PROFIT EFFICIENCY OF RED ONIONS PRODUCTION IN SIRONKO DISTRICT

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DECLARATION

I, Elias MUNEZERO declare that this study is my original work which has never been presented, submitted, or published for any award in any institution of higher learning.

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DEDICATION

I dedicate this thesis to my beloved Mother Francine NDEREYIMANA and all onion farmers around the World.

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LIST OF ACRONYMS

AE	Allocative Efficiency
CD	Cobb-Douglas
DEA	Data envelopment analysis
EAC	East African Community
EE	Economic Efficiency
FAO	Food and Agriculture Organization of the United Nations
FYM	Farm Yard Manure
GM	Gross Margin
Kg	Kilogram
MAE	Master of Science in Agri-enterprises Development.
MP	Monoammonium Phosphate
MT	Metric Tonnes
OPV	Open Pollinated Varieties
ROI	Returns on Investment
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SFA	Stochastic Frontier Analysis
SPF	Stochastic Profit frontier
TE	Technical Efficiency
Tk	Bangladesh currency
TSP	Triple superphosphate
UGX	Uganda Currency
UGX	Ugandan Shillings
VRS	Variables Returns to Scale

ABSTRACT

Onion (*Allium cepa* L.) is one of the most consumed food spices globally due to associated benefits making it a crop with unique market opportunities in agribusiness. Despite Uganda having a favorable climate for red onion production, its production remains very low compared to the world average production. The aim of this study was therefore to analyze the profit efficiency of red onions production in Sironko district of Eastern Uganda. A structured questionnaire was employed to collect data from 216 red onion producers. Analysis was done using descriptive statistics, gross margin, and the Cobb-Douglas type stochastic profit frontier function model. The study results showed that red creole and Afri seed were the only varieties of red onions that were grown in the study area. Onion farmers had an average farming experience of 15 years, had completed primary school. Married males dominated onion production. Additionally, onion production was characterized by low access to credit, extension services, and farmers' group membership. The Gross Margin and Return On Investment revealed that red onion production was profitable in Sironko district. An average of Ugandan shillings 884,500 for Afri seed producers and Ugandan shillings1,724,414 for red creole were obtained per acre of land. Factors that significantly influenced profit efficiency of red onion production include: seed cost ($p<0.01$), fertilizer cost ($p<0.1$), pest control cost ($p<0.05$), weeding cost ($p<0.1$), farming experience ($p<0.1$), extension services ($p<0.1$) and selling price ($p<0.1$). The study recommends that to improve the profit efficiency in onion production, the focus should be on the provision of tailored agricultural extension services and affordable credit facilities to the farmers. Further, appropriate policy instruments and agri-business strategies are needed to spur onion profitability.

Key words: *Profit efficiency, Stochastic Frontier Approach, Descriptive Analysis, red onions, Uganda*

CHAPTER ONE: INTRODUCTION

1.1 Background

Onions (*Allium Cepa* L.) locally known as "***obutungulu***" in Luganda are cool-season biennial crops belonging to the family, *Liliaceae* (Boukary *et al.*, 2012). This vegetable typically cultivated throughout the world as an annual crop is said to have originated from Southwest Asia, (Jo *et al.*, 2020). With a global production of two million metric tonnes, onions are a commercially significant crop on all continents and are fourth among the most consumed vegetables after tomato, cabbage, and watermelon (Ddamulira *et al.*, 2019). China is recognized as the major producer of onions around the world with an annual production of 22.3 million tons. In China, the good quality and affordable prices of onions produced make them competitive on the international market (Joachim, 2018).

Other top onions producers in the world are India, USA, Iran, Egypt, Turkey, Brazil, Pakistan, the Republic of Korea, and the Russian Federation (Pareek *et al.*, 2017). In terms of productivity, the Republic of Korea comes on the top with 66.16 tons per hectare followed by USA (56.26 tons per hectare), Spain (53.31 tons per hectare) and Netherlands (51.64 tons per hectare). Based on their colors, onions are classified into red onions, white onions, and yellow onions, with red onions being the most predominant and highly consumed (Nile *et al.*, 2021).

Onions are one of the important ingredients of daily meals by households and other domestic food preparations including other institutions, hotels, and restaurants. Onions can be consumed as raw and as many other vegetable species, the consumption of onions is not limited to a specific season and the dry bulb onions are harvested after the leaves have died back and the bulbs fully matured.

As a spice, they add flavor to meals and also carry some restorative components important for health. The crop is rich in carbohydrates, proteins, water-soluble vitamins, calcium, iron, and other nutrients (Li *et al.*, 2020). Onions are also produced for medicinal purposes as they contain health benefits like anticancer properties, antiplatelet activity, antithrombotic activity, antiasthmatic activity, and antibiotic effects (Liubov, 2019).

In 2013, the yield of red bulb onions produced among the East African Community (EAC) countries was estimated at 497,843 MT (metric tonnes). Statistics shows that in 2020, there was an increase of 50% in onion consumption in EAC since 2013 and the consumption was estimated to be 743,795 metric tonnes (Kilimo, 2017; USAID, 2021). The trade of onions in EAC is relatively low. However, Onions are the most traded compared to other horticultural crops such as tomatoes. The reasons for extensive trade in onions is due to the fact that onions can be easily transported over long distances and have a long shelf-life. Brokers from EAC region prefer importing onions from Tanzania since onions there are harvested at the right time, have good quality, good size (medium to big), have long shelf-life, and are well dried which are the qualities most preferred by traders and consumers (Dijkxhoorn *et al.*, 2019). In East Africa, the most traded variety at the market is red onions and this is the reason why most farmers prefer producing red onions compared to the other varieties.

Tanzania comes first in onions production followed by Uganda while Kenya and Rwanda's production is even below consumption (Kilimo, 2017). Different varieties including Jamba, Red Creole, Red cornet, Red Bombay, Afri seed, Red Pinoy, Red snack Pearl, Red passion, and Texas Grano are commonly grown mainly in the district of Rakai, Kigezi, Mbale, Sironko, Tororo, and

Mbarara , and onions production in Uganda occupies 3,700 ha with an estimated yield of 147,000 ons per hectare (Bua *et al.*, 2017).

The rapid growth of the Ugandan population contributes to the increase in the demand for foods in towns including onions which are one of the most scarce and expensive food items in different markets of Uganda, especially during the dry season (Tumuhe *et al.*, 2020). Generally, household consumers prefer medium-sized onions that are well rounded while large institutions are interested in the big sizes for the easiest preparations of meals. Onions are also sold to wholesale markets, processing companies of snacks, restaurants, schools, roadside stands, and bigger markets (Rwakipamba *et al.*, 2020)

In different areas of Uganda, onions are grown as a major source of income. However, there is limited access to information on the commercial production of onions and this limits farmers' access to technologies needed to increase the efficiency in onion production. The other challenge faced by most onions farmers is the decrease of the yield due to pests such us thrips in case of late application of pesticides or the use of resistant varieties (Ddamulira *et al.*, 2019). The shortage of post-harvest handling practices and storage facilities is another challenge affecting negatively the efficiency in red onions production, thus rendering onions vulnerable, especially during the rainy season and this makes farmers fail to provide constant and high-quality onions in the market. This also affects onion profitability which pushes them mostly to sell their crop to traders or middlemen when the harvest nears. Therefore, this research aimed to analyze the profit efficiency on all resources used in red onions production.

1.2 Statement of the problem

Onion is one of the most consumed food ingredients globally, making it a crop with unique market opportunities in agribusiness (Ren *et al.*, 2020). In Uganda, onions are among the top vegetables most consumed, and Uganda contributes 47% of onions produced and 41% of onions consumed in East Africa (Nyangau *et al.*, 2022).

Despite its socio-economic importance to the country, onion production remains low in Uganda at just five metric tonnes per hectare. This is only 20% of the world average of 19.7 tonnes per hectare (Ddamulira *et al.*, 2019). Thus, the level of domestic production has failed to meet the increasing domestic and regional demand; a fact that has resulted in remarkable volumes of onions being imported from Tanzania to fill up the supply gap (Dijkxhoorn *et al.*, 2019). Official records shows that Uganda imported up to 18,000 metric tonnes of onions in 2018 (Dijkxhoorn *et al.*, 2019). This volume of imported onions is very high despite Uganda having very favorable climate conditions for onion production. This is not helped by the fact that poor storage facilities in the country contribute immensely to onion post-harvest losses especially during rainy seasons. This pushes onion farmers to sell their produce at giveaway prices, thus explaining the minimum return in onion production which have a negative effect on the profit efficiency of onion farmers (Dijkxhoorn *et al.*, 2019).

Gebremariam et al. (2019) concluded that technological advancement such as the use of good quality and improved onions seeds, the setup of irrigation systems for farmers to produce in the dry season, the market information, among others, intended to increase smallholder farmers' efficiency, would be profitable only if farmers are sufficiently efficient in allocating their available resources. However, it remains unclear how the uptake of modern technologies has improved the

productivity and profit efficiency of this crop. In light this, it was therefore imperative to explore the profit efficiency of onion production. This study, therefore, investigated the profit efficiency of red onions production in Sironko district, one of the high potential production areas located in eastern Uganda.

1.3 Objectives of the Study

1.3.1 General objective

Generally, this study evaluated the profitability and profit efficiency of smallholder red onion producers in Sironko district, eastern Uganda

I.3.2 Specific objectives

The specific objectives of this study were to:

1. Characterize onion producers in the study area
2. Determine the profitability of onion production in the study area
3. Ascertain the factors that influence the profit efficiency of onion production in the study area

1.4 Research questions

The following questions were answered;

1. What are the characteristics of onion producers in the study area?
2. How profitable is onion production in the study area?

3. What are the factors that influence the profit efficiency of onion production in the study area?

1.5 Conceptual framework

Figure 1 shows the interrelatedness of the different variables that are involved in this study. Socio-demographic factors of farmers that include the age, gender, education level, farming experience, household size, marital status and some production variables that include seeds, farm size, pesticides, urea, human labor, and capital can influence either positively or negatively the technical efficiency (TE) of onions production. Farell (1957) initiated a framework of efficiency measurement which was described by Kumar& Gulati (2010) as an excellent measure of resource allocation of a productive unit. When a farm is technically efficient it is usually also profit efficient.

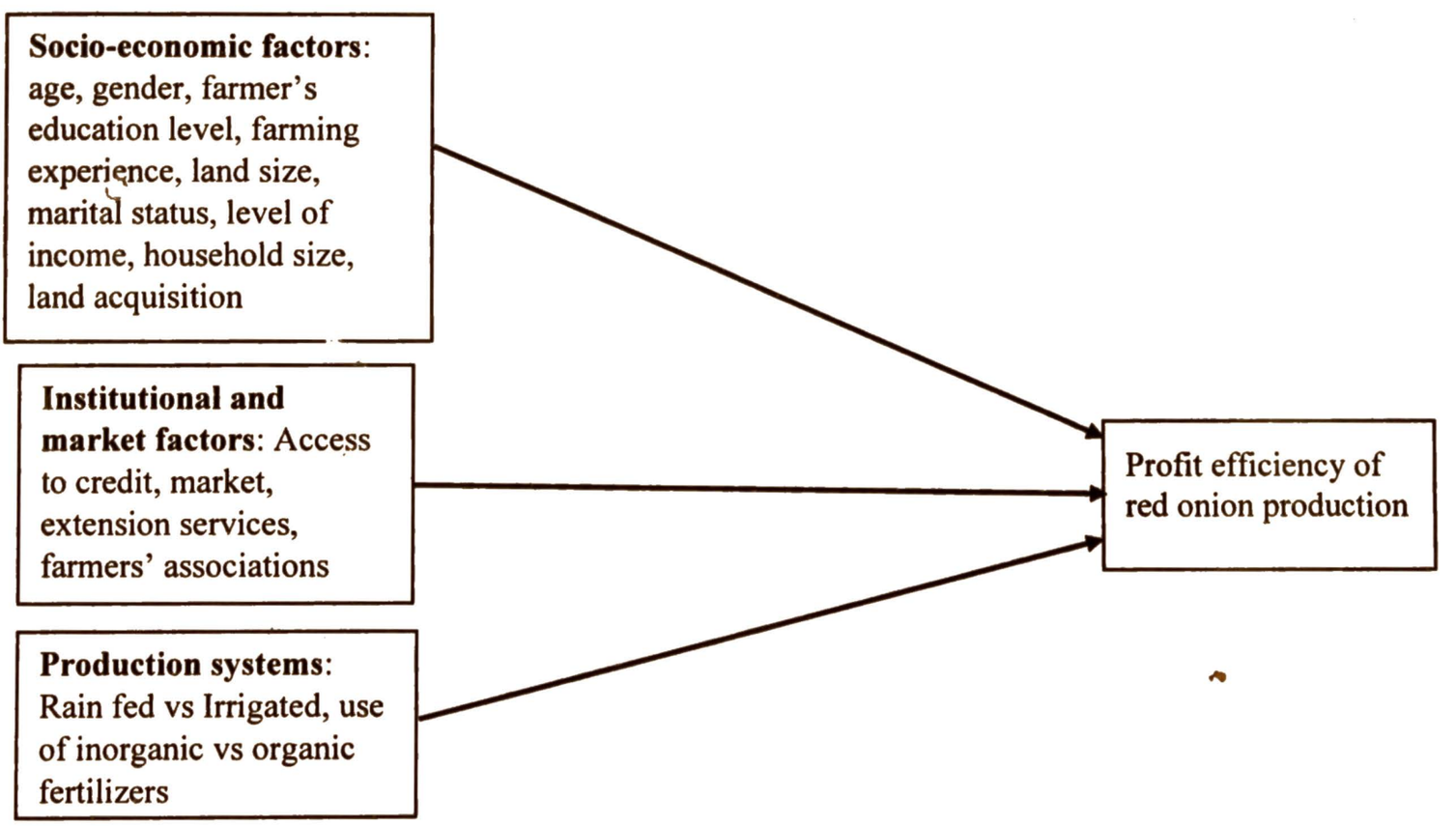


Figure 1: Conceptual framework relating socio-economic, institutional, market and production systems factors to profit efficiency of onions.

Source: *Own conceptualization*

1.6 Scope of the study

The scope of this study was in three dimensions: content, geographical, and time scope. The first scope was in terms of content. This study was designed to understand the drivers of profit efficiency for smallholder red onion producers using cross-sectional data. This was motivated by the desire to understand why the domestic production has consistently failed match local demand for onions in Uganda.

Secondly was the geographical scope and this entailed the investigation of profit efficiency of onion production in Eastern Uganda. The study was conducted based on the reason that the productivity of onions remains low in the country, and data were collected from Sironko district which was chosen as one of the areas where onions are mostly grown in Eastern Uganda (Okiror & Muchunguzi, 2019). It is, therefore, crucial to focus on improving the efficiency of producing this crop to improve household incomes.

Lastly, in terms of time scope, the study focused on red onion farmers where information related to their characteristics, how profitable is their production and the factors that affect onion production were captured. Data were gathered within two weeks of May 2022, and for inclusion in the study, only farmers who cultivated red onions during at least one of the two seasons (rain season and dry season) of the last year 2021 were interviewed.

1.7 Justification of the Study

The profit efficiency analysis of onion production serves as a suitable tool for agricultural researchers and planners. It will also avail farmers of the relative importance of the factors of onion production which may help to make decisions that are expected to enhance productivity. This could

result from the efficiency in the onion production system, thus promoting the economic growth of the country. The findings of this study are expected to attract the attention of researchers as it will provide to them with updated and insightful information related to red onions production in Sironko district. Further, it will promote awareness among scientists, policymakers and technocrats the issues faced by farmers so as to lobby for innovative solutions to enhance their productivity and their level of income.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical framework for efficiency analysis

Gindi *et al.* (2019) and Omotayo *et al.* (2021) described efficiency in three forms; namely technical efficiency (TE), allocative efficiency (AE), and economic efficiency (EE). Omotayo *et al.*(2021) refer to the Technical efficiency (TE) as the effectiveness with which farmers get the maximum possible output using a given level of input or set of inputs. Technically efficient farmers are those that operate on the production frontier which represents maximum output attainable from a given input combination. The inputs generally include capital, labor, and land. All feasible points below the frontier are considered technically inefficient points. In other words, Technical Efficiency leads to profit efficiency (Ogunniyi, 2011).

Economic efficiency consists of technical efficiency and price or allocative efficiency. The capacity of a firm to produce the maximum possible output using a given set of inputs and technology is referred to as Technical Efficiency; while the capacity of a firm to remain on the same production possibility curve by using the least-cost combination of inputs and available technology is called Allocative Efficiency (Lebailly, 2020). Profit efficiency refers to the farm's ability to attain the highest possible profit given the prices and levels of fixed factors of that farm while profit inefficiency is the loss of profit from not operating on the frontier(Musaba & Chibalani, 2021). Profit efficiency in terms of onion production describes the level of efficiency of farmers against the best profit-efficient farmer on the production possibility curve (Lebailly, 2020). Therefore, the stochastic profit function model was employed in this study to estimate farm-specific efficiency directly.

2.1.1 Theory of production

Production theory refers to the principles to be applied in the decision-making process. Production decisions include the decisions to acquire resources (inputs), utilize resources, organize production, distribute the output of the production activity, and in general to manage the unused production resources. Production is the ratio of output to inputs used to produce goods and services. Production is the output of goods and services coming from the production (manufacturing) process. The terms input and output only have meaning in connection with a particular production process. In the agricultural production process, what constitutes input are land, labor, capital, and management resources. The farmer or farm firm whose goal may be profit maximization, output optimization, cost minimization, and or maximization of satisfaction is organizing these resources. The farmer or farm firm has several ways of attaining either or combination of these goals by employing the use of these resources in its production processes (FAO, 2015).

2.2 Methods for assessing the efficiency of agricultural production

The efficiency of agricultural production is mostly assessed using Stochastic Frontier Analysis (SFA) and data envelopment analysis (DEA) (Lebailly, 2020). These two approaches estimate the efficiency frontier and calculate the firm's cost, technical and profit efficiency which are related to (Musaba & Chibalani, 2021).

2.2.1 Stochastic Frontier Approach

The stochastic frontier function specifically measures the relationship between the output and input used in crop production, the mean technical efficiency, and the technical inefficiency of crop

production. As proposed by Meeusen and van den Broeck (1977) Stochastic frontier production function is represented by equation (1):

$$Y_i = f(X_i; \beta) + e_i \qquad (1)$$

Where,

Y_i represents the output of i^{th} farmer, X_i represents the inputs variables of i^{th} farmer and β represents the vector of parameters to be estimated

$$e_i = V_i - U_i$$

V_i represents random disturbances cost due to factors beyond the control of the farmers which is assumed to be independent and identically (iid) distributed with a mean of zero and constant variance of $V \sim N(0, \sigma^2 v)$ and independent of U. U_i = nonnegative random variable associated with technical production efficiency, and is assumed to be independently identically and normally distributed. $U \sim N(0, \sigma^2 u)$ where the conditional mean μ is assumed to be related to farm and farmers-related socio-economic characteristics". The more the magnitude of U_i is great from the production function, the more the higher the inefficiency model of the farmer (Lebailly, 2020).

The stochastic production frontier function used to estimate allocative, technical, and economic efficiency can be estimated by the Cobb-Douglas frontier production function which is shown in equation (2):

$$\log Y_i = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \cdots + (V_1 - U_1) \qquad (2)$$

Where

Log = natural logarithm,

$i = 1, 2, 3, 4.... n$

U_i= Inefficiency component of the error term.

V is a two-sided, normally distributed random error, while *U* is a one-sided efficiency component with a half-normal distribution.

Inefficiency model $U_i = \delta_0 + \delta_i Z_i$, Where: U_i = Technical inefficiency, δo = Constant term, δ_i= Coefficient to be estimated, Z_1 = Gender, Z_2 = Age (in years), Z_3 = Household size, Z_4 = Level of Education, Z_5 = Farming Experience, etc. The value of U_i may be obtained from the observable value of $V_i - U_i$ with the assumption that the composed error. $V_i - U_i$ is known and is the best predictor for technical efficiency.

2.2.2 Data envelopment analysis

Data envelopment analysis (DEA) is a nonparametric approach employed in the analysis of efficiency in crop production and it doesn't allow for stochastic variables and measurements errors, which precludes separating inefficiency effects from random noise and shocks i.e all shortfalls are attributed to the inefficiency term (Geusmi et al., 2015). Nonparametric DEA techniques don't rely on specific functional forms and ignore the stochastic component of production, which can also lead to biased technical efficiency measures. The strength of the DEA approach is that multiple inputs and outputs can be considered simultaneously, and inputs and outputs can be calculated using different units of measurement (Musaba & Chibalani, 2021).

As proposed by Färe *et al.* (1994), the Data Envelopment analysis model can be expressed as in equation (3):

$\text{Max } \phi$ (3)

$\emptyset\lambda$

S.t

$-\emptyset Y_i + Y\lambda \geq 0$

$X_i - X\lambda \geq 0$

$N_1, \lambda = 1$

$\lambda \geq 1$

Where,

$1 \leq \phi \leq \infty$

N represents the number of firms

X represents a d x N matric of inputs

Y represents a 1 x N matrix of outputs

The ratio 1/ ϕ helps to get the technical efficiency scores. The constraint N1' is used to allow variables returns to scale (VRS). That constraint is important in the way that without it, the constant returns to scale will be assumed.

2.3 Onion Production in Uganda

In Uganda, Agriculture occupies a highly important place as it contributes 40% to the Gross Domestic Product (Theeuwen *et al.*, 2021) , and employs almost 80 percent of the population (Mugizi & Matsumoto, 2021). Apart from consumption, onion in Uganda is grown as one of the sources of income, it is also grown for medicinal purposes(treatment of heart and blood diseases) and source of Vitamin D and E (Ddamulira *et al.*,2019). Onion is one of the most consumed food ingredients, making it a crop with unique market opportunities in agribusiness (Kilimo, 2017). Uganda comes first among East African countries in Onion production and Onion is mostly grown in the Eastern region (Kapchorwa, Bukwo, Bududa, Naminsidwa, Bulambuli, Kween, Sironko,

Manafwa, Tororo), Western region (Rukiga, Kabale, Kisoro, Ntungamo, Kasese, Kabarole) and some areas of the Central region (Dijkxhoorn *et al.*, 2019).

In addition, onions can be produced in two different seasons in a year. The first season starts in March and the harvest time is June; the second season starts from September and harvest time is in December. More so, in a wet season, when conditions are favorable and good agricultural practices are used, the hybrid seeds can give a yield that varies from 10 to 20 tonnes per acre per season depending on the variety grown and from 2 to 5 tonnes per acre for OPV (open-pollinated varieties) per season. However, their result revealed also that onion production is challenged by the limited cultivation area and the limited extension services which explain the poor agricultural practices. Ddamulira et al. (2019) in their study found that the major challenges faced by onion farmers are the lack of pesticides on time, the lack of resistant varieties, and the post-harvest losses due to the lack of post-harvest handling practices and storage facilities.

Farmers mostly sell their crops to traders, middlemen, wholesale markets, restaurants, roadside stands, and bigger markets. The most popular varieties traded at the market are Red Creole and Red Bombay (Ddamulira *et al.*,2019).

2.4 Efficiency of Onion Production

Several studies have been conducted on the efficiency of onion production. Haque et al. (2011) adopted the use of gross margin analysis to examine the profitability and efficiency of onion production in some districts of Bangladesh. Their findings revealed that gross margin and net returns were Tk 85308 and 79487 per hectare, respectively. The benefit-cost ratio was found to be 1.85. Inputs like human labor, seedling, manures, urea, TSP (Triple superphosphate), irrigation,

and insecticide had positive effects on the yield of onion. Using a Cobb-Douglas production function, human labor, TSP, insecticides, and seed had a positive effect on profit efficiency and significant co-efficient (Haque *et al.*, 2011). An increase of 1% in seedling, TSP, insecticides, and human labor holding other factors constant led to an increase in onion yield by 0.01, .005, .002, and 0.01%, respectively. However, in the same study, MP (Monoammonium Phosphate), manures, and urea had a negative and significant coefficient on profit efficiency because the soils of the study area contained already the ingredients contained in those inputs.

Khan (2015) conducted research in Pakistan and found that the technical efficiency of farmers varied from 0.7478 to 0.9851. Gamma (γ) was estimated at 0.93, and the production of onions varied as a result of inefficiency factors. In the same study, the Stochastic frontier production function and technical inefficiency model revealed that the production elasticity estimation for the irrigation variable of onion growers rose above the set value that's to say higher (0.7080). The variables for urea, FYM (Farm Yard Manure), irrigation, and pesticides were positive and statistically significant according to an asymptotic t-test. Production elasticity for urea (0.0186), FYM (0.1171), irrigation (0.7080), and pesticides (0.1213) were important in terms of contribution towards higher onion yield. The same author concluded that the efficiency of onion production can be improved through factors that could influence the efficiency of farmers such as better use of urea, FYM, irrigation, and pesticides, and also through improved hybrid technology, by providing either formal or informal education.

Gindi et al. (2019) examined the profitability and technical efficiency of onion production in Nigeria. The result indicated that onion production was profitable and the mean profit efficiency obtained was 83.6%, indicating that there was a 16.4% opportunity for improving efficiency in

2019. In addition, the outcome showed that factors such as the farmers' educational level, years of farming experience, the use of new farming techniques were significant and positively affected profit efficiency of onions farming in the study area.

According to Yasin (2020) in their study conducted in Kelafo District, Somali Regional State, Ethiopia using a sample size of 120 farm households to analyze the efficiency of onion production; the technical, economic, and allocative efficiency of onion production was 70.5, 65.9 and 95% respectively. Their findings revealed also that better use of production technology holding the number of inputs cost constant could lead to an increase of the average farmers' efficiency of their output by 29.5%, 34.1%, and 5% respectively. In addition, family size, age, farm size, education status, experience of household head, access to credit, and access to extension service were found as factors affecting onion producers in the study area. On the other hand, the findings of a study conducted by Lebailly (2020) estimating technical, economic, and allocative efficiencies among onion farmers in the Volcanic Highlands in Rwanda showed that the most important determinants of the efficiency of onions production were seed costs and organic fertilizers. Lebailly (2020) reported also that household size and education contribute significantly to farm efficiency in onion production.

In another study, Abdulkadir, (2015) investigated the determinants of technical, allocative, and economic efficiencies among small-scale onion farmers in the North Wollo zone of Amhara National Regional State, Ethiopia. The results showed that land ownership, land distance, and land fragmentation affect socio-economic characteristics of farm households like training access, years of experience in onion farming, age, market access, farm income, and field visits influence significantly the technical efficiency. Allocative efficiency was found to be affected by different

elements which were market access, plot distance, extension visits, sources of irrigation water, field visits, and farm income. Economic efficiency was determined by soil fertility, age of the household, plot distance, source of irrigation of water, experience in onion production, extension visits, farm income, and land fragmentation. It was also found out that tenure insecurity and land fragmentation played an important role for farmers in the area to adopt the new technologies and maximize the output in the irrigated farms. In addition, other factors like land consolidation among farmers, soil management, and a high level of investment in irrigation services could affect positively the efficiency of onion farmers in the study area.

2.5 Determinants of profit efficiency

Previous researches have revealed onion profit efficiency to be affected by farm size, use of agro-chemicals, seed, labor, farmers' education, family size, access to credit, and onion farming experience. An increase in the size of land cultivated for onion production may increase the output of the commodity, other factors held constant (BAREE, 2012). However, Abdulkadir (2015) in his study conducted in Ethiopia observed that land size had a negative effect on onion yield and was inversely related to the technical and profit efficiency of onion production, signifying the theory of the inverse relationship between land size and productivity in production of onions.

Optimal use of fertilizers and other agrochemicals such as herbicides have also been found to increase the output of onions (Adeoye, 2016). This is expected because low soil fertility reduces productivity and *vice* versa; while heavy weed infestation is responsible for high yield losses. The use of herbicides has been found to contribute significantly to yield benefits in Nigeria (Gindi *et al.*, 2019).

An increase in the output of onion production also depends on the quality and quantity of seeds used. Ddamulira et al.(2019) conducted a peri-urban study in Uganda to ascertained the need for farmers to adopt high-yielding and well-adapted onion varieties to achieve potential yields and profit efficiency, and better incomes. Improved onion varieties were superior in economic yields to the local cultivars. Therefore, emphasis should be put on improving the genotype of the local onion cultivars to enable farmers to attain economic efficiency in onion production. Seed quality mostly influences onion production implying that farmers should observe seed quality as a major determinant of the level of profitability of crop production (Lebailly, 2020). The same author reported also that seeds cost and organic fertilizers cost were significant and positively affected the profit efficiency of onion production, where he stated that a unit increase in seeds and organic fertilizers costs lead to a rise of 71.7% and 14.8% in onion output respectively, holding other factors constant.

Such salient information is still unavailable in the onion production systems of Uganda. Optimized labor for technical and profit efficiency is important in the production process of any crop including onions (Adeoye, 2016). An increase in labor use leads to an increase in onion output, although in some cases it can lead to a reduction in the revenue generated by farmers, if not properly managed. The existence of an imperfect labor market has also been found to cause smallholder farmer households to majorly rely on family labor, in which larger family sizes were found to provide a ready source of cheap family labor (Gindi *et al.*, 2019).

The education level of farmers is another factor that affects the profit efficiency of onion production (Gindi *et al.*, 2019). An increase in the level of education of farmers was found significant and had a positive influence on profit efficiency. The advanced education level of

armers plays a crucial role in technological dissemination, adoption of innovations, research indings, and understanding of factors and product markets which are all paramount in influencing rofit efficiency (Gindi *et al.*, 2019). Similarly, the education of farmers in Kenya showed that armers who were exposed to agricultural seminars, training, and extension had access to technical nowledge and information on agriculture, increasing their profit efficiency (Bakhshoodeh and Shahnushi, 2009).

As for family size, studies in Nigeria showed that smallholder farmers strived to make efficient use of their available resources, and would endeavor to minimize the usage of paid labor, due to the scarcity of resources at hand (Tanko *et al.*, 2012). Many family members help to offset field labor requirements at peak times during cultivation (Berhan, 2015).

Access to credit is an important element that affects onion production (Yasin, 2020). The findings of his study showed that access to credit helps farmers to increase their level of capital during the production cycle and farmers who get credit during the production season perform well than those who do not.

Cumulative experience in onion production was also found to be significant on the profit efficiency of onion production. Experience in the production of onions gives a substitutional measure of managerial and technical knowledge. It has been found that the more years farmers spend growing onions, the more experienced they became (Berhan, 2015), and the more efficient their profit was. Gindi et al. (2019) also ascertained that previous experience aids farmers to set genuine time and cost targets bearing in mind production risks and challenges. This agrees with the findings of Abdulkadir (2015) in Ethiopia, who established that experience had a positive and significant

fect on farmers' technical efficiency in onion production, and therefore, a corresponding effect
ı their profit efficiency.

ased on this review, it is clear that there are limited studies on the factors affecting profit
ficiency of red onions production in Uganda. Moreso, determinants of profit efficiency of red
nions production in other regions may not be applicable in Uganda. This study, therefore aimed
› ascertain the factors influencing profit efficiency of red onions production in Sironko district,
astern Uganda.

CHAPTER THREE: METHODOLOGY

3.1 Study area

This study was conducted in Sironko district in Eastern Uganda. This district was selected based on the fact that it is one of the leading districts in onion production (Bua *et al.*, 2017). Sironko main town is located at 34°15'E and 01°14'N. The district has a total area of 421 km^2 and lies between 1,299 metres and 1,524 metres above sea level. It is a highland area with steep slopes, intensely cropped hillsides, and high population densities. The region has experienced outmigration for many years due to the scarcity of land. The average annual precipitation is about 1500 mm.

The temperature variability in the area is influenced by altitudinal differences, the average maximum temperature of 27–32°C, and minimum temperature of 15–17°C, with an annual average temperature of 21.5°C. The beautiful green scenery has woodlots in the valleys, meandering rivers, streams, escarpments, and waterfalls over the cliffs. Over 80% of the green beauty is crop vegetation, bananas, coffee and seasonal crops, maize, onions, beans, and horticultural crops. Most people in Sironko district are mainly peasants living on small farm holdings. Hand tools such as pangas, axes, and hoes play major roles in opening up fields for cultivation. Due to the hilly terrain and the fragmented nature of the plots, mechanization is not possible in the area.

3.2 Research design

A cross-sectional survey was employed for this study which involved quantitative and qualitative data. It was adopted because it is cost effective, time-saving, good for establishing conclusions across the whole population, and does not require follow-up (Levin, 2006). Primary data were collected directly from the farmers with the use of a well-structured questionnaire.

3.3 Sample size and sampling design

The target population of this study was red onion producers in Sironko district. A multistage sampling procedure was used in the selection of a representative sample. In the first stage, Sironko district was purposively selected based on its predominance in onion farming (Bua *et al.*, 2017). In the second stage, four sub-counties (Namaguli, Namugabwe, Masaba, and Zesui) were purposively sampled based on their relative concentration of onion farmers. In the final stage, a simple random sampling was used to select 54 onion farmers from each sub-county to give a total of 216 onion farmers that were interviewed. This was done using a list that was obtained from the district agricultural production officer. The sample size n was calculated using Yamane's simplified formula expressed as in equation (4):

$$n = \frac{N}{1+Ne^2} \qquad (4)$$

Where n=sample size

N= total size of onion farmers

e = error of precision

The target population in Sironko district is 5000 (Source: Farmer profiling done by HORTIMAP Project) and the error of precision is at e=7%,

$$n = \frac{5000}{1+5000(0.07*0.07)} = 196.07 \sim 196$$

10% of the 196 respondents which is 20 was added to cater for the non-response and this resulted in a total adjusted sample of 216 respondents.

n=216 onion farmers

3.4 Data type and data collection

Primary data were collected using a structured questionnaire from selected red onion farmers found in the study area. A pretest was done in Mbale district 2 weeks prior to the actual data collection to test for validity and reliability of the data collection instruments. Relevant modifications were made to the questionnaire to ensure that all required data for the study is captured. Enumerators were trained on how to administer the questionnaire to farmers. The questionnaire comprised two main sections: The first section collected data on the socio-demographic, institutional, and production characteristics of the respondents, while the second section collected data on the profitability of onions farmers and factors that influence the profit efficiency of onions production in the study area. Secondary data were collected from different sources like Government surveys and the Food and Agriculture Organization (FAO).

3.5 Limitation of the study

Limitations for this study arose from the survey tool that was employed for data collection. A structured questionnaire that was used for data collection was designed in English yet it was administered to semi-literate respondents. This could have adverse effects on the quality of farmers 'responses. However, this was checked by using educated and well-trained enumerators who were able to translate the survey tool items into 'Lumasaba', a local language in the area of the study.

3.6 Data analysis techniques

The collected data were edited and entered into SPSS v25 and STATA 14 for analysis. Prior, to analysis, the SPSS data were cleaned for errors in entry. The data were then summarized, tabulated, and analyzed to achieve the objectives of this study. Data analysis involved descriptive statistics, Gross margin, and stochastic profit frontier model estimation. The subsequent subsections present the details of the analysis methods used for each of the three objectives. The results were presented in the form of tables and inference was drawn from the study.

3.6.1 Characterizing onion producers

In characterizing onion producers, this study utilized the arithmetic mean, standard deviations, frequencies, and percentages were used for objective one which is to summarize the socio-economic characteristics of the respondents. An independent sample t-test was used to compare numerical farmers' characteristics by onion variety cultivated, while, the categorical chi-square test of associated was used to test the association between onion varieties cultivated and categorical farmers' characteristics.

3.6.2 Determining profitability of onion production

Gross margin analysis was employed for the second objective to determine the profitability of onion production in the study areas. Gross margin (GM) analysis is a method of computing the profitability of small-scale enterprises. It is a useful planning tool in situations where fixed capital is a negligible portion of the farming enterprises in the case of small-scale (Gindi *et al.*, 2019).

Profitability describes the financial benefits realized when the revenue generated from a business activity exceeds the expenses as seen in equation 5 It is calculated as total revenue minus total expenses. Mathematically, the GM employed in this study is expressed as in equation (5):

$$GM_{ij} = TR_{ij} - TVC_{ij} \quad (5)$$

Where ij is to the jth observation of the ith farmer, GM is the gross margin in Uganda shillings, TR is the total revenue in Ugandan shillings estimated following equation (6) and TVC is the total variable cost in Ugandan shillings estimated following equation (7).

$$TR = \sum PQ \quad (6)$$

Where: P is the price per kilogram of onion, and Q is the quantity of onions sold (in kilograms).

$$TVC_i = W_{labour\ i}Y_{labour\ i} + W_{seed}Y_{seed\ i} + W_{pesticide}Y_{pesticide\ i} + \cdots + W_nY_n \quad (7)$$

Where W is the price of the variable inputs and Y is the quantity of variable inputs.

The Return on Investment (ROI) was calculated to determine to estimate the profitability (Ojiakor *et al.*, 2018). The higher the ROI, the higher the profitability, and ROI is expressed as in equation (8):

$$ROI = \frac{GM}{TVC} \quad (8)$$

Where GM and TVC are as stated in equation (5).

3.6.3 Ascertaining factors influencing profit efficiency of onion production

Stochastic Profit Frontier (SPF) was used for objective 3 which was to determine the factors that affect the profit efficiency of onion production in the study area. This method was employed due to the fact that it allows to fit the profit frontier with noisy data. It specifically measured the relationship between the GM of onions production and the factors of production used. Cobb-Douglas (CD) type model was employed to estimate the contributing factors to the GM from onion production and all the inefficiency factors used in the model had reasonably low correlations. The model is as specified in equation (9):

$$Y_{i=} \; \Omega X_1^{b1} X_2^{b2} \ldots\ldots X_n^{bn} e^{ui} \quad (9)$$

The profit function was linearized by transforming it into the following logarithmic form as shown in equation (10)

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + V_i - U_i \quad (10)$$

Where Y is the unit profits from onion production (UGX/acre), X1 is the Land size (Fixed Input), Y is the unit profit from onion production (UGX/acre), X_2 is the unit cost of seedling (UGX/kg), X_3 is the unit cost of fertilizers (UGX/kg), X_4 is the unit pest control cost (UGX/Man-day), and X_5 is Unit weeding cost (UGX/Man-day), A is the intercept, $\beta 1 \rightarrow \beta 5$ is Coefficients of the

respective variables to be assessed, Ui is the farm characteristics related to production efficiency and Vi is the stability disturbance term.

The profit inefficiency is calculated by using the inefficiency effects model specified in equation (11).

$$U_i = \delta_0 \sum_{h=1}^{n} \delta_h X_{hi} \qquad (11)$$

Where, δ_0 represents the constant term, δ_h represents the parameters to be estimated, U_i represents the profit inefficiency and X_{hi} represents the vector of *h*th independent variable of the *i*th farm including farming experience (years), household size(number), Education level(years), Farm size(acres), Marital status (Single, married, widow, widower), Gender (Male or female), access to credit, access to extension service, farmers' group membership, land acquisition(free hold, family land, community land, hired land, or personal land), methods used in onions production (direct sowing, transplanting or both), participation in non-farming activities, and selling place (farmgate or market place). The measurement and *a priori* expectations of these variables are presented in Table 1.

Table 1: Description of variables used in profit efficiency analysis

Variables	Units of Measurement	*A priori* expectation	Citation
Household characteristics			
Age	Years	+/-	Teklewold*et al.*, 2006
Gender	Male=1 and Female=2	+	Chikezi *et al.*, 2012
Farmers' education level	Years	+/-	Dipeolu &Akinbode, (2013); Gindi *et al.*, 2019
Farming Experience	Years	+	Bantayeho *et al.*, 2018
Household size	Number of persons	+	Berhan, 2015
Marital status	Single, married, widow, widower	+/-	Khan, (2015)
Level of income	UGX	+	Haque *et al.*, (2011)
Production and market variables			
Farm size	Acres	+/-	Baree (2012); Abdulkadir, (2015)

Tenancy	%	+	Tanko *et al.*, 2012
Capital	UGX	+	Nigatu *et al.*, (2019)
Price of Organic manure, urea, MP, TSP	UGX/Kg	+/-	Bua *et al.*, 2019
Human labor	UGX/Man-day	+	Adeoye, (2016)
Price of Seedling	UGX/quantity	+/-	Ddamulira *et al.*, (2019)
Price of Weedicide	UGX/container	+/-	Adeoye, (2016), Gindi *et al.*, 2019
Pesticides	UGX/container	+/-	Adeoye, (2016)
Quantity of output	Kg/acre		
Quantity of output sold	Kg		
Total cost of production	UGX		
Total revenue for produce	UGX		
Total Profit	UGX		
Profit/ acre	UGX		

3.7 Ethical considerations

This study observed all legal and ethical expectations governing research as defined within the context of the Republic of Uganda. Before starting the study, ethical clearance was obtained from the Gulu University Research Ethics Committee (GUREC). An approval letter was obtained from the Chief Administrative Officer (CAO) to research the districts. During data collection, respondents consented by signing the consent form and this was voluntary. The research ensured that human rights are fully respected and that all respondents and research assistances were participating under healthy and favorable conditions. Proper referencing was ensured to avoid all forms of plagiarism and fraud. More so, all resources meant for the study were directed to it and the results of the research shall be published for the benefit of all the stakeholders.

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CHAPTER FOUR: RESULTS

4.1 Socio-economics characteristics of red onions farmers

The findings in Table 2 presents a comparison of onion farmers characteristics by onion variety grown. This comparison was done to see whether farmers' socio-economic characteristics have a significant influence to their choice of the variety grown. Only two varieties were identified with majority of the farmers planting the red creole variety. Results showed that 18% of the farmers cultivated Afri seed while the rest were engaged in red creole production. The red onions farmers had an overall mean farming experience of 15 years with red creole producers being significantly more experienced than Afri seed producers (Table 2). Overall, the average household size was seven individuals with Afri seed producers having significantly more household members than red creole producers. The average overall education level was about 7 years which indicates that most of the farmers at least completed primary school with Afri seed producers having significantly slightly lower education level than red creole producers. This implies that red onions farmers in the study area can read, write, adopt easily new agricultural techniques, and keep a record of their farming activities.

The mean of owned land size of red onions farmers in this study was found to be 2.08 acres with Afri seed producers owning significantly fewer acres of land than red creole producers. On average, red onions farmers had about 0.12 acres of rented land with red creole producers having statistically significant ($p<0.01$) more rented land than Afri seed producers. Afri seed producers were found to have statistically significant ($p<0.01$) more rented land sizes under agricultural production than red creole producers. Similarly, Afri seed producers had significantly ($p<0.01$) more land under onion production than red creole producers.

Table 2: Comparing farmers' characteristics based on the variety of onions grown (n=216)

		Overall (n=216)	Afri seed (n=39)	Red creole (n=177)		
Numerical Variables			**Mean (SD)**		**t-stat**	***p-value***
Age (years)		39.36(12.73)	41.92(12.02)	38.79(12.84)	1.394	1.165
Farming experience (years)		15.14(11.19)	11.92(7.08)	15.85(11.80)	-1.997**	0.047
Household size		6.59(3.62)	7.64(3.06)	6.36(3.70)	2.024**	0.044
Education level (years)		7(3.23)	6.05(3.28)	7.27(3.18)	-2.146**	0.033
Owned size of landholding (acres)		2.08(1.84)	1.30(1.04)	2.25(1.93)	-2.976***	0.003
Rented size of landholding (acres)		0.12(0.30)	0.33(0.49)	0.80(0.22)	4.922***	0.000
Total farm land owned (acres)		1.48(1.50)	1(0.93)	1.59(1.58)	-2.238	0.260
Total farm land rented (acres)		0.14(0.33)	0.29(0.41)	0.10(0.31)	3.171***	0.002
Land size under onion production (acres		0.91(0.65)	1.26(0.69)	0.84(0.62)	3.794***	0.000
Categorical variables	**Category**		**Frequency (%)**		**$\chi 2$**	***p-value***
Gender	Male	158(73.1)	29(74.40)	129(72.9)	0.360	0.851
	Female	58(26.9)	10(25.60)	48(27.10)		
Marital status	Married	197(91.20)	36(92.30)	161(91.00)	0.720	0.788
	Otherwise	19(8.80)	3(7.70)	16(9.00)		
Access to credit	Yes	47(21.80)	23(59.00)	24(13.60)	38.717***	0.000
	No	169(78.20)	16(41.00)	153(86.40)		
Access to extension service	Yes	27(12.50)	0(0.00)	27(15.30)	6.799***	0.009
	No	189(87.50)	39(100.00)	150(84.70)		
Belong to farmers' associations	Yes	44(20.40)	17(43.60)	27(15.30)	15.819***	0.000
	No	172(79.60)	22(56.40)	150(84.70)		
Acquisition of land	Family land	101(46.80)	30(76.90)	71(40.10)	17.394***	0.000
	Hired land	64(29.60)	5(12.80)	59(33.30)		
	Personal land	51(23.60)	4(10.30)	47(26.60)		
Sources of labour	Family labour	10(4.60)	2(5.10)	8(4.50)	144.484***	0.000
	Hired labour	167(77.30)	4(10.30)	163(92.10)		
	Community labour	39(18.10)	33(84.60)	6(3.40)		
Decision on labour charges	Fixed amount	188(87.00)	37(94.90)	151(85.30)	2.589*	0.108
	By bargaining	28(13.00)	2(5.10)	26(14.70)		
Method used in onion farming	By direct sowing	5(2.30)	0(0.00)	5(2.80)	166.409***	0.000
	By transplanting	170(78.70)	3(7.70)	167(94.40)		
	Both	41(19.00)	36(92.30)	5(2.80)		
Sources of onions seeds	Buying from market	173(80.10)	34(87.20)	139(78.50)	3.587	0.166
	Buying from fellow farmers	2(0.90)	1(2.60)	1(0.60)		
	Retail shops	41(19.00)	4(10.30)	37(20.90)		
Specialized only in onions	Yes	35(16.20)	24(61.50)	11(6.20)	72.039***	0.000
	No	181(83.80)	15(38.50)	166(93.80)		
Involved in non-farm activities	Yes	119(55.10)	24(61.50)	95(53.70)	0.799	0.371
	No	97(44.90)	15(38.50)	82(46.30)		

Note: For continuous variables, the means are presented with the standard deviation in brackets, while for categorical variables, the frequencies are presented with percentages in brackets

Source: Survey data & Author 's calculation, 2022. *Significant at 10% probability level. **Significant at 5% probability level. ***Significant at 1% probability level

The findings indicated that about 73.1 % and 91.2 % of red onions producers were males, with no significant association between gender the two onion varieties grown. The study findings also showed that the majority (78.2 %) of red onions producers did not have access to credit with a significant ($p<0.01$) association between access to credit and the two onion varieties grown. Only 13 % of the onion farmers had access to agricultural extension services with a significant ($p<0.01$) association between access to agricultural extension services and the onion varieties. About 20.4% of the red onions farmers were only involved in the farmers' group with significantly ($p<0.01$) more Red creole farmers belonging to the farmers' group than Afri seed farmers.

Over 47 % of the onion farmers produced red onions using family land, 30% were using hired land and 24% used personal land with a statistically significant ($p<0.01$) association between land acquisition and the varieties grown. Results also showed that the majority (77%) of the onions farmers relied on hired labour, 5% used family labour, and 18% used community labour in red onion production with a significant ($p<0.01$) association between sources of labour and the varieties grown. About 87% of the onion farmers paid labour with a fixed amount per day, while 13% bargained on the labour charges with significantly ($p<0.1$) association between the decision on labour charges and the two varieties produced.

Results also indicated that 2%, 79%, and 19% of the onions farmers produced onions using the method of direct sowing, transplanting, and/or both methods (direct sowing and transplanting) at once respectively, with significantly ($p<0.01$) association between methods used in onions production and varieties grown. Ninety-four percent of red creole producers employed the transplanting method in red onions production while 92% of Afri seed producers employed both methods. Results also show that 16% of the red onions farmers were specialized only in onions

production with significantly ($p<0.01$) more Afri seeds producers specializing only in onions than red creole producers. About 55% of the red onions farmers were also involved in non-farm income generating activities with no significant association between participation in non-farm income generating activities and the verities grown.

4.2 Production costs and returns in Afri Seed and Red Creole farming

4.2.1 Variation of production cost and returns by variety cultivated per acre

Table 3 presents the summary statistics of costs incurred and returns to onion production for the two varieties cultivated. Revenue and costs were evaluated during the survey based on the prices which were prevailing in the previous production season 2021. Results indicated that the overall mean cost of red onions seeds was UGX 157,546 with the cost of seeds being on average significantly ($p<0.01$) higher than red creole seeds' cost. Overall, the fertilizers were found to be with the highest cost in red onions production in the study area with an average cost of UGX 487,646 with no significant differences in the cost of fertilizers for Afri seed producers and red creole producers. The mean cost of pesticides was UGX 32,829 with significantly ($p<0.1$) Afri seeds producers spending more money on pesticides than red creole producers. Red onions farmers spent an overall average of UGX 10,667 on drying and storing labour charges with Afri seeds significantly($p<0.05$) used up less amount on labour for drying and storing than red creole producers.

Table 3: Costs and returns (average values) of red onions production per acre

Variables	Mean (SD)			t value	*p*-value
	Overall (n=216)	Afri seed (n=39)	Red creole (n=177)		
Cost of seeds (UGX)	157,546(110,046)	259,102(90,640)	135,169(101,148)	7.051***	0.000
Cost of fertilizers (UGX)	487,646(407,893)	502,654(435,813)	484,339(402,710)	0.253	0.800
Cost of pesticides (UGX)	32,829(62,138)	48,756(95,113)	29,319(51,912)	1.777*	0.077
Cost of herbicides (UGX)	7,273(14,666)	11,538(18,875)	6,333(13,450)	2.021**	0.045
Cost of labour for drying/storing (UGX)	10,667(29,580)	615(3,843)	12,881(32,324)	-2.369**	0.019
Cost of nursery bed preparation and management (UGX)	31,852(26,505)	32,692(23,640)	31,667(27,154)	0.218	0.827
Cost ploughing (UGX)	85,704(77,265)	59,128(41,350)	91,559(82,053)	-2.399**	0.017
Cost of transplanting (UGX)	77,560(52,755)	81,744(59,861)	76,638(51,200)	0.546	0.586
Cost of weeding (UGX)	114,502(105,082)	86,359(100,595)	120,703(105,309)	-1.858*	0.065
Cost of pest control (UGX)	8,611(7,820)	7,077(9,988)	8,949(7,247)	-1.356	0.176
Cost of harvesting (UGX)	53,903(74,966)	87,385(149,249)	46,525(41,931)	3.143***	0.002
Cost of transportation from farm to home (UGX)	53,375(99,481)	100,628(219,021)	42,963(33,592)	3.354***	0.001
Marketing costs (UGX)	22,219(74,004)	30,000(57,807)	20,504(77,151)	0.725	0.469
Quantity sold (Kg)	1,552(1,072)	1,278(924)	1,613(1,095)	-1.774*	0.078
Selling price (UGX/Kg)	1,773(328)	1,746(345)	1,779(325)	-0.558	0.578
Total cost (UGX)	1,143,686(718,660)	1,307,679(967,574)	1,107551(649,239)	0.078	0.116
Total revenue (UGX)	2,716,449(1,872,653)	2,192,179(1,583,084)	2,831,966(1,915,328)	-1.944*	0.053
Gross Margin (UGX)	1,572,763(1,538,854)	884,500(1,190,221)	1,724,414(1,577,629)	-3.149***	0.002
ROI	1.50(1.44)	0.67(1.10)	1.56(1.46)	-3.323***	0.001

Source: Survey data & Author 's calculation, 2022. *Significant at 10% probability level. **Significant at 5% probability level. ***Significant at 1% probability level

The results also showed that the overall mean cost of nursery bed preparation and management was 31.852 and the cost of nursery bed preparation and management did not vary across Afri seed producers and red creole producers. The overall average cost of ploughing was UGX 85,704 and Afri seeds producers had significantly ($p<0,05$) spent less amount on the cost of ploughing than red creole producers. The total cost of transplanting was UGX 77,650 with no significant difference in the cost of transplanting to the Afri seeds producers and red creole producers. The red onions farmers spent on average UGX 114,502 on weeding with Afri seed producers spending significantly ($p<0.1$) less amount on weeding than red creole producers. The findings revealed also that farmers spent on average UGX 8,611 on pest control with no significance difference in the cost of pest control between Afri seed producers and red creole producers. The overall mean cost of harvesting was UGX 53,903 with Afri seeds producers having significantly ($p<0.01$) spent a higher amount than red creole. Overall average, the cost of transportation of red onions from the farm to home was UGX 53,375, and the Afri seed producers significantly ($p<0.01$) spent a lesser amount than red creole producers. The overall mean marketing costs were UGX 22,219, and marketing cost was the sum of the costs of packing, packaging material, tax, transport, loading and offloading, sorting, and grading. Marketing costs did not vary across the Afri seed producers and red creole producers.

The overall average quantity of red onions sold was 1,552 kg with Afri seed producers selling significantly ($p<0.1$) less quantity of red onions than red creole producers. On average a kilo of red onions was sold at UGX 1,777 with no significant differences in the selling price between the two varieties. Similarly, the total cost of red onions production amounted to UGX 1,143,686 and the total cost did not vary across the Afri seeds producers and red creole producers. Results indicated also that the total revenue in red onion production was UGX 2,716,449 with Afri seed

production having significantly ($p<0.1$) generated lesser revenue than red creole production. On average, red onions production generated a profit of UGX 1,572,763. The gross margin (GM) obtained was significantly ($p<0.01$) lower for Afri seed production than red creole production. The results showed that onion production was profitable with an overall average return on investment (ROI) of 1.50 with Afri seed production having significantly ($p<0.01$) lower ROI than red creole production.

4.2.2 Production Cost and Returns across sub-counties

The results presented in Table 4 show a comparison of the various costs involved and associated returns of red onions production in the 4 different sub-counties. In the 4 sub-counties, the cost of fertilizers was the major item of red onions production followed by seedling cost, and weeding cost. The yield of red onion was found higher in Masaba (1,821kg/acre), and Zesui (1,786kg/acre) compared to Namaguli (1,324kg/acre) and Namugabwe (1,279kg/acre). The mean total costs and mean total revenue accounted during the last production season for Namaguli, Namugabwe, Masaba and Zesui were UGX 1,054,602, UGX 915,963, UGX 1,502,661, UGX 1,101,519 and UGX 2,315,055, UGX 2,126,759, UGX 3,185,370, UGX 3,238,611 respectively. The results indicated a GM of UGX 1,260,454, UGX 1,210,796, UGX 1,682,709, and UGX 2,137,093 for Namaguli, Namugabwe, Masaba, and Zesui respectively, and the return on investment was found to be higher where Zesui comes first with the ROI of 1.94 followed by Namugabwe, Namaguli, and Masaba with a ROI of 1.32, 1.20, and 1. 12 respectively.

The difference in the mean of the costs of production variables and the returns in onions production in the 4 sub-counties was determined using a one-way analysis of variance (ANOVA). For example, the *P-value* for the mean profit of onions production was significant at 5% and this allows this research to reject the null hypothesis which stated that there is no significant difference in the mean profit on onions production in the four sub-counties and this research fail to reject the alternative hypothesis. This is explained by the fact that between groups (Table 4), the mean profit of Zesui was different from the mean profit of Namaguli and Namugabwe.

Table 4: Costs and returns (average values) of onions production per sub-county (n=216)

Variables	Units	Namaguli	Namugabwe	Masaba	Zesui
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Cost of seeds	UGX	165,740(117,073) [a, b]	162,407(129,483) [a, b]	179,907(96,781) [b]	122,130(86,070) [a]
Cost of pesticides	UGX	28,648(37,095) [a]	16,944(22,638) [a]	59,130(104,542) [b]	26,593(42,734) [a]
Cost of fertilizer	UGX	435,463(267,790) [a]	354,630(355,677) [a]	635,324(559,631) [b]	525,167(345,055) [a, b]
Cost of herbicides	UGX	8,167(15,023) [a, b]	2,444(5,179) [a]	10,815(19,536) [b]	7,667(14,171) [a, b]
Cost of nursery bed preparation and management	UGX	32,407(28,972) [a]	24,778(19,941) [a]	36,759(24,897) [a]	33,463(30,241) [a]
Cost of ploughing	UGX	71,111(60,631) [a]	73,204(69,528) [a]	116,737(102,241) [b]	81,963(62,411) [a]
Cost of transplanting	UGX	77,759(58,508) [a, b]	59,370(38,645) [a]	99,463(60,486) [b]	73,648(43,280) [a]
Cost of weeding	UGX	111,935(148,730) [a]	94,130(70,544) [a]	134,185(106,703) [a]	117,759(74,000) [a]
Cost of pest control	UGX	7,519(6,380) [a]	7,722(6,935) [a]	8,963(8,936) [a]	10,241(8,635) [a]
Cost of harvesting	UGX	46,315(44,388) [a]	37,167(22,465) [a]	87,222(128,097) [b]	44,907(48,730) [a]
Cost of transport from farm to home	UGX	31,722(20,175) [a]	44,389(46,160) [a, b]	90,519(182,166) [b]	46,870(49,141) [a, b]
Cost of labour during drying/storing	UGX	22,852(42,582) [b]	4,333(16,537) [a]	5,259(17,631) [a]	10,222(30,494) [a, b]
Marketing costs	UGX	14,963(34,897) [a, b]	34,444(87,164) [a, b]	38,578(111,427) [b]	889(6,532) [a]
Quantity sold	Kg	1,324(1,041) [a, b]	1,279(933) [a]	1,821(1,172) [b]	1,786(1,036) [b]
Selling price	UGX	1,707(361) [a, b]	1674(273) [a]	1,874(302) [c]	1,835(333) [b, c]
Total Cost	UGX	1,054,602(602,232) [a]	915,963(577,262) [a]	1,502,661(917,610) [b]	1,101,519(602,639) [a]
Total revenue	UGX	2,315,055(1,935,4678) [a]	2,126,759(1,536,961) [a]	3,185,370(1,824,439) [b]	3,238,611(1,941,306) [b]
Gross margin	UGX	1,260,454(1,533,209) [a]	1,210,796(1,185,686) [a]	1,682,709(1,647,201) [a, b]	2,137,093(1,602,127) [b]
ROI		1.20(1.29) [a]	1.32(1.13) [a]	1.12(1.47) [a]	1.94(1.65) [b]

Source: Field survey (2022)

The mean value with different subscripts indicates a significant difference at 5% (p-value ≤0.05)

4.3 Stochastic frontier analysis of onion production profit efficiency

Factors that affect onions production were determined using an estimated stochastic profit frontier and are presented in Table 5. These results are for respondents who got a profit greater than one Ugandan shilling. Results show that most explanatory variables have an impact on the profit efficiency of onions production. The estimated coefficients of the inefficiency function provide some explanations for the relative efficiency levels among individuals' farms. Since the dependent variable of the inefficiency function represents the model of inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative influence on efficiency and a negative sign indicates the reverse.

For instance, the cost of seeds positively significantly ($p<0.01$) influences the profit efficiency of red onions production and shows that a unit increase in the cost of seed fertilizers is more likely to lead to an increase in profit efficiency in red onions production. Similarly, the cost of pest control and weeding were significant ($p<0.5$), and ($p<0.01$) respectively which indicate that a rise in one Ugandan shilling in these inputs was associated with an increase in the profit efficiency of red onion production.

On the other hand, findings revealed that the coefficients of the dependent variables of the inefficiency such as farming experience positively significantly ($p<0.01$) influenced the efficiency of red onions production and indicated that if farming experience increases by one unit, the more likely the profitability of onion farming will increase. Results also indicated that the access to extension services influenced positively ($p<0.01$) the efficiency of red onions production was statistically significant and exerted a positive influence on the profit efficiency of onions farmers in the study area. This shows that as one unit rise in extension services, the more likely the profit

efficiency of red onions production increases. In addition, the place where farmers sold onions produced (farmgate) positively significantly ($p<0.01$) influenced the profit efficiency of red onions production and shows that the more farmers sell their harvest to the wholesalers or retailers at the farmgate, the more their profit efficiency is increased

Table 5: Maximum likelihood estimates of the stochastic frontier profit function (n=192)

Variables	Coefficients	Standard error	P>|z|
Profit efficiency			
Constant	3.160***	0.631	0.000
Land size	0.143	0.117	0.220
Cost of seeds	0.294***	0.113	0.009
Cost of fertilizers	0.136*	0.073	0.062
Cost of pest control	0.173**	0.087	0.048
Cost of weeding	0.314***	0.104	0.003
Inefficiency model			
Constant	-9.729*	5.164	0.060
Years of farming experience	-0.758***	0.282	0.007
HH Size	0.382	0.243	0.116
Education level	0.420**	0.185	0.024
Marital status	-2.228	1.453	0.125
Gender	-1.373	1.088	0.207
Access to credit	6.143***	2.132	0.004
Access to extension service	-11.681***	3.996	0.003
Belong to farmers' associations	3.458**	1.392	0.013
Land acquisition	-1.414	1.264	0.263
Methods used in onion farming	2.322	1.744	0.183
Involved in non-farm activities	2.396**	1.154	0.038
Selling place	-7.808***	2.593	0.003
Variances parameters			
Usigma constant	0.089	0.520	0.863
Vsigma constant	-0.334***	0.114	0.003
Sigma-u	1.046***	0.272	0.000
Sigma-v	0.846***	0.048	0.000
Lambda	1.236***	0.286	0.000
Log-likelihood	-256.2683		

*Source: Survey data & Author 's calculation, 2022. *Significant at 10% probability level. **Significant at 5% probability level. ***Significant at 1% probability level*

Conversely, results showed that education level negatively influenced the profit efficiency of red onions production, with farmers having a high level of education significantly ($p<0.05$) less likely to increase the profit efficiency. Results also indicated that access to credit negatively significantly ($p<0.01$) influenced the profit efficiency of red onion farmers and indicated, which implies that an increase in access to credit is more likely to decrease the profit efficiency in onion production. Participation in farmers' associations was as well found statistically significant at ($p<0.01$) and negatively influence the profit efficiency of onion production. The more farmers are members of farmers 'associations, the less likely they increase their profit efficiency. Results also showed that red onions farmers who were engaged in non-farm income-generating activities were significantly ($p<0.05$) less likely to increase to profit efficiency of red onion production.

Table 6 shows the profit efficiency scores of the sampled onions farmers. The results indicate that the estimated sigma value was 0.846 and was statistically significant at 10%. More so, the estimated model had a log-likelihood value of -256.2683. About 53% of the respondents fell in the modal profit efficiency score of above 0.90. The mean profit efficiency of onions farmers was 0.81 which implies that onions farmers have a scope of increasing profit efficiency of onions farmers by 19%.

Table 6: Profit efficiency distribution of onions production in Sironko district

Efficiency scores	Frequency	Percentage
<0.40	20	10.42
0.40-0.70	15	7.81
0.71-0.80	16	8.33
0.81-0.90	39	20.31
>0.90	102	53.12
Total	192	100
Mean	0.8064	
Minimum	0.0051	
Maximum	0.9764	
Std. Dev.	0.2353	

***Source**: Field survey (2022) computed using Stata version 14*

CHAPTER FIVE: DISCUSSION OF RESULTS

5.1 Characteristics of onions farmers

This study aimed to characterize red onions farmers in Sironko district. The findings were presented to provide a brief description of the sampled respondents. The mean age reported in this study indicates that onions farmers in the study area were middle-aged, and energetic which could result in effective production. Onion production is intensive and tends to favor those who have energy to work. This mean is typical of mean age of onion farmer reported in previous studies (Grema & Gashua, 2014). Similarly, most of the onion farmers had the inherent experience in onion farming. Experience in red onion production plays a paramount role in raising profitability and reducing the inefficiency. These results concur with those of other studies. For instance, Miriti et al. (2021) reported that the sorghum farmers from Lira, Serere and Kumi district were young-aged with significant farming experience . The household sizes were averagely large and typical of rural areas of Uganda (UNHS, 2016).

Most of the respondents had completed primary seven, and this implies that they can easily read and write. This result corroborates with the findings of Gabriel, (2021) who reported that the majority of tomato producers in Uganda had seven years of formal education. The average mean experience coupled with the mean education level implies that farmers in Sironko district can be able to adopt new technologies and research findings that are related to onion production. Onion farmers in Sironko allocated about half of their total land to onion production. This is typical of cash crops especially in smallholder settings where the average land size is usually less than five acres (de Haas, 2017).

Majority of the onion farmer were male and married. This implies that red onions farmers are dominated by men and this is mostly the case for the income-generating activities. This is a high manifestation of gender inequality in distribution and correlates with the finding of Acosta et al., (2021) who showed in their study that the agricultural income generating activities in Uganda are dominated by men.

Results in this study also showed that access to credit was very low among the onion farmers. This could be the reason why they operate their activities on a small scale while rural credit could enable them to acquire seeds, agricultural tools, fertilizers, pesticides, and other inputs and even expand their business of onion farming (Chandio et *al.*, 2018). Similarly, only about one out of ten onion farmers had access to extension services. This shows that there was a low frequency of contact or exchange between onion farmers and extension workers. The low access to extension services correlates with the findings of Gebremariam et al., (2019) who reported the lack of inadequate extension services in irrigated onion production in Uganda. In addition, the majority of the sampled farmers don't belong to any farmers' groups. Not belonging to a farmer group could be affected negatively by onion farming reason being that the farmers' associations are the main mean used by extension officers to deliver a bunch of information about new farming technologies and market opportunities (Norton & Alwang, 2020).

The results show that most of the respondents used either family land or personal land in owned production. This low use of rented land is in line with the findings of Kaibartya et al. (2018) who reported that beans producers in Mbeya Tanzania rely majorly to the household member-owned land. The findings indicate also that over eight out of ten onion farmers had other income-generating activities (including other agricultural enterprises) besides onion production.

Specifically, more than half were involved in off-farm activities in addition to farming. This could be explained by the fact that farmers try not to rely only on one crop as there are risks that may arise in onion production. The majority of onion seeds were purchased from the input shops and the variety Red Creole is most preferred by the respondents over Afri seed.

5.2 Profitability of Afri Seed and Red creole production in the study area

It was observed that between the two varieties grown (red creole and Afri seed) in Sironko district, within the four sub-counties, red creole is the most grown variety and productive with the higher gross margin. The seeds cost, harvesting cost and transportation of onions to home were statistically significant at 1% level, and ploughing cost, drying/storing cost, and herbicides cost were significant at 5% level whereas weeding cost, and pesticides cost were significant at 10% level. This shows that those factors are critical in red onions production in the study area. Although the cost of fertilizers was not significant, Table 3 revealed that Afri seed and red creole farmers invested a big amount in fertilizers. This is a clear indication of the importance of fertilizers in onion production in the study area and could be explained by the fact that the use of fertilizers is a long-time investment in soil fertility. The results agree with the findings of Dalchiavon et al. (2019) who indicated in their study conducted on economic opportunity for investment in the Soybean and Sunflower crop system in Mato, Grosso Brasil that costs of inputs impacted those crops with fertilizer ranking first with 26% of the total variable costs.

Based on the results presented in Tables 3 and 4, there is a confirmation of the profitability of onions production in Sironko district looking at the result of the gross margin supported by the result of return on investment. This indicates that more than 60% of the amount invested was gained by Afri seed producers and red creole producers. This corroborates similar results reported

by (C. Wongnaa *et al.*, 2019). Similarly, Table 4 shows that on one Ugandan shilling invested in onion production, more than 100% of gain was obtained by producers from the four sub-counties of Sironko district. All the findings stated above indicated that farmers engaged in red creole and Afri seed in the different sub-counties are making a remarkable profit.

5.3 Determinants of profit efficiency of onions production

Results of the stochastic profit frontier showed that 14 factors were found statistically significant and influence the profit efficiency of onions production in the study area. The coefficients of the physical estimated parameters such as cost of fertilizers, seeds, weeding, and pest control conform to a prior expectation positive sign which implies that a unit rise in those factors will increase the profitability of onion production, *ceteris peribus*. These results contradict those of C. A. Wongnaa & Mensah, (2018) who reported that an increase in the costs of fertilizer, pesticide, herbicide, and seeds affected significantly and negatively the profitability of maize production in Ghana. However, results of the analysis done by Nigatu et al. (2019) indicated that an increase in the cost of fertilizer leads to an increase in the yield of onion production in Dembyia District of Amhara Region, Ethiopia.

It was also observed that an increase in farming experience will lead to an increase in the profit efficiency of onions production. This implies that onion farmers with more years of experience operate significantly at a higher level of profit efficiency, which means that the more they are experienced the more they perform better. These results are in line with those of other studies. For instance, Tasila Konja et al.(2019) reported that farming experience was significant and affect positively the profit efficiency of certified groundnut seed production in Northern Ghana.

Furthermore, it was observed that the rise in education level in the study area will lead to an increase in the profit inefficiency of onions farmers. This could be explained by the fact that educated people in Sironko district could be engaged in other activities than farming. This result contract the findings of other studies by Tadesse et al.(2021) and Mdoda et al.(2022) who reported that as a farmer is exposed to agricultural and innovative techniques used in crop production, the productivity of their production increases as well.

Results revealed also that access to credit decreases the profitability of onions farmers. This could be simulated to the fact that they are not guided well on how to handle credit money. It could also be explained by the high-interest rate fixed by banks or other institutions or microfinance institutions that push onion farmers not to contract credit money. This result is in line with the findings of (Mdoda *et al.*, 2022) who reported a significant and negative effect of access to credit on Spinach Production under Small-Scale Irrigated Agriculture in the Eastern Cape Province, South Africa as well as the findings of Lebailly (2020) who stated in his study that access to credit was significant and negatively affected the technical efficiency, thus the profit efficiency of onion production in volcanic highlands in Rwanda.

The access to extension services was expected to be signification and influence positively the profitability of onion production and the findings revealed a negative relationship between extension services and profit inefficiency of onions production. The negative and significant relationship with profit inefficiency justifies the contribution of extension workers in onions farming which help red onion farmers to boost the ability of farmers to use the optimal use of available resources which in turn improves productivity and thereby raises the profitability of onion production (Abrha *et al.*, 2020). Conversely, Taye et al. (2018) in their study indicated that

farmers who had access to extension services do not apply new techniques and advice given by the extension workers.

Participation in farmers' associations is a pertinent factor that was predicted to be significant and positively influencing profit efficiency of onion farming in the study area as farmers' associations facilitate agricultural extension, help to supply farm credit among farmers in the group, and contribute to providing supply and marketing services. However, the research findings indicate that farmers' associations are significant but have a negative correlation with the profit efficiency in the study area. In contrast, the findings of Kaibartya et al. (2018) showed that group networks enable beans' producers in Mbeya, Tanzania to improve their productivity, as well as their profitability.

It was also found that a rise in onion producers who are engaged in other businesses (non-farm activities) results in a decrease in the profit efficiency of onion production. This could be simulated by the fact that they allocate their time and money to non-farm income-generating activities. Odoh et al. (2019) reported that farmers invest in other activities due to the fact that the income received by farmers who depend solely on farm ventures is inadequate and that reason pushes them to engage in other activities to increase their revenues.

Furthermore, it was also found that the selling place (farmgate) was significant and negatively affect the profit inefficiency of red onion production. This could be explained by the high amount of marketing costs paid by farmers when selling onions to the marketplace.

CHAPTER SIX: SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

Onions are one of the most important and most consumed spices for foods, salads, soups, and stews in many restaurants, hotels, schools, and households in Uganda. The main objective of this study was conducted to assess the profit efficiency of onions production in Sironko District. Specifically, the research was to; identify the socio-economic characteristics of onions producers, determine the profitability of onions production, and ascertain the determinants of profit efficiency in the study area. Sironko district is one of the potential onion-producing districts found in the Eastern part and the four sub-counties within the district were purposively selected based on their high concentration of farmers engaged in onions production. Primary data was collected from 216 onion producers randomly selected and interviewed through interviews using a well-structured questionnaire. Data were analyzed using descriptive statistics, gross margin, and stochastic profit frontier with the Cobb-Douglas function model.

The results showed that two varieties of red onions (Afri seed and red creole) were grown with the majority of the respondents engaged in red creole production. It was also found out that the majority of onions growers' households were male-headed, with seven household members and almost all of them were married. The producers were on average young, with more years of experience in red onion production, and have completed primary school. The findings also revealed that more than seventy-five percent of the respondents did not have access to credit facilities, or agricultural extension services and neither did they belong to any farmers' group. In addition, more than fifty percent of the respondents' average farm size was allocated to onions production.

Generally, the findings showed that red onions production was profitable in the Sironko district with a higher gross margin for the red creole producers. The total costs of production included costs of seeds, fertilizers, pesticides, herbicides, drying and storing, nursery bed preparation and management, ploughing, transplanting, weeding, pest control, harvesting, transportation of onions from the farm to the household, and marketing costs. In addition, seedling cost was found to be higher compared to other input production costs.

From the 4 sub-counties where data was collected, the gross margin and return on investment of onions producers were positive with Zesui having the highest gross Margin and return on investment compared to other sub-counties.

This study showed that farmers were efficient in producing red onions. Several production factors and socioeconomic factors were found to significantly influence onions production in the study area. These include seedling cost, cost of fertilizers, cost of pest control, cost of weeding, farming experience, education level, access to credit, extension service, farmers' group membership, engaging in other businesses, and the selling place.

This study presented some limitations that are needed to be stated. To begin with, data collection was collected using a cross-sectional survey to analyze the profit efficiency of red onions in Sironko district. It is, therefore, worthwhile to conduct other studies in other districts of Eastern and Western Uganda where onions are also most grown to test the validity of the finding comparing them with those of this study since results might be peculiar across regions.

Another pertinent limitation is that this study was conducted in areas where farmers grow onions only in the rainy season. It is therefore advised to conduct other studies considering sub-counties

where red onions are produced through irrigation and test the validity of the results, whether there are variations in terms of profitability or not.

6.2 Conclusions

The study examined the profit efficiency of onion production in Sironko district. Data collected for the three specific objectives of this study such as socio-economic characteristics, the profitability of onion production, and factors that influence the profitability of onion production were analyzed. The findings indicated that onion producers experienced in onion production completed primary school and were most of a young age which, enable them to be versatile in farming activities.

Although red onion production is generally profitable for both Afri seed and red creole producers, it is obvious that the seeds of Afri seed are expensive compared to red creole while the yield, thus the profitability of red creole is higher compared to Afri seed.

Additionally, the findings revealed that onion production is dominated by men and this showed a manifestation of gross inequality in gender distribution. Onion production in the study area is characterized by low access to credit, and extension services and most of producers do not belong to any farmers' associations. The low access to credit and extension services could lead to poor adoption of productivity-enhancing technologies.

Furthermore, the study indicated that factors such as the cost of seeds, cost of weeding, extension services, access to credit, and selling places were observed to have significant effects on profit efficiency.

6.3 Recommendations

6.3.1 Policy recommendations

The results of this study showed that onion production was profitable in Sironko district and could also help farmers to generate more revenue on a sustainable basis in case they remain in it. Based on the research findings, the following recommendations should be considered to improve the profitability and hence the income generated from onions production:

1. It was observed that onion production is a male-dominated activity. Women should be sensitized, encouraged and empowered by the Government to venture into red onion production.
2. Red creole was found to be more profitable compared to Afri seed. Farmers should invest considerably in this variety
3. It was also observed that a few onion farmers belong to farmers' associations and do not have access to credit services hence negatively affecting the profit efficiency of onion production. Where farmers do not have adequate capital, access to credit plays a vital role in helping farmers acquire inputs including seeds, tools, fertilizers, pesticides in addition to expanding their farm business. Credit facilities should be made available to onion farmers by financial institutions. They should also be encouraged to use credit obtained judiciously for the expansion of onion production and not for other purposes.

4. Government and other relevant stakeholders should make extension services available to onion producers so as to sensitize them on the adoption of innovative techniques and research findings that will help enhance farmers' productivity and hence increase their

level of income. Extension officers should ensure farmers employ best agricultural practices in onion production.

5. The red onions' value chain actors should note that the profit efficiency of onion production in Uganda could be improved through adequate use of available resources, an improved state of technology and through agricultural policies that would encourage the enlightenment of onion farmers.

6.3.2 Recommendations for further studies

This study presents limitations that should be considered for further studies:

First, data were collected using a cross-sectional survey in Sironko district of Eastern Uganda. Further research should be done in other districts of Eastern and Western Uganda where red onions are grown in abundance to test the validity of the results of this study since there might be dissimilarities across regions.

Second, since all the respondents produced red onion during the rainy season, further study should be done in Eastern and Western Uganda to test the validity of the findings of this study across seasons. There is need to capture data from both rainfed and dry season onion production and compare profit efficiencies across regions and seasons.

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APPENDICES

APPENDIX A

Informed consent document

Title of the study: PROFIT EFFICIENCY OF ONIONS PRODUCTION IN SIRONKO DISTRICT.

Investigator: Elias MUNEZERO

Institution: GULU UNIVERSITY

Introduction

Hello, my name is Elias MUNEZERO, a master's student /researcher from the Department of Rural Development and Agribusiness, Faculty of Agriculture and Environment, Gulu University, Uganda. I am collecting data on the topic: "Profit efficiency analysis of onions production in Sironko district" This study is purely academic and purposely intended to help researchers understand the profit efficiency of red onions produced in Sironko district. You have been selected randomly to participate in this survey. please note that the information provided by you will be treated confidential and there will be no way to identify you as the one who gave specific information. I would be glad if you could spare some time (between 20 to 30 minutes) to answer our questions. As an appreciation for your time, you will be given a bar of soap.

Thank you.

A brief description of the sponsors of the research project

This study is funded by Mastercard RUFORUM in Collaboration with TAGDev Gulu University.

Purpose:

The study seeks to analyze the profit efficiency of red onion production in Sironko district. The study will serve as a suitable tool for agricultural researchers and planners. It will also avail farmers the information on the factors of onion production which may help them to make decisions that will enhance productivity in onion production thus promoting the economic growth of the country. The discoveries of the study will attract the attention of researchers, and promote awareness among scientists, policymakers, consumers, and producers.

Procedures:

Your participation in this study will involve answering the questions while filling in the questionnaires as requested.

Who will participate in the study?

You have been chosen to participate in this study because you are an onions farmer. The interview will last for approximately thirty minutes or less and the participants will be 216 with you inclusive.

Risks/discomforts:

There is no foreseeable risk of harm or discomfort that will arise from your participation in this study. The only risk or discomfort will be the inconvenience in terms of time spent during the

interview.

Benefits:

The potential benefit of this study is that it will increase onions production and enable access to inexpensive onions for Ugandans, thus augmenting their income intake level with you inclusive for the good of livelihood development and economic well-being in the long run. The study will inform you of the factors that influence onions production. Research participants will also get feedback on the findings and progress of the study, and any new information that affects the study participants (including incidental findings) will be made available to research participants.

Confidentiality:

Your identity will not be revealed to anyone as we shall only use codes to identify participants. Information obtained will only be accessible to the research team. Soft copies of the data will be protected by password and hard copy files will be kept under lock and key. Confidential information will only be accessed by the principal investigator.

Alternatives: You do not have to participate in this study if you are not interested. You will not lose any benefit in case of no participation.

Cost: There will not be any additional cost incurred as a result of participating in this study.

Questions:

If you have any questions related to the study or your rights as a research participant, you can contact the principal investigator, Elias MUNEZERO on telephone 0779831879 or via email at enias016@gmail.com

Statement of voluntariness:

Participation in the research study is voluntary and you may join of your own free will. You have a right to withdraw from the study at any time without penalty.

If you have any issues about your rights and participation in the study, please contact the Chairperson, Gulu University Research Ethics Committee, Dr. Gerald Obai Tel: No., 0772305621; email: lekobai@yahoo.com/lekobai@gmail.com; or the Uganda National Council for Science and Technology, on plot 6 Kimera Road, Ntinda, Kampala on Tel 0414705500.

Statement of consent

.....has described to me what is going to be done, the risks, the benefits involved, and my rights as a participant in this study. I understand that my decision to participate in this study will not affect me in any way. In the use of this information, my identity will be concealed. I am aware that I may withdraw at any time. I understand that by signing this form, I do not waive any of my legal rights but merely indicate that I have been informed about the research study in which I am voluntarily agreeing to participate. A copy of this form will be provided to me.

Name of participant.....Signature/Thumbprint.....Date.....

Name of witness.....Signature..... Date.....

Name of interviewer..... Signature..... Date.....

APPENDIX B

Translated Consent Form

MUTWE MUKULU GWEGUMUSOOMO: "KUYODELESA NIKUZULA MAGOOBA GAAMA MUKULIMU BITUNGULU MUU DISITURICTI YESIRONKO".

UMUSOOMI: Elias Munezero

LISOMELO: Iunivasitee Yee Gulu.

Kwiyangula

Lisino lyose, bananga, Elias Munezero, indu umusomi wee master mulubeega lwee inkulakulakulana yee bibyalo mukyalo nii byebusubuzi mubyebulimi ni bubaayi, mu bye agricacha nii eesi kumenya kwaama ku-univasitee yee Gulu mu-Uganda.

Indikukoola musomo goose ni gumutwe gulooma gutii; kuyodelesa nikuzula magooba gama mukulima bitungulu muu disituricti yesironko. Musoomo guuno guli gwe kusomelako konyene ate guli gwekuyeeda bandi bayodelasa ni kuzula bategele magooba gaama mukulima bitungulu bibesemu mudisituricti yesironko. Waalondelewe akaali kusosola kuuba mudwela mumusoomo guuno.Ingaana ukyimanye otti byosi byesi unambulila, binayiliwa nga kyaama ate kawo eesi bakamanyile baati iwowe niyo wambulila biitu binno dda.

Innasayuka ate inasima naabi nga wapeele ko buude boowo zidakika nga abiili (20) kwa asaatu (30) wilemo biteebo biino.

Mukukusima lwe buude bowo, inaakuwa muti goo sabuumi. "wanyala naabi".

APPENDIX B

Translated Consent Form

MUTWE MUKULU GWEGUMUSOOMO: "KUYODELESA NIKUZULA MAGOOBA GAAMA MUKULIMU BITUNGULU MUU DISITURICTI YESIRONKO".

UMUSOOMI: Elias Munezero

LISOMELO: Iunivasitee Yee Gulu.

Kwiyangula

Lisino lyose, bananga, Elias Munezero, indu umusomi wee master mulubeega lwee inkulakulakulana yee bibyalo mukyalo nii byebusubuzi mubyebulimi ni bubaayi, mu bye agricacha nii eesi kumenya kwaama ku-univasitee yee Gulu mu-Uganda.

Indikukoola musomo goose ni gumutwe gulooma gutii; kuyodelesa nikuzula magooba gama mukulima bitungulu muu disituricti yesironko. Musoomo guuno guli gwe kusomelako konyene ate guli gwekuyeeda bandi bayodelasa ni kuzula bategele magooba gaama mukulima bitungulu bibesemu mudisituricti yesironko. Waalondelewe akaali kusosola kuuba mudwela mumusoomo guuno.Ingaana ukyimanye otti byosi byesi unambulila, binayiliwa nga kyaama ate kawo eesi bakamanyile baati iwowe niyo wambulila biitu binno dda.

Innasayuka ate inasima naabi nga wapeele ko buude boowo zidakika nga abiili (20) kwa asaatu (30) wilemo biteebo biino.

Mukukusima lwe buude bowo, inaakuwa muti goo sabuumi. "wanyala naabi".

(MUBUYIMPI KUBIHAMBAGANA KUBAATU BAALI INYUUMA YEGUMUSOMO GUUNO).

Musoomo guuno gwa telewelemo silingi kwama mukitongole kye Mastercard Ruforum hadwena nii kitongole kye TAGDev kye Univasitee ye Gulu.

Kyizililwa

Musoomo guuno, gulikuyodelesa kumagooba gaama mukulima bitungulu mu-disituricti yesironko.

Elaa musoomo guunogunayedeko baakola kubyekuyodelesa mu byebulimi nga bye agricacha nii baabipulaningila. Kyinawako nii balima kusooma kubitagiwa mukulima bitungulu ate gubayede mukukalawo mugeri innogela infuuna kwama mubitungulu ate nihawenewo ligwanga likulakulane mu bye fuuna.

Binazuliwa mu musoomo guuno, binasikiliza babaasoma bandi ate binaletawo kumanya mubanaasayansi, bakalawo, babadya bitungulu ni balimi bebitungulu.

Ingeli yesikunakolamo musoomo guuno.

Kuuba mumusoomo guuno kowo kunabaamo kwilamo biteebo billi kulupapula luuno

Naanu unabaamo mumusoomo guuno?

Umulimi webitungulu wosi afugilisiwa ate anaalodewa kuba mumusoomo guuno.

Kyinayila zidakika nga asaatu (30) obaa ni qwika haasi kwilamo biteebo byesi inakutaba ko.

Baatu banaaba mumusoomo guuno banaba bibili kuminamukaga (216) ninaawe nga uliko.

Buziibu bulimo mumusoomo guuno.

Kaawo busiibu bwesi kulengele oba bunyara bwabawo nga wabeele mumusomo guuno wobula bwe kuyila buude bowo kuuba mumusoomo guuno.

Bilayi bili mukuuba mumuusomo guno.

Kyilayi kisangayo kwama mumusoomo guuno kyili inti, gunogelako infuna kwama mukulima bitungulu ate kunanguwisako kufuna bumizo bwebitungulu bukali bwebeyi ingali eesi banauganda.

Ninankityo,nii infuna mungeli yesilingi lwe bulamu bulayi nikulakulana mubisela bye mumaaso.

Nakyindi,musoomo guuno gunakumanyisa biitu bibitagisiwa mukulima bitungulu. Babaanaba mumusomo guuno bakamayisiweko kubikaamemo ni bihambako baatu bosi bakaabe mumusoomo guuno.

Kukugumisa

Kaawo ukamanye ati ewowee niyo ubele mumusoomo guuno lwekuba inzakukozesa zicodi kumanya babeere mumusoomo guuno.

Mageesi oba bilomo byeesi innakufunako bikamanyiwe ni babaatu babele mumusoomo guuno bonyene. Elaa, mageesi gaano gakadabuliweko nuu mukulu wee gumosoomo guuno enyene.

Kusaalawo kundi

Kolinikuuba mumusoomo guuno nga beele wakugaana dda. elaa kawo kyesi ufila nga

wakubamo mumusoomo guuno dda.

Byeekutamu

Kaawo silingi zeesi unaatamo nnga eesi uba mumusoomo guno dda.

Biteebo

Nnga beele uliko nikyiteebo kyosi eesi musoomo guuno, usoboola kukubilako umukulu wegumusoomo guuno (Elias Munezero) kunamba yesimu; 0779831879.

Kyilomo kyekuba mumusoomo guuno.

Kuuba mumusoomo guuno kyaama mukukalawo kowo, ela usoboola kubaamo oba kawo ate ufugisiwa kutulamo inyanga yesi uganile nga kawo kyibonelezo kyosi dda.

Inga beele uliko ni kwimulungunya koosi eesi musoomo gunno oba eesi lidembe lyowo eesi musoomo guuno, tebaako umukulu ukulila biitu bye kuyodelesa oba banaasayansi kulugudo lwe Kimera, Ntinda, Kampala kunamba; 0414705500.

Ilomo yekufugilisa

.....inga eesi wubulile kumusoomo gunno, buziibu bulimo, bilayi, bifugilisiwa kuuba mumusoomo guuno. Nateegele ntii, kukalawo koose kuuba mumusoomo guuno kawo kyesi infila mugeli yosi dda. Ate,kumanyika itii imbeele mumusoomo guuno kekyikabewo dda. Ate nakyindi nategele itti esobola kutula mumusoomo gunno inyanga yosi.

Ela, integeele itti, nga eesi nisako mukono kulupapula luuno, kekyiyigiliza lidembe lyose

wabula kyimanyisa kyitii nategeele musoomo gwesi indi kubaamo.

Nasese, bakampeko ikopi yee lupapula luuno.

Lisino Lyo Muntu Ubelemo.....Isiginicha.....Zinaku.....

Lisino Lyo Mugulizi.....Isiginicha.....Zinaku.....

Lisino Lyo Musoomi .....Isiginicha.....Zinaku.....

APPENDIX C

Research Questionnaire

GULU UNIVERSITY
FACULTY OF AGRICULTURE AND ENVIRONMENT
DEPARTMENT OF RURAL DEVELOPMENT AND AGRIBUSINESS

Title: PROFIT EFFICIENCY OF RED ONIONS PRODUCTION IN SIRONKO DISTRICT

This study is concerned with **profit efficiency of red onions production in Sironko district.** Being an onions farmer in this area, you have been selected to participate as a respondent in this study. Any information that you provide to us will not be disclosed to any other party but will only be used for the completion of this study. I therefore humbly request your time and candid response to the following questions.

In case you are consenting to this interview, kindly sign/ thumb-print: .....

Interviewer's Name..... Questionnaire No.....
Date.....

District.....Sub-County.....

Parish.....Village.....

SECTION 1: Socio-economic characteristics of the respondent and other onion farmers' information. Please indicate and tick where applicable.

	Question	Responses
	Gender of the respondent **(observe)**	1 = Male 2 = Female
	Age of farmer (in completed years)	.....
	Farming experience	..... Years
	Number of household members	.....persons
	Marital status	1 = Married 2 = Single 3 = Widow/Widower 4 = Divorced
	How many of the household members are working on the farm?	.....persons
	Education level (completed years?	..... Years
	Size of landholding (in acres)	..... Owned..... Rented
	Land under agricultural production (in acres)	..... Owned..... Rented
	Are you specialized only in Onions or do you grow other crops?	1=Yes 2= No

1	Are you involved in non-farm income-generating activities?	1= Yes 2= No	
2	If yes, what types of non-farm activities? (Tick all that apply)	1= Salaried employment 2= Shopkeeping 3= Casual work 4= Boda-boda 5=Brick making 6=Charcoal selling 7=Firewood selling 8= Others (specify).....	
3	What is the estimate of the amount of money realized from other occupations monthly? Ugx	1. Less than 100k 2. 100k-500k 3.500k-1M 4. More than 1M	
4	Income from non-farm sources for the last year? Ugx	1. Less than 100k 2. 100k-500k 3.500k-1M 4.1M-5M 5. More than 5M	
5	In which season do you grow onions?	1= Rain season (rain fed) 2= Dry season (irrigation) 3= Both	
6	How many times did you grow onions in the last rainy season?	1= Once 2= Twice 3= More (specify the number)	
7	How many times did you grow onions in the last dry season?	1= Once 2= Twice 3= More (specify the number)	
8	Income from onion farming for the last production cycle? Ugx (Tick where applicable)	Rain season	Dry season
		1. Less than 100k 2. 100k-500k 3.500k-1M 4.1M-5M 5. More than 5M	1. Less than 100k 2. 100k-500k 3.500k-1M 4.1M-5M 5. More than 5M
9	Do you have access to agricultural credit?	1= Yes 2= No	
10	If yes (in 19), what was the last source of agricultural credit you accessed?	1= Banks 2= Farmers' group 3= Peer farmers 4= Relatives 5= Others (specify).....	
11	Do you have access to extension services?	1= Yes 2= No	
12	Do you belong to any farmers' association?	1= Yes 2= No	

23	How do you acquire land for your onions farm?	1 = Freehold 2 = Family land 3 = Community land 4 = Hired land 5 = Personal land
24	What are your sources of labour?	1 = Family labour 2 = Hired labour 3 = Community labour 4 = Others (specify).....
25	How do you decide on labour charges?	1 = Fixed amount per labour/day 2 = By bargaining 3 = Others (specify)
26	What varieties of red onions do you grow?	a....., b..... and c.....
27	What methods do you use in onion farming?	1 = by direct sowing 2 = by transplanting 3 = Both 4 = Others (specify).....
28	What are the sources of onion seeds	1 = Buying from the market 2 = Buying from my fellow farmers 3 = Other (specify) .....

SECTION 2: INPUT AND RETURNS (Last Production Cycle)

Qn.	Question	Responses							
1	Land size under onion production?	**Rain season**				**Dry season**			
		Owned..... Rented..... total..... ..... (Acres)				Owned..... Rented..... total..... ..... (Acres)			
2	Cost of land rent (per acre)	**Rain season**				**Dry season**			
		.....Ugx				.....Ugx			
3	If the land is owned, how much would you have paid to rent land per acre?	.....Ugx							
4	Quantity of onions seeds planted at the beginning of the season	**Rain season**				**Dry season**			
		Variety		Quantity (kg)		Variety		Quantity (Kg)	
5	Quantity of inorganic fertilizer used for onions production in the last season	**Rain season**				**Dry season**			
		Fertilizer type	Qty (Kg)	Price/Kg	Tot	Fertilizer type	Quantity in Kg	Price/Kg	Tot.
6		**Rain season**				**Dry season**			

	How many wheelbarrows of organic manure do you use on that farm?	Type of manure	Qty (kg)	Price/wheel barrow	Total	Type of manure	Qty	Price/wheel barrow	Tot.	
7	Estimate the quantity of pesticides used last season	**Rain season**					**Dry Season**			
		Qty	Unit	Rate	price	Total	Qty	Unit	Rate	Price / Tot
8	Estimate the quantity of Weedicides used last season	**Rain season**					**Dry season**			
		Qty	Unit	Rate	Price	Total	Qty	Unit	Rate	Price / Tot
9	Other inputs (specify)	**Rain season**					**Dry season**			
		Qty	Unit	Rate	Price	Total	Qty	Unit	Rate	Price / Tot
10	How often do you sell the onions in the market?	1 = Daily 2 = Weekly 3 = Monthly 4 = Seasonally								
11	Whom do you sell to?	1 = Wholesalers 2 = Retailers 3 = Consumers 4 = Restaurants and hotels 5 = Others specify								
12	Do you sell them at harvest time or after a certain period? specify number of months	**Rain season**					**Dry season**			
		1= When in the field 2= harvest time 2= After a certain period..... months					1= When in the field 2= harvest time 2= After a certain period..... months			
13	Estimate the quantity harvested	**Rain season**					**Dry season**			
		Variety		Quantity (kg)			Variety		Quantity (kg)	

14	Estimate the quantity sold at farmgate and at the marketplace (kg)	**Rain season**				**Dry season**		
		Variety	Farm gate	Market place		Variety	Farmgate	Market place
15	At what rate/prices do you sell onions? (Ugx/kg)	**Rain season**				**Dry season**		
		Variety	Farm gate	Market Place		Variety	Farm gate	Market place
16	In case you sell after a certain period, how much does drying/storing cost you?	Rain season				Dry season		
		Quantity (Kg)		Price (Ugx)	Tot (Ugx)	Quantity (Kg)	Price (Ugx)	Tot (Ugx)
17	How much was the cost of labour while drying and storing?	**Rain season**				**Dry season**		
		Quantity (Kg)		Price (Ugx)	Tot (Ugx)	Quantity (Kg)	Price (Ugx)	Tot (Ugx)

Marketing costs

Rain season				**Dry season**			
Input	**Qty (kg)**	**Price /Unit**	**Tot. cost**	**Input**	**Qty (kg)**	**Price/unit**	**Tot. cost**
Transport				Transport			
Taxes				Taxes			
Packaging				Packaging			
Loading/offloading				Loading/offloading			
Sorting				Sorting			
Grading				Grading			
Others (specify)				Others (specify)			

Labour used in onions production

Activity	Number of people involved		Number of days		The average number of hours worked per day		Daily rate/ head		Total Cost	
Seasons: Rain season (RS) Dry season (DS)	**RS**	**DS**	**RS**	**DS**	**RS**	**DS**	**RS**	**DS**	**DS**	**RS**
Nursery bed preparation and management										
First ploughing										
Second ploughing										
Transplanting										
Watering after transplanting										
First weeding										
Second weeding										
Pest control (spraying)										
Harvesting										
Transporting home										
Others (specify)										

Thank you

APPENDIX D

Stochastic Profit Frontier for analyzing factors influencing profit efficiency of onion production

Stoc. frontier normal/tnormal model

Number of obs = 192
Wald chi2(5) = 47.30
Prob > chi2 = 0.0000

Log likelihood = -256.2683

logProfit	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
logCost_Seeds	.294213	.1129464	2.60	0.009	.0728421	.5155838
logCost_fertilizers	.1357517	.0728185	1.86	0.062	-.00697	.2784734
TotLandSize_under_onions	.143302	.1167117	1.23	0.220	-.0854486	.3720527
logCost_PestControl	.1725935	.0874271	1.97	0.048	.0012396	.3439475
logCost_Weeding	.3140219	.1038807	3.02	0.003	.1104195	.5176244
_cons	3.160047	.6308542	5.01	0.000	1.923596	4.396499
Mu						
Age	.3195598	.1156218	2.76	0.006	.0929452	.5461745
Farming_expce	-.7578913	.2823692	-2.68	0.007	-1.311325	-.2044579
HH_Size	.3817907	.2428423	1.57	0.116	-.0941715	.857753
Educ	.4199022	.1853983	2.26	0.024	.0565282	.7832763
MaritalStatusdummy	-2.227861	1.452876	-1.53	0.125	-5.075446	.6197247
Genderdummy	-1.373049	1.088309	-1.26	0.207	-3.506096	.7599974
AccessTocreditdummy	6.143296	2.132041	2.88	0.004	1.964572	10.32202
BelongToFarmersAssocdummy	3.457535	1.392282	2.48	0.013	.7287117	6.186359
LandAcquisitondummy	-1.414188	1.2639	-1.12	0.263	-3.891386	1.06301
MethodsUsedOnionFarmingdummy	2.322409	1.743958	1.33	0.183	-1.095686	5.740504
InvolvedNonFarmActivitiesdummy	2.396499	1.153766	2.08	0.038	.1351585	4.65784
SellingPlacedummy	-7.808221	2.593265	-3.01	0.003	-12.89093	-2.725514
SpecializedOnlyOnionFarmingdummy	-6.086423	1.951487	-3.12	0.002	-9.911267	-2.261579
AccessToExtensionServicedummy	-11.68144	3.996101	-2.92	0.003	-19.51366	-3.84923
_cons	-9.729377	5.163593	-1.88	0.060	-19.84983	.3910788
Usigma						
_cons	.089374	.5196345	0.17	0.863	-.9290909	1.107839
Vsigma						
_cons	-.3341461	.1136968	-2.94	0.003	-.5569877	-.1113045

sigma_u	1.045701	.271691	3.85	0.000	.6284207	1.74006
sigma_v	.8461378	.0481016	17.59	0.000	.7569229	.945868
lambda	1.235851	.2863341	4.32	0.000	.6746468	1.797056

APPENDIX E

Pairwise correlation results between the variables in the inefficiency model

```
. cor Farming_expce HH_Size Educ MaritalStatusdummy Genderdummy AccessTocreditdummy AccessToExtensionServicedummy
>  BelongToFarmersAssocdummy LandAcquisitondummy MethodsUsedOnionFarmingdummy InvolvedNonFarmActivitiesdummy Sell
> ingPlacedummy
(obs=192)
```

	Farmin~e	HH_Size	Educ	Marita~y	Gender~y	A~tdummy	A~edummy	Belong~y	LandAc~y	Method~y	Involv~y
Farming_ex~e	1.0000										
HH_Size	0.4081	1.0000									
Educ	-0.1525	-0.1287	1.0000								
MaritalSta~y	0.1986	0.2000	-0.1283	1.0000							
Genderdummy	-0.0186	0.0536	0.0841	-0.0401	1.0000						
AccessTocr~y	-0.0904	0.2086	-0.2568	-0.0337	0.0843	1.0000					
AccessToEx~y	0.0629	0.1956	0.0619	0.1152	0.1308	0.1220	1.0000				
BelongToFa~y	0.0712	0.2411	-0.0378	-0.0054	0.1395	0.3484	0.1926	1.0000			
LandAcquis~y	0.0340	0.0829	0.0604	-0.0500	-0.0860	0.0048	0.1945	0.0910	1.0000		
MethodsUse~y	0.1122	-0.1628	0.1257	0.0134	-0.0650	-0.3702	0.1474	-0.2823	-0.1987	1.0000	
InvolvedNo~y	-0.0844	-0.0563	0.0965	-0.1422	0.0446	-0.0103	0.0769	0.0899	0.2967	-0.0949	1.0000
SellingPla~y	-0.1030	0.1165	-0.2028	-0.0222	0.1042	0.2723	-0.1471	0.1661	0.0950	-0.4394	-0.1505

	S~lace~y
SellingPla~y	1.0000

APPENDIX F

Ethical Approval

GULU UNIVERSITY

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+256 776 812 147

RESEARCH ETHICS COMMITTEE

17/02/2022

To: Elias Munezero

Gulu University
0779831879

Type: Initial Review

Re: GUREC-2022-204: PROFIT EFFICIENCY ANALYSIS OF RED ONIONS PRODUCTION IN MBALE DISTRICT, UGANDA, 2.0, 2022-04-26

I am pleased to inform you that at the **81st** convened meeting on **17/02/2022**, the Gulu University REC, committee meeting, etc voted to approve the above referenced application.
Approval of the research is for the period of **17/02/2022** to **17/02/2023.**

As Principal Investigator of the research, you are responsible for fulfilling the following requirements of approval:

1. All co-investigators must be kept informed of the status of the research.
2. Changes, amendments, and addenda to the protocol or the consent form must be submitted to the REC for re-review and approval **prior** to the activation of the changes.
3. Reports of unanticipated problems involving risks to participants or any new information which could change the risk benefit: ratio must be submitted to the REC.
4. Only approved consent forms are to be used in the enrollment of participants. All consent forms signed by participants and/or witnesses should be retained on file. The REC may conduct audits of all study records, and consent documentation may be part of such audits.
5. Continuing review application must be submitted to the REC **eight weeks** prior to the expiration date of **17/02/2023** in order to continue the study beyond the approved period. Failure to submit a continuing review application in a timely fashion may result in suspension or termination of the study.
6. The REC application number assigned to the research should be cited in any correspondence with the REC of record.
7. You are required to register the research protocol with the Uganda National Council for Science and Technology (UNCST) for final clearance to undertake the study in Uganda.

The following is the list of all documents approved in this application by Gulu University REC:

GULU UNIVERSITY
INSTITUTIONAL REVIEW COMMITTEE
APPROVED UNTIL
★ 17 FEB 2023 ★
FACULTY OF MEDICINE
P. O. Box 166, Gulu

No.	Document Title	Language	Version Number	Version Date
1	The covid19 risk management plan	English	2.0	2022-04-26
2	Protocol	English	2.0	2022-04-26
3	Informed Consent forms	Lumasaba	2.0	2022-04-26
4	Informed Consent forms	English	2.0	2022-04-26
5	Data collection tools	English	2.0	2022-04-26

Yours Sincerely,

Julaina A. Obika (PhD)
For: Gulu University REC

GULU UNIVERSITY
INSTITUTIONAL REVIEW COMMITTEE
APPROVED UNTIL
17 FEB 2023
FACULTY OF MEDICINE
P. O. Box 166, Gulu

APPENDIX G

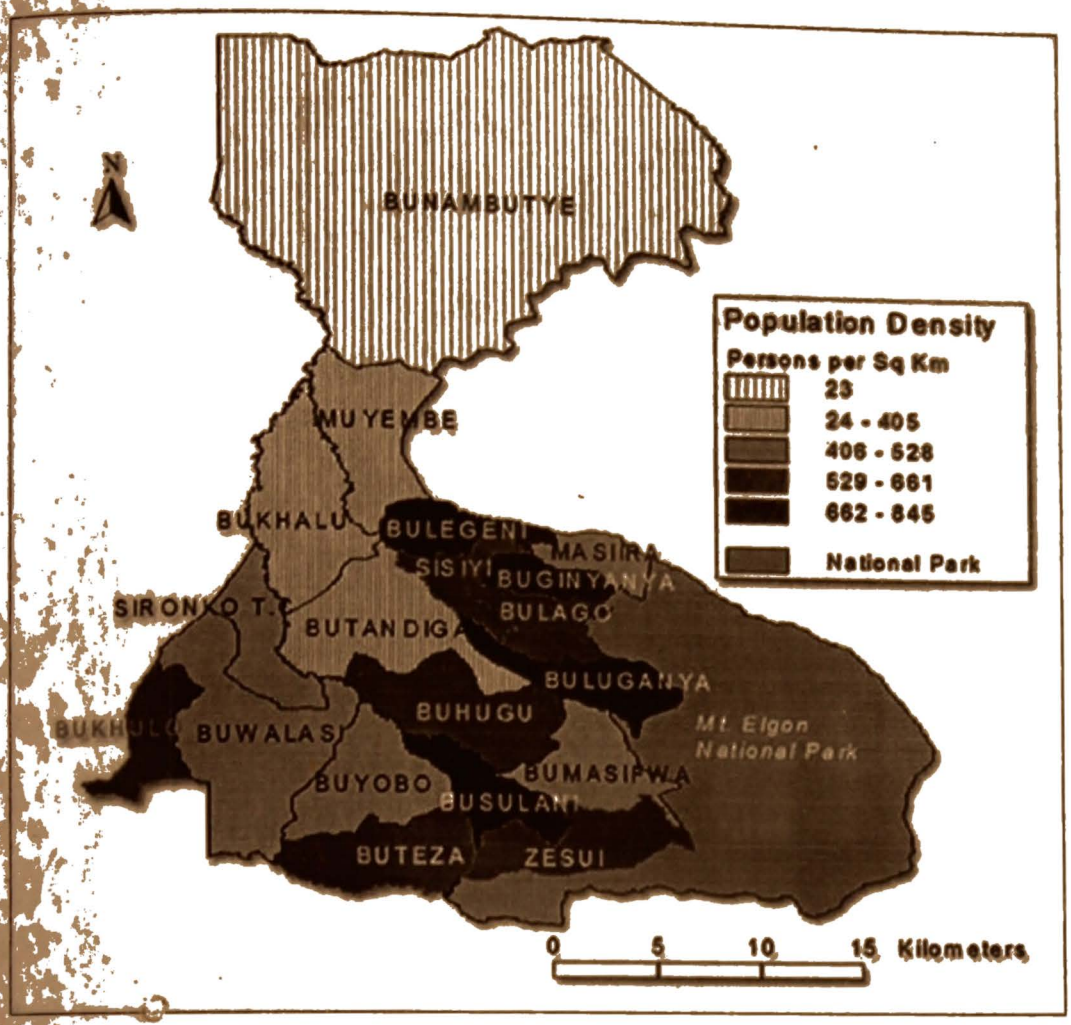


Figure 1. Map of Sironko district, eastern Uganda showing the various sub-counties