
</tr>
<tr>
<td>1</td>
<td>Female</td>
<td></td>
<td>9 (15)</td>
</tr>
<tr>
<td>D</td>
<td>Period in agriculture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0-9</td>
<td></td>
<td>19 (31.7)</td>
</tr>
<tr>
<td>2</td>
<td>10-19</td>
<td></td>
<td>24 (40)</td>
</tr>
<tr>
<td>3</td>
<td>20-29</td>
<td></td>
<td>5 (8.3)</td>
</tr>
<tr>
<td>4</td>
<td>30-39</td>
<td></td>
<td>6 (10)</td>
</tr>
<tr>
<td>5</td>
<td>40-49</td>
<td></td>
<td>3 (5)</td>
</tr>
<tr>
<td>6</td>
<td>50+</td>
<td></td>
<td>3 (5)</td>
</tr>
<tr>
<td>E</td>
<td>Education level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Non</td>
<td></td>
<td>7 (11.7)</td>
</tr>
<tr>
<td>2</td>
<td>Primary</td>
<td></td>
<td>11 (18.3)</td>
</tr>
<tr>
<td>3</td>
<td>Secondary</td>
<td></td>
<td>35 (58.3)</td>
</tr>
<tr>
<td>4</td>
<td>Tertiary</td>
<td></td>
<td>11 (18.3)</td>
</tr>
<tr>
<td>F</td>
<td>Use of fertilizers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Use</td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>2</td>
<td>No use</td>
<td></td>
<td>100 (60)</td>
</tr>
</tbody>
</table>

Note, the values in the parenthesis indicate the percentage to the total. (Source- primary data)

Main food crop in the study area.
Figure 1: Food crops in the study area

From the Figure 3.1 above, a number of food crops were and most of the respondents depend on maize (Zea mays L) as the main food crop in the that is 83.3 percent of the people in the study area depend on maize for their survival and this indicates that maize is a very important crop in the area and Uganda as a whole and this is in line with the view that Maize (Zea mays L) is one of the world’s important cereal crops (Ambrose et al 2008)

In East Africa, the crop is a major staple food for a large proportion of the population, in addition to being an important animal feed. Also Maize is gradually becoming a very important cereal in Uganda in terms of area under cultivation, production and human consumption. In an average year, maize acreage accounts for about 10 percent of the total area under annual crops and maize consumption accounts for about 12 percent of cereals consumption (An overview of maize in Uganda, Ambrose Agona, Jane Nabawanuka H. Muyinza) http://www.egfar.org/.../A-2-008-001-A18_Maize_in_Uganda.

Contribution of sugar cane and the main food crop (maize) to farmer’s income.
The contribution to farmers income is this research was based on the net returns got from the two enterprises that is sugar cane and maize and this was analyzed using a budget as shown in the Table below 2 below.
Table 2: Analysis of the average cost and average returns for maize and sugar cane for a period of five years

<table>
<thead>
<tr>
<th>Crop enterprises</th>
<th>Sugar plant</th>
<th>sugarcane raton 1</th>
<th>sugarcane raton2</th>
<th>sugarcane raton3</th>
<th>Maize years for 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average costs (shillings/ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ploughing</td>
<td>309,671.605</td>
<td></td>
<td></td>
<td></td>
<td>809,666.67</td>
</tr>
<tr>
<td>Planting</td>
<td>250,617.284</td>
<td></td>
<td></td>
<td></td>
<td>486,629.65</td>
</tr>
<tr>
<td>Weeding</td>
<td>36,255.140</td>
<td></td>
<td></td>
<td></td>
<td>505,145</td>
</tr>
<tr>
<td>Harvesting</td>
<td>475,884.774</td>
<td>475,884.774</td>
<td>475,884.774</td>
<td>475,884.774</td>
<td>374,074.07</td>
</tr>
<tr>
<td>sub total cost</td>
<td>1,398,725.10</td>
<td>1,398,725.10</td>
<td>1,398,725.10</td>
<td>1,398,725.10</td>
<td>2,175,515.38</td>
</tr>
<tr>
<td>seeds (tones)</td>
<td>175,057.03</td>
<td></td>
<td></td>
<td></td>
<td>209,396.45</td>
</tr>
<tr>
<td>Transport</td>
<td>126,963.24</td>
<td>126,963.24</td>
<td>126,963.24</td>
<td>126,963.24</td>
<td>No transport costs</td>
</tr>
<tr>
<td>land rent</td>
<td>166,831.58</td>
<td>145,800</td>
<td>145,800</td>
<td>145,800</td>
<td>3,288,065.84</td>
</tr>
<tr>
<td>trash alinement</td>
<td>143,1000</td>
<td>145,800</td>
<td>145,800</td>
<td>145,800</td>
<td></td>
</tr>
<tr>
<td>Average total expenditure</td>
<td>7,485,873.4</td>
<td>1,891,324.01</td>
<td>1,891,324.01</td>
<td>1,891,324.01</td>
<td>5,672,977.67</td>
</tr>
<tr>
<td>Average yield/ha</td>
<td>98.8 (t)</td>
<td>93.8 (t)</td>
<td>93.13 (t)</td>
<td>93.13 (t)</td>
<td>11,111 (kgs)</td>
</tr>
<tr>
<td>Average price</td>
<td>70,000</td>
<td>70,000</td>
<td>70,000</td>
<td>70,000</td>
<td>558 (per kg)</td>
</tr>
<tr>
<td>Average gross returns/ha(shs)</td>
<td>6,916,000</td>
<td>6,566,000</td>
<td>6,519,100</td>
<td>6,519,100</td>
<td>6,199,938</td>
</tr>
<tr>
<td>ANR/ha(shs)</td>
<td>-569,873.4</td>
<td>4,674,675.99</td>
<td>46,277,75.99</td>
<td>46,277,75.99</td>
<td>526,960.33</td>
</tr>
<tr>
<td>ANR/ha(shs) for 5 years</td>
<td>13,360,355</td>
<td>13,360,355</td>
<td>526,960</td>
<td>526,960</td>
<td></td>
</tr>
</tbody>
</table>

Contribution of the main food crop (maize) to farmer’s income.

As per this study maize growing was one of the major contributors to the farmers income and on average the area used for cultivation of maize was 1.51667 acres (0.6138 hectares) of the overall land available to a small scale farmer and this contributes much to the livelihood of the farmers in form of both providing food and providing income for other family needs and this is in agreement with the view that, Maize is Uganda’s most important and highly cultivated crop. It is the number one source of income for most farmers in Eastern, Northern and Northwestern Uganda and is a key staple food crop. http://programs.lwr.org/site/c.asKTjbNP112F/b.8022175/k.23FF/Improving_Livelihoods_of_Farmers_Through_Enhanced_Participation_in_the_Maize_Value_Chain.htm

Contribution of maize basing on the average net returns.

From Table 2 the average yield of maize by a small scale farmer in the study area was 900kgs per acre (11,111 kgs per hectare) for a period of five years with an average price of 558 shillings per kilogram and this yielded an average net returns of 526,960 Uganda shillings per hectare with in the five years, which is the contribution to farmers income basing on the assumption that was used in the study that the average net returns per acre of maize indicates the contribution of maize to farmers income. The farmers in the study majorly depend on local seed varieties and also it was found out that the do not apply fertilizers and this account for the low returns from the maize as also noted that, despite the importance of Maize production that is accorded in Uganda, farmers continue to face a number of challenges. Maize farmers lack access to quality inputs and the technical knowledge needed to improve farm production.
According to (http://www.egfar.org/.../A-2-008-001-A18_Maize_in_Uganda) was found out that most of the maize that is got is used for home consumption that it is used as food and the remaining portion is sold in order to get other home requirements such as clothes and school fees for the children. But this is contrary to the view that about one percent of the total maize produced in Uganda is consumed by the household on the farm and the rest of the crop is sold. This means that maize is now produced mainly for sale.

**Contribution of sugar cane to farmer’s income.**

From the result of the findings sugar cane is the main cash crop in the study area and sugar cane cultivation occupies about 4.416667 acres (1.7874 hectares) on average of the total land area owned by the small scale farmers in the study area as indicated in Table 3.4 below and from this sugar cane is the main source of income in the study area, and this is in line with the argument that the cultivation of sugarcane provides a livelihood for millions of farmers and estate workers around the world. (http://solidaridadnetwork.org/sugarcane)

This is similar to what was found out by Singh et al (2008) that in western Uttar Pradesh region major income source of farmers in the area has been found sugarcane (58 per cent), followed by livestock and cereal crops.

**Contribution of sugar cane based on the average net returns.**

From the findings of the study basing on the formula defined for calculating the net returns a small scale farmer in the study area maximizes an average net return of 13,360,354. Uganda shillings per hectare for a period of five years as indicated in Table 2 above.

Comparing the net returns of maize and sugar cane as indicated in Table 2, this indicates that sugar cane is a profitable business compared to maize and from this study it was found out that the people in the area majorly depends on income from sugar cane growing though it is associated with a lot of problems and from this study it was found out that sugar cane growing leads to problems such as soil erosion, reduction of soil fertility, climate change in general and food insecurity because most of the land is used for sugar cane growing and less is used for growing food crops such as maize.

However, assuming an individual only grows sugar cane as the only source of income, then the average net returns got from sugar cane growing is not enough for a family of six people to survive for all the requirements in the home. That is as indicated in the food required for the period of five years is 12,750,000 Uganda shillings, it means that the remaining balance is 610,355 Uganda shillings from the average returns per hectare, which when divided by the number of days within the five years the money available for use by a farmer a day is 339 Uganda shillings a day.

The above indicates that the growing of sugar cane with out caring out any other employment opportunity or with out growing any other food crop in order to reduce on the money spent on food, sugar cane growing as a single project by an individual or by a farmer is not profitable.

There for it is not advisable to only grow sugar cane with out growing other food crops with in the study area.

**Contribution of sugar cane basing on the net present value**

<table>
<thead>
<tr>
<th>Table 3: Net present value of sugar cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data (bank discount rate)</td>
</tr>
<tr>
<td>15%</td>
</tr>
<tr>
<td>-569873.4</td>
</tr>
<tr>
<td>4, 674,675.99</td>
</tr>
<tr>
<td>4627775.99</td>
</tr>
</tbody>
</table>

Transforming rural livelihoods in Africa: How can land and water management contribute to enhanced food security and address climate change adaptation and mitigation?  
The positivity of the net present value indicates that the investment in the sugar cane project is financially attractive. And from the above findings it was found out that sugar cane enterprise contributes to a large extent to farmer’s income in the vicinity of Kakira sugar estate specifically in Busedde Sub County.

**Optimal resource combination.**

Under this the interest was to find out the optimal solutions that maximizes net returns and also to find out how the sugar cane and maize crop enterprises can be combined using the available resources in a period of five years.

Before examining the details of determining the optimal combination of sugar cane and maize crop enterprises, the farm resource base and crop requirements were assessed. It was calculated that the mean farm size in the study area was about 2.6305ha and this was the land constraint. The total average labor supply on each farm for a period of five years was 195. This was the farm’s labor constraint disregarding the possibility of using labor from the house holds. On average the amount of seeds supply on the farm for a period of five years measured in kilogram was 7029.58335kgs. The data in Table 3.4 summarizes the resource levels and requirements as well as returns for sugar cane and maize in the study area.

**Table 4: Mean Farm Resource Levels and Requirements for sugar cane and maize in Study area for a period of five years**

<table>
<thead>
<tr>
<th>Resources considered</th>
<th>Average Resource Level available</th>
<th>Resources Required/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Land (ha)</td>
<td>2.6305</td>
<td>Sugar cane 1.78731</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maize 0.613773</td>
</tr>
<tr>
<td>Average Labour (number of people)/ha</td>
<td>195</td>
<td>Sugar cane 140</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maize 55</td>
</tr>
<tr>
<td>Average Seed (kgs)/ha</td>
<td>7029.58335</td>
<td>Sugar cane 7000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maize 29.58335</td>
</tr>
<tr>
<td>ANR(shs)</td>
<td>13,360,354.57</td>
<td>Sugar cane 526,960.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maize 526,960.33</td>
</tr>
</tbody>
</table>
Transforming rural livelihoods in Africa: How can land and water management contribute to enhanced food security and address climate change adaptation and mitigation?


Figure 2: Illustration of optimal combination of maize and sugar cane crop enterprises

In the Figure above the shaded region is the feasible area and crop combinations outside this area are now unattainable by the farmer that is it's the region were by any combination of the resources can yield the famer profits.

In this analysis, the highest corner point that the profit line passes through is (1, 1) which is the optimal solution for the study. That is, if the smallholder farmer grew maize and sugar cane as mono crops or as different crop enterprises for a period of five years with 10 seasons of maize growing and four seasons of sugar cane that is plant, raton 1, raton 2 and raton 3 with in a period of five years, the optimal combination would be the optimal combination would be production of 1 units of sugar cane and 1 units maize for a period of five years using 1.8 ha of land for sugarcane and 0.6 ha for maize and full utilization of the available labor and seeds ,of the total resources available.

The above optimal solutions yield the farmer maximum profits of 13, 887,315 Uganda shillings in a period of five years as indicated by the pay off equation in the Figure 2 above, this plan of allocation helps in increasing the gross margin and the yield got from the two enterprises.

That is there is a difference in the net average net returns received in the existing resource allocation patterns and the average net returns in the optimal resource allocation pattern and this is similar to the conclusion made by Igwe et al, (2013), that resource allocation patterns in the optimum plan were remarkably different from that in the existing plan.

Thus optimal crop enterprise combination will in turn help in improvement of the live hood of the small scale farmers in the study area were by maximum net returns will be generated by the farmers if it is put into practice, and the generated income can be used to acquire the basic needs of the farmers.

This is in agreement with the view that it is recommended that the optimal combination of enterprises be integrated in developing a prototype for the zone. (Igwe et al., 2013)

Degree of utilization of each constraint at the maximum profits.

Table 5: Degree of utilization of each constraint for both maize and sugarcane for a period of five
Transforming rural livelihoods in Africa: How can land and water management contribute to enhanced food security and address climate change adaptation and mitigation?


<table>
<thead>
<tr>
<th>Constraint</th>
<th>Average resources utilized/ha</th>
<th>Average resources available/ha</th>
<th>Average % utilization/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land (ha)</td>
<td>2.4011</td>
<td>2.6310</td>
<td>91.3</td>
</tr>
<tr>
<td>Labor /ha</td>
<td>195</td>
<td>195</td>
<td>100</td>
</tr>
<tr>
<td>Seeds /ha</td>
<td>7029.5833</td>
<td>7029.5833</td>
<td>100</td>
</tr>
</tbody>
</table>

From Table 5 above, for maximization of the average net returns indicated in Figure 3.2 above, 91.3% of the available land should be utilized for both sugar cane and maize enterprises and on the average amount of labor available per ha 100% of the available labor per ha has to be utilized in the production of both maize and sugar cane in the study area, in addition also 100% of the available seeds per ha should be utilized in order to attain the maximum average net profits and the combination of the three leads to the maximum average net returns to the farmer per hectare in a period of five years.

**Table 6: Degree of utilization of each constraint for maize and sugar cane respectively**

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Average resources utilized for maize</th>
<th>Average resources utilized for sugarcane</th>
<th>Average % utilization for maize</th>
<th>Average % utilization for sugarcane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land (ha)</td>
<td>0.613773</td>
<td>1.78731</td>
<td>25.6</td>
<td>74.4</td>
</tr>
<tr>
<td>Labor /ha</td>
<td>55</td>
<td>140</td>
<td>28.2</td>
<td>71.8</td>
</tr>
<tr>
<td>Seeds /ha</td>
<td>29.58335</td>
<td>7000</td>
<td>0.4</td>
<td>99.6</td>
</tr>
</tbody>
</table>

From the Table 6 above, 25% of the average total land utilized has to be allocated for maize and 74% of the average total land utilize has to be directed to sugar cane growing in order to attain the maximum average net returns. Also in addition 28.2% of the average total labor utilized should be directed to maize production and 71.8% of the labor has to be directed to sugarcane growing if the farmer is to attain the maximum net returns with in a period of five years further more most of the average utilized seeds have to be directed to sugarcane that is 99.6% of the utilized seeds are directed to sugar cane only 0.4% of the seeds is directed to maize production per hectare and this indicates that the seeds required by maize per hectare are less that the required seeds for sugar cane for profit maximization.

**Optimal combination and food security.**

Under this the intention was to assess the influence of optimal crop enterprise combination on the level of food requirements in the study area assuming the maximum returns were to be used for purchasing of food for a period of five years.

With reference to the findings of Moses 2005 that in Mayuyge a family of six people require 391 $ to purchase maize meal (1700 kg) to last one year which in this case implied that 1700kg are enough to ensure food security a home for a year, this implies that for a period of 5 years a family of six people requires 1700kg×5 which gives an equivalent of 8500kg.

Using the current unit price of maize meal in the study area that is 1500 Uganda shillings the food requirement in a period of five years costs 12,750,000 Uganda shillings on assumption that the average family size of the small scale famer is six people.

Comparing the required money to purchase food for a period of five years that is 12,750,000 Uganda shillings with the maximum average net returns in the optimal combination of maize and sugar cane enterprises using the available limited resources for a small scale farmer for a period of five years that is 13,887,315 Uganda shillings as indicated in the Figure 3.2 above its enough to purchase the food.
required for the household in the study area and also remain with a balance of 1,137,315 for other requirements and this is so if he puts into consideration of the optimal decisions obtained in this study for a period of five years.

This is in line with the view that developing optimum farm plans for smallholder farmers could lead to the resolution of the food crisis. To date, little attention has been devoted to the role of farm planning in the resolution of the food crisis (Igwe et al., 2013).

However when the remaining balance after securing food, when it is divided by the number of days in a period of five years assuming a year consists of 360 days which totals up to 1800 day and then divided by the family size of six people comes up with an average value of 105 Uganda shillings per day.

Conclusions and recommendations

Conclusions of the study

From the observations, analysis secondary data and face to face interview conducted in the objectives during the study, that is to identify the main food crop and its contribution to farmer's income in the vicinity of Kakira sugar estate specifically in Busedde sub county, to find out the contribution of sugar cane growing to farmer's income in a sugar cane based farming system, to determine the optimal crop enterprise combination in the vicinity of Kakira sugar estate specifically in Busedde sub county and to identify recommendations about the best crop combination in a sugar cane based farming system in Jinja district specifically in Busedde sub county the following conclusions were made;

It has been found that maize is the main food crop with in the sub county of Busedde were by it was found out that 83.3% of the people in the study area depend on maize as the main source of food. In addition it was also found out that most of the people in Busedde sub county depend on agriculture as the source of income and a few are employed in other employment opportunities such as trade, that is 80% of the study population depend on agriculture as a source of income, and most of them depend on income from sugar cane growing because it is proved to be a profitable business as per the study.

However, from the findings of the study it was revealed that sugar cane growing as a single enterprise using the available resources is not a profitable business because it can not enable an individual to both have food and also cater for other requirements in a home. So it is not advisable to grow sugar cane while leaving some resources to growing of other food crops.

Also it has been found out that most of the small scale farmers in Busedde Sub County have spent a period of 10-19 years in agriculture and also most of the farm owners are male and do not apply fertilizers on their farms and this account for the low yields.

Further more it was found out that for farmers to increase their profitability and also solve the problem of food security they should use 25% of the land utilized for agriculture that is for growing maize and sugar cane has to be allocated to maize growing and 74% has to be allocated to sugarcane growing, while producing 1 hectare of maize and 1 hectare of sugar cane. And also in the situation of optimal combination of sugar cane and maize the average maximum revenue gained for a period of five years is enough to ensure food security in the house holds consisting of an average of six people in the study area.

Recommendations.

First and fore most the small scale farmers should adopt the use of fertilizer such as use of the green manure in order to help them in increasing the productivity of the soil and this will in turn increase the yields on their farms hence increasing their levels of incomes and solving the problem of food insecurity in the vicinity of Kakira sugar estate.
Also farmers should find off farm employment opportunities so that they reduce the dependence on agriculture because it is associated with problems which may be beyond their control such as climate change, and this would help in increasing their incomes.

The farmers in the study area should also adopt ways of reducing on the number of dependants and children and these may include family planning in order to reduce on the amount of food required by the house holds in the area.

There is a need for the smallholder sugarcane farmers to adopt new technologies that are cost effective so that they can still continue to make profits from the product such as inter cropping and zero tillage.

Also the small scale farmer should acquire more land for maize production and also land for other food crops in order for them to stop depending on incomes from sugarcane in buying food and this could help in ensuring food security with in Busedde Sub County and Busoga region as a whole.

The small scale farmers should also use improved maize and sugar cane seed varieties which are resistant to the circumstances of climate change in order to increase their yields and also reduce the impacts of climate change on the yields.

Also the problem of food insecurity could be reduced by educating the small scale sugarcane farmers in improved techniques and proper use of available resources to boost their experience in the sugarcane production, hence policies designed to educate sugarcane farmers through proper agricultural extension services could have a great impact in increasing the level of technical efficiency and hence their crease in sugarcane productivity and levels of income.

Acknowledgement

I would like to thank God for enabling me reach this far in my academic life struggles

Also I would like to extend my regards to the staff of Busitema University Namasagali Campus whose moral, friendly, psychological and academic support has enabled me reach this far.

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