# GENDERED YIELD GAP ANALYSIS IN GROUNDNUT PRODUCTION IN TANZANIA: SOCIAL AND ECONOMIC IMPLICATIONS

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIR EMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS OF THE SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.**

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**ABSTRACT**

The study explored groundnut gendered yield gap and socio-economic factors for groundnut production in Tanzania. The study was based on ICRISAT survey data collected from 938 farmers randomly selected in 9 producing regions namely; Shinyanga, Mwanza, Geita, Dodoma, Tabora, Mbeya, Songwe, Rukwa and Mtwara representing different socio-cultural and agro-ecological zones. Data were analyzed using stochastic frontier production function to establish groundnut yield gap and factors affecting groundnut production in Tanzania. The results revealed that, groundnut is the most important crop in all age groups, across sex and agro ecological zones. Youth (16-35 years) had the highest actual groundnut yield of 0.4984 Mt/ha, relative to adults (36-60 years) with 0.3643 Mt/ha and elders (above 60 years) with 0.3216 Mt/ha. However, youth participation was low compared to adults and elders. Actual groundnut yield for male groundnut farmers was 0.4205 Mt/ha and female was 0.3363 Mt/ha, differences in actual groundnut yield between sex was significant at 5%. The overall actual groundnut yield was 0.3868 Mt/ha and the potential groundnut yield was 0.8271 Mt/ha, making the groundnut yield gap of 0.4403Mt/ha. Results from the maximum likelihood estimates revealed that amount of groundnut seed in kilograms, plot size in hectares and labor measured in man days were the factors associated with changes in groundnut yield and all of the factors were significant at 1%. Analysis of socio-economic and physical factors that can significantly increase the groundnut yield indicated that a farmer being male, being in youth age group, having formal education and being in southern highland and southern zone increases the efficiency of producing groundnut. It was concluded that since there is economies of scale with the use of more labors and groundnut seed, thus these factors and socio-economic factors should be considered for increased groundnut yield per hectare.

# DECLARATION

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

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The above declaration is confirmed;

Prof. Joseph Phillip Hella                Date

(Supervisor)

## COPYRIGHT

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## DEDICATION

This work is dedicated to my father George Casmir Mwakimata and my mother Scholastica Joseph Fivawo for laying foundation of my education.

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## LIST OF ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| AEZs | Agro-ecological Zones |
| COSTECH | Tanzania Commission for Science and Technology |
| DEA | Data Envelope Analysis |
| Exp | Exponent |
| FAO | Food and Agriculture Organization |
| FAOSTAT | FAOSTATISTICS |
| GAF | Gender Analytical Frameworks |
| GDA | Gender and Development Approach |
| GM | Gross Margin Analysis |
| Ha | Hectares |
| HAF | Harvard Analytical Framework |
| ICRISAT | International Crop Research Institute for Semi Arid Tropics |
| MAF | Moser Analytical Framework |
| MALF | Ministry of Agriculture Livestock and Fisheries |
| Mt | Metric tons |
| NARI | Naliendele Agricultural Research Institute |
| NBS | National Bureau of Statistics |
| NGOs | Non-government Organizations |
| PAM | Policy Analysis Matrix |
| SFA | Stochastic Frontier Analysis |
| SPSS | Statistical Package for Social Sciences |
| SUA | Sokoine University of Agriculture |
| TE | Technical Efficiency |

| | |
|---|---|
| TVC | Total Variable Cost |
| URT | United Republic of Tanzania |

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background Information

Worldwide groundnut is the second most important oil seed crop after soya beans, third most important source of vegetable edible oil and thirteenth most important food crop (Dwivedi and Upadhyaya, 2015; Giroh *et al.*, 2015). Groundnut is cultivated on about twenty six million hectares worldwide with total production of thirty seven million metric tons and average yield of 1.4 Mt/ha (Madhusudhana, 2013). The crop is grown in more than 100 countries; developing countries account 97% of total area under groundnut production and 94% of total groundnut production or groundnut output (Katundu *et al*., 2014; Madhusudhana, 2013).

Groundnut production is concentrated in Asia and Africa; Asia account 56% of global area of groundnut cultivation and 68% of global groundnut production meanwhile Africa account 40% of global area of groundnut cultivation and 25% of global groundnut production (Madhusudhana, 2013). China, India, Nigeria, Senegal, Sudan, Burma and United States of America are the major groundnut producing countries in the world (Dwivedi and Upadhaya, 2015; Madhusudhana, 2013).

In Africa, major groundnut producing countries are Nigeria, Sudan, Tanzania, Chad, Senegal and Cameroon (Fig. 1). Nigeria was the leading groundnut producer during the 2010 to 2014 period with an average groundnut production volume of about 3 192 599.40 Mt (Fig. 1). During that period, Tanzania produced 997 404.4 Mt and was the third in groundnut production in Africa (Fig. 1).  Average groundnut yield in Africa for the past period of five years (2010 to 2014) stood 1.01Mt/ha.

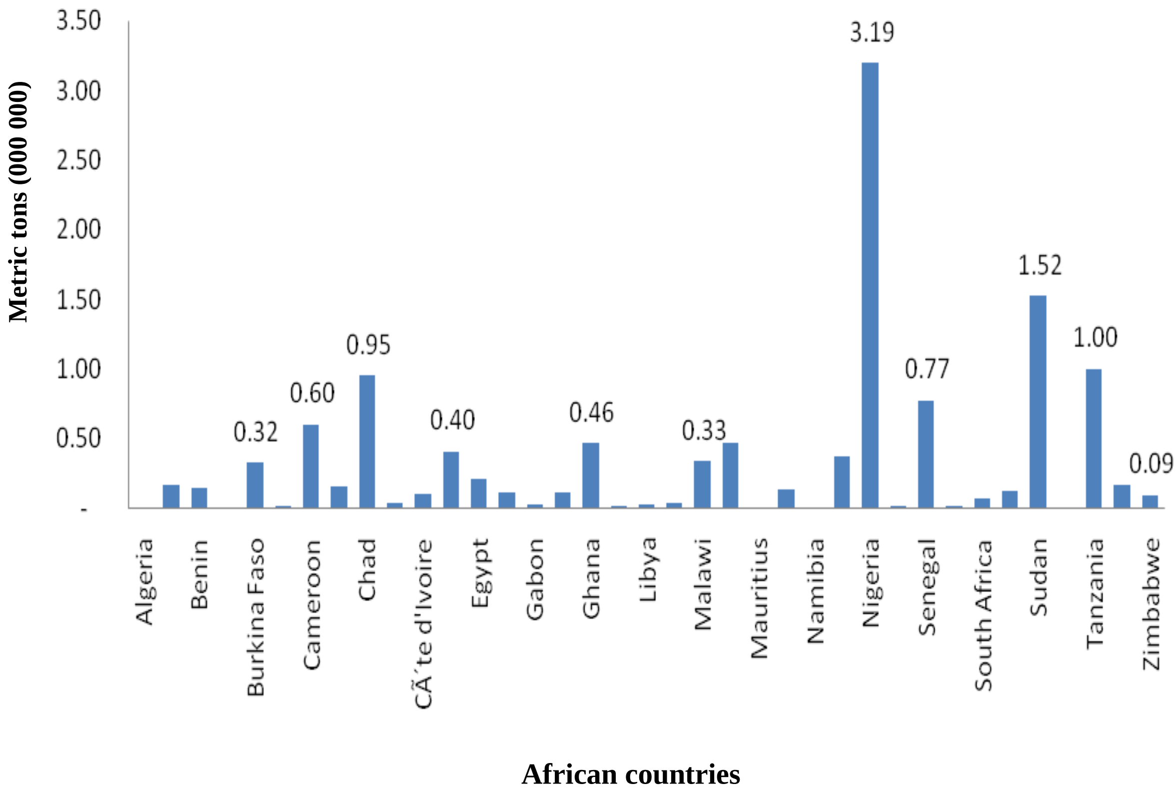


**Figure 1: Average groundnut production in Africa from 2010 to 2014 (Source: FAOSTAT, 2017)**

Average groundnut yield in Africa for the past period of five years (2010 to 2014) stood at 1.02Mt/ha with the yield being highest in 2014 of 1.03 Mt/ha and lowest in 2013 of 0.9957 Mt/ha (Appendix 1). The groundnut yield varied widely in African countries, from the highest yield 3.201 Mt/ha in Egypt to the lowest yield of 0.489 Mt/ha in Niger (Fig. 2). Thus, countries with high groundnut production in Africa like Nigeria, Sudan, Tanzania and Chad, higher production were more attributed by large area under groundnut production rather than higher groundnut yield (Fig. 1 and 2).

Tanzania being the third groundnut producing country in Africa, has been experiencing an increasing groundnut production volume at an average of 19.23% for the past 20 years, 1995 to 2014 (FAOSTAT, 2017).

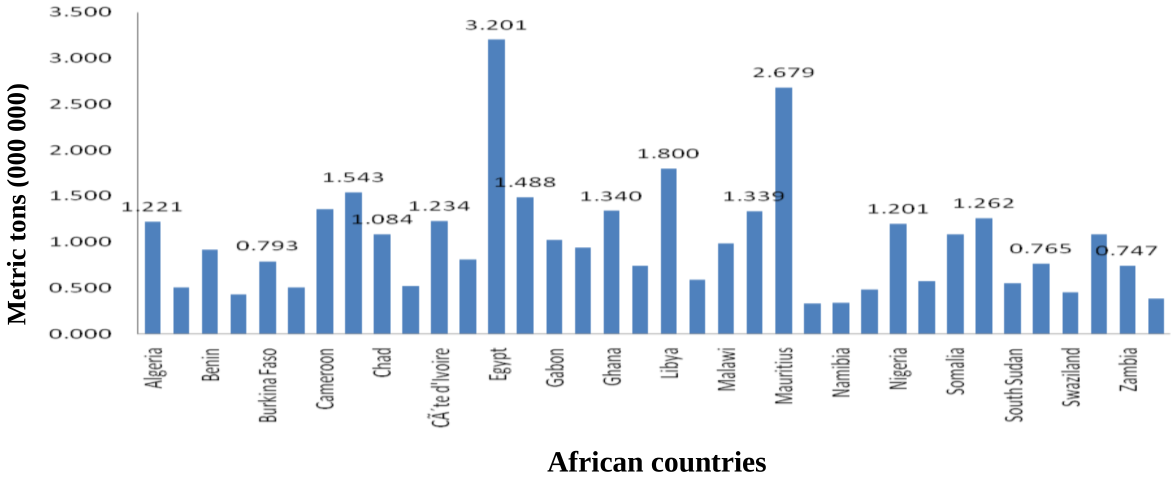


**Figure 2: Average groundnut yield in Africa from 2010 to 2014 (Source: FAOSTAT, 2017)**

According to Fig. 3, groundnut production was lowest in 1997 with the production volume of 111 844 Mt and highest in 2014 with the production volume of 1 619 500 Mt. Tanzania experienced the greatest jump in groundnut production in 2001 with the production increase of 111.36% relative to 2000 and in 2014 with the production increase of 71.62% relative to 2013 (FAOSTAT, 2017).

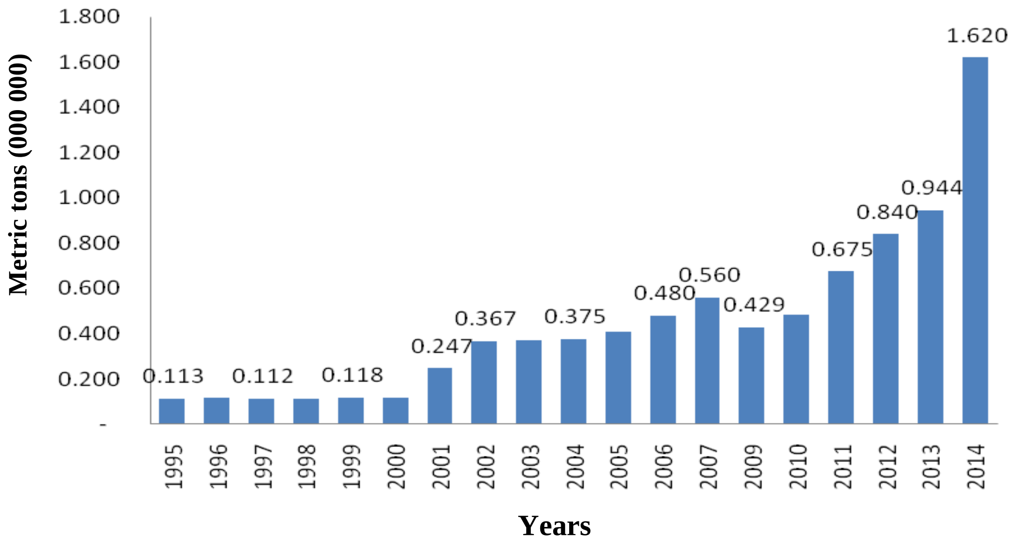


**Figure 3: Groundnut production in Tanzania from 1995 to 2014 (Source: FAOSTAT, 2017)**

Tanzania has been experiencing an increasing groundnut yield at a cyclical trend for the past 20 years 1995 to 2014 at a rate of 5.57% (Fig. 4). The mean groundnut yield from 1995 to 2014 was 0.822 Mt/ha. It varied from an estimated average groundnut yield of 0.637 Mt/ha in 1995 to an estimated average groundnut yields of 1.01 Mt/ha in 2014 (Fig. 4). The highest average groundnut yield of 1.510 Mt/ha was achieved in 2014 while the lowest average groundnut yield of 0.444 Mt/ha was achieved in 2000 (Fig. 4).

Furthermore, Tanzania experienced the greatest jump in groundnut yield in 2001 and 2013 at a rate of 88.15% and 56.54% respectively, however 2000 and 2014 was the period with the highest decline in groundnut yield at rate of -29.05% and -33.13% (Fig. 4).

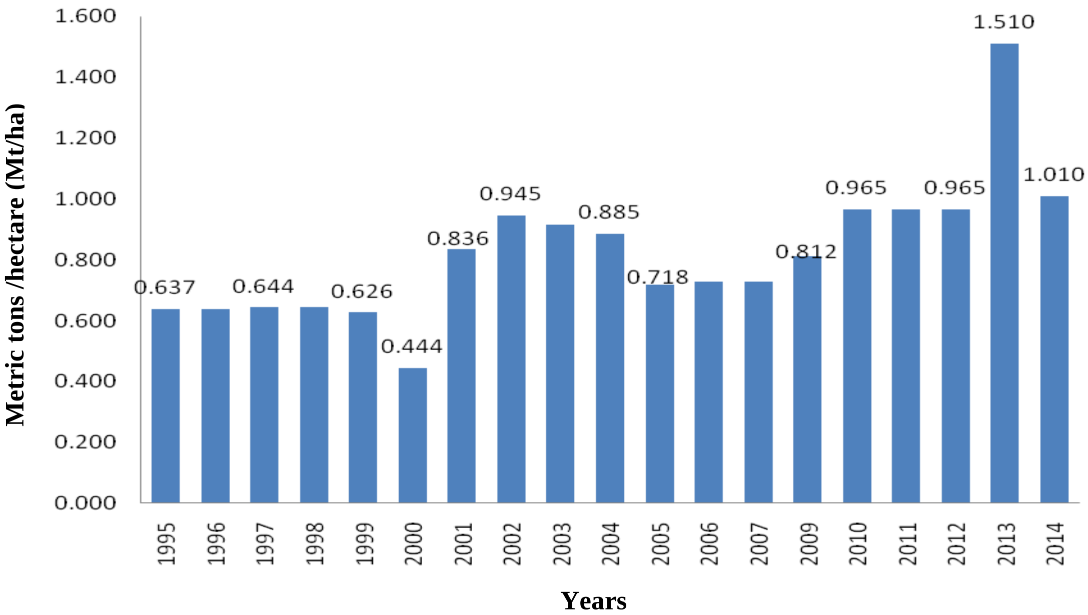


**Figure 5: Groundnut yield in Tanzania from 1995 to 2014 (Source: FAOSTAT 2017)**

Groundnut production in Tanzania is mostly done by smallholder farmers for food as it is an important source of nutrients and for commercial purposes (Katundu *et al.*, 2014). Thus, groundnut production is important for food security and for households' income. However, in some areas of Tanzania like Tabora farmers were reported to stop growing groundnut due to low return per capital invested, low yields, lack of reliable market and lack of improved varieties (Bucheyeki *et al.,* 2010). Women are the major providers of labor for groundnut production in Tanzania and it has been regarded that groundnut production is a women crop because they are more involved in producing it relative to men for meeting the household food demands and income (Katundu *et al.,* 2014). Despite women being major producers of groundnut in Tanzania, it has been observed that groundnut is more grown for subsistence rather than for commercial purposes (Battista *et al.,* 2014).

Groundnut production is important in Tanzania because it provides the raw material for meeting domestic and foreign industrial demand for producing vegetable cooking oil, butter and snacks products (Kuboja and Temu, 2013). Furthermore, groundnut production form an important source of local supply of nutrients (proteins) among many small scale farmers in Tanzania especially the poor who are un able to access nutritional food through purchase. Also groundnut production is an important source of employment especially to women who provides most of their labor power for groundnut production in Tanzania (Katundu *et al.,* 2014). Moreover, the production of groundnut is an important source of income from the sale of surplus production volume (Katundu *et al.,* 2014). Therefore, increasing groundnut yields to farmers of Tanzania will lead to multiple benefits in the economy.

## 1.2 Problem Statement and Justification

Groundnut yield in Tanzania varies across agro-ecological zones and among the varieties. For example, Tabora region, which is in western agro-ecological zone the mean groundnut yield for local variety was between 0.499 Mt/ha and 0.772 Mt/ha (Bucheyeki *et al.,* 2010). Pendo, an improved groundnut variety had the mean yield of between 1.309 Mt/ha and 1.512 Mt/ha (Bucheyeki *et al*., 2010). Dodoma region which is in central agro-ecological zone had the mean groundnut yield of 0.4 Mt/ha (Godio, 2013) and Kiteto which is in northern agro-ecological zone had the mean groundnut yield of 0.45 Mt/ha (Potaka *et al*., 2013). Thus, groundnut yield of the farmers from Dodoma in central agro-ecological zone and Kiteto in northern agro-ecological zone were far below from the national average groundnut yield of 1.5 in 2013 (Fig. 4), African average of 1.02 Mt/ha (FAOSTAT, 2017) and World average of 1.4 Mt/ht (Katundu *et al*., 2014; Madhusudhana, 2013).

Lower groundnut yield have the implications of food insecurity and poor household income which may affect the sustainability of groundnut production and trapping the farmers into the poverty (Giller and Tittonell, 2013). Taking into consideration the historical cyclical trend of groundnut yield in Tanzania (Fig. 4), there is no recent study that has been done to document the regional and national average groundnut yield. Studies done by Katundu *et al.* (2014) and Bucheyeki (2010) in groundnut were based in assessing socio-economic factors limiting smallholder groundnut production in Tabora region Tanzania and on-farm evaluation of promising groundnut varieties for adaptation and adoption in Tanzania.

Furthermore, Kuboja and Temu (2013) did a study on comparative economic analysis of Tobacco and groundnut in Tabora region, Tanzania. Thus, it can be observed that limited studies done in groundnut were based at addressing challenges and economic viability of groundnut production, however none of them have explained regional and national production status of groundnut production based on the demographic characteristics of the farmers. Thus, this study aimed at analyzing the gender yield gap for groundnut production in Tanzania. Findings from this study provides a good production bench mark at regional level based on agro ecological zone and national level for increased groundnut yield to meet national and foreign groundnut demand as one of the important raw materials for industries manufacturing products like vegetable oils, butter and snacks. Following a current emphasis by the Tanzanian government of promoting development of industries for the purpose of becoming a middle income country by 2025, this study also provides findings in groundnut sub sectors that are helpful to achieve that target.

## 1.3 Objectives of the Study

### 1.3.1 General objective

The overall objective of the study was to analyze the gender yield gap for groundnut production in Tanzania considering social and economic implications.

### 1.3.2 Specific objectives

Specifically, the study was sought to;

i. To characterize household resource ownership structure in Tanzania according to gender.
ii. To determine groundnut yield gap based on gender in Tanzania.
iii. Determining socio-economic factors that influence the difference in the adoption of improved groundnut variety in Tanzania.
iv. To determine the profitability differences between female and male groundnut farmers in Tanzania.

### 1.3.3 Hypotheses of the study

The study was guided by four research hypothesis

i. There is no significant difference in household resource ownership structure based on gender in Tanzania.
ii. There is no groundnut yield gap in Tanzania especially between males and females.

iii. There is no difference in socio-economic factors that influence adoption of improved groundnut variety in Tanzania.

iv. There is no significance difference in gross margin between male and female groundnut farmers in Tanzania.

## 1.4 Organization of the Dissertation

This dissertation is organized in five chapters. The first chapter presents the study background, statement of the problem and justification, overall and specific objectives of the study and research hypotheses. The second chapter reviews definition of concepts that are relevant to the study, importance of yield gap assessment, review of empirical studies on gender in agriculture, review of literature on yield gap estimation, review of studies on stochastic frontier analysis for quantifying yield gap and conceptual framework. The third chapter presents the research methodology, data analysis, theoretical framework in relation to yield gap in groundnut production and analytical framework of the study. The fourth chapter presents the results and discussion of the research findings and fifth chapter presents conclusion and recommendations.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

## 2.1 Definition of Key Concepts

### 2.1.1 Sex

According to March *et al.* (2005) sex is the biological difference between men and women (March *et al.,* 2005). Sex differences are concerned with men's and women's bodies whereby men produce sperm; women bear and breast feed children (March *et al.*, 2005). Sex differences are the same throughout the human race (March *et al.*, 2005). Therefore, sex defines the biological difference of men from the woman which does not change over times or place or race. Thus, there is the distinction of sex from gender as the definition of gender is provided below from the sociologist point of view.

### 2.1.2 Gender

Sociologist define gender as all socially given attributes, roles, activities and responsibilities connected to being a male or a female in a given society (March *et al*., 2005). The experience of being male or female differs from culture to culture (March *et al.*, 2005). Gender identity in a given society determines how males and females are perceived and how males and females are expected to think and act as women and men in the way the society is organized (March *et al.*, 2005). Therefore, it can be observed that sex is a fact of human biology while gender is not.

### 2.1.3 Gender relation

March *et al.* (2005) and MALF (2017) explained gender relation as the social relationship between men as a sex and women as a sex. Also gender relation can be viewed as a simultaneous relation of cooperation, connection and mutual support and of conflict, separation and competition, of difference and inequality (March *et al.*, 2005). Thus, gender relation is concerned with how power is distributed between sexes (March *et al.*, 2005 and MALF, 2017). It is concerned with how responsibilities are allocated to members of the household and the value given to those responsibilities (March *et al.*, 2005 and MALF, 2017). Gender relation tends to vary across time, place, culture, race and ethnicity and off course between different groups (March *et al.*, 2005 and MALF, 2017).

### 2.1.4 Gender analysis

According to March *et al.* (2005) gender analysis explores and highlights the relation of women and men in society and the inequality in those relationships by asking who does what? Who has what? Who decides? How? Who gains? Who loses? By asking these questions we should also ask which men and which women. Gender analysis looks at how power relations within the household relate with those at international, state, market and community level (March *et al.*, 2005). Gender analysis further explores the intensity of the roles and the return from the relaxation of the roles in term of monetary value. A study by Tibaijuka (1994) found that by liberalizing gender roles, cash income could increase by up to 10% while the productivity of labor and capital would improve by 15% and 44% respectively.

### 2.1.5 Households

Economists view households as collection of individuals, who behave as if in agreement on how best to combine time and goods (purchased or produced at home) to produce commodities that maximizes some common welfare index (Chiappori *et al*., 1993). From the cooperative approach of collective model of household behavior an individual may choose to remain single or forming a household (Chiappori *et al*., 1993). He or she may choose to form a household when the utility levels associated with being married outweigh the utility level associated from being single (Chiappori *et al*., 1993). For example there may be economies of scale associated with the production of certain household goods (Chiappori *et al*., 1993).

### 2.1.6 Yield gap

Agronomist defined yield gap as the difference between potential yields and actual yields; potential yield is a yield of a crop cultivar when grown with water and nutrients non-limiting and biotic stress effectively controlled while actual or average yield is a yield actually achieved in a farmer's field (Cassman *et al.*, 2013). Economist have defined yield gap as the difference between technically full efficient yield and observed farmers yield (Alemu and Kitila, 2014). Technically full efficient yield refers to the highest possible yield obtained given observed levels of inputs in a well- defined biophysical environment and actual yield refers to the yield observed in farmers' field (Laborte and Reidsma, 2016). Thus, yield gap is the amount representing the difference between technically full efficient yield and yield observed in farmers' field.

### 2.1.7 Agro-ecological zones (AEZs)

According to HarvestChoice, (2010) agro-ecological zones are geographical areas exhibiting similar climatic conditions that determine their ability to support rain fed agriculture. At regional scale, agro-ecological zones are influenced by latitude, elevation and temperature, as well as seasonality and rainfall amounts and distribution during the growing season (HarvestChoice, 2010; Sebastian, 2009). Understanding the nature and extent of agro-ecological variations with respect to groundnut production is important because local agro-ecological conditions often strongly predict the feasibility and effectiveness of improved technologies and production practices (Sebastian, 2009).

## 2.2 Importance of Yield Gap Assessment

Yield gap quantification at field level is important as it provides a benchmark for assessing effectiveness of current crop management practices, potential for further yield increases and is used as groundwork for identifying limiting factors for higher yield (Casman *et al.*, 2013). Yield gap estimation at regional or national scales is necessary for (i) prioritizing investment in agricultural research and development based on greatest opportunities for returns on that investment, (ii) provides yardstick for measuring progress in agricultural productivity and food self- sufficiency and (iii) estimating food production capacity on existing farm land (Casman *et al.*, 2013). However, it is not profitable or cost effective and environmentally sound to producers to produce at the level of output nearer the potential yield ceilings (Casman *et al.*, 2013), because of the diminishing return of inputs on existing farm land as yield approach the ceilings especially when it reaches 75 to 85% of potential yield, the average farm yields begin to plateau (Casman *et al.*, 2013). Policy makers, development practitioners, and researchers will find it is difficult to accurately assess future state of food security and land use change without yield gap assessment coupled with appropriate socio-economic analysis of constraints to improved productivity thus may lead to policy development and research prioritization that are not well informed (Casman *et al.*, 2013).

## 2.3 Review of Empirical Studies on Gender in Agriculture

A study done by Koirala *et al.* (2015) on farm productivity and technical efficiency of rural Malawian household looking whether gender makes a differences on production of maize, found that female headed household are more technically efficient compared to male headed household after using stochastic frontier production function estimation approach. The results were consistent with the study done by Dadzie and Dasmani (2010) on gender differences and farm level efficiency on food crops in Ghana, they found that farms under female farmers' management were more efficient and also nearer to the potential output compared to farms owned by men after using stochastic metafrontier production function in estimating efficiency.

The results from the above studies are contrary with the findings of Boakye *et al.* (2013) on his study of gender, resource use and technical efficiency among rice farmers in the Ashanti region, Ghana, he found that female rice farmers were relatively technically inefficient than their male counterpart after using stochastic frontier production function. Differences in efficiency between female and male managed farms might be attributed by the differences in individual characteristics like age, education and some physical factors like seeds, amount of fertilizer used, chemicals, as both of these factors were observed by Dossa and Mohammed (2016) and Boakye *et al.* (2013) to significantly influencing farm output.

## 2.4 Yield Gap Estimation Methods

Yield gaps have been estimated differently by agronomists and agricultural economists. Agronomists have relied on field experiments and crop growth models in assessing the contribution of different management practices on crop yield based on the theory of production ecology (Laborte and Reidsma 2016). However, field experiments and crop growth models do not take into account the farmers objective and constraints (socio-economic conditions), also they do not have explicit aim at estimating the yield gap, in most cases they are aimed at estimating current yield and sensitiveness of these yields to variations in management practices or climate (Casman *et al.*, 2013, Laborte and Reidsma, 2016). Thus, agricultural economists have based on stochastic frontier analysis (SFA) for yield gap estimation because SFA explicitly aim at estimating the yield gap. Also SFA considers the farmers resource constraints and objective of maximizing output or profit.

SFA have been used by Muller *et al.* (2010) on their study of yield gap of global grain production and Laborte *et al.* (2016) explaining rice yields and yield gaps in central Luzon, Philippines.

Efficiency of a production unit or firm or farmer which ultimately determines the yield of a farmer may be defined as how effectively the firm or farmer uses the variable resources for the purpose of profit maximization (Gunaratne *et al.,* 2003). The concept of efficiency is decomposed into two components, technical efficiency and allocative efficiency (Gunaratne *et al.*, 2003). According to Addai and Owusu (2014), farm technical efficiency refers to the ability of the farmer to maximize output with given quantities of inputs and a certain technology (output oriented) or the ability to minimize input use with a given objective of output (input oriented) while allocative efficiency refers to the degree where a farmer utilizes inputs in optimal proportions, given the observed input prices or allocative efficiency is the condition that exists when resources are allocated within a firm according to market prices (Dire *et al.,* 2013). Economic efficiency is the combination of allocative and technical efficiency.

Parametric (Stochastic Frontier Analysis) and Non-parametric (Data Envelope Analysis) measures of efficiency are the mostly used econometric approaches to measure efficiency (Gunaratne *et al.,* 2003). Stochastic Frontier Analysis (SFA) a parametric approach has been preferred over Data Envelope Analysis (DEA) a non-parametric approach in studies relating to yield gap analysis because stochastic frontier analysis (SFA) recognizes errors in the data or measurement of the underlying efficiency while data envelope analysis (DEA) assume there is no random error in the model, with data envelope analysis (DEA) any error and statistical noise are reflected in the inefficiency score (Chen *et al.*, 2015). However, data envelope analysis (DEA) can be used for multiple outputs and is capable of handling inputs and outputs expressed in different measurement units unlike stochastic frontier analysis (SFA) is mostly applicable to single output or aggregate measure (Chen *et al.*, 2015). Thus, for the purpose of this study stochastic frontier analysis (SFA), a parametric approach was used based on the stated strength of accounting for random error and as long this study used output from a single crop which is groundnut thus stochastic frontier analysis was used as was used by Muller *et al.* (2010) on spatial analysis of yield gap of global grain production and as has been suggested by Cassman *et al*. (2013) in their study of yield gap analysis with local to global relevance-a review.

## 2.5 Stochastic Frontier Analysis

According to Battese *et al.* (2005) stochastic production frontier model represents (the logarithm of) output as a function of non-negative random error which represents technical inefficiency and a symmetric random error which accounts for noise.[1] The model can be represents below.

$lnq_i = x_i'\beta + v_i - u_i$…………………………………..……………………….eqn (1)

$q_i$ represents output of the i-th firm;

$x_i$is a $K \times 1$ vector containing the logarithms of inputs;

$\beta$is a vector of unknown parameters;

$v_i$is a random error[2] to account for statistical noise and

$u_i$is non negative random variable associated with technical inefficiency

The above Cobb-Douglas stochastic frontier model can take the following forms;

$lnq_i = \beta_0 + \beta_1 lnx_i + v_i - u_i$………………………………………..……………eqn (2)

[1] Statistical noise arises from omission of relevant variables from the vector $x_i$, as well as from measurement errors and approximation errors with the choice of functional form (Battese*et al*. 2005).

[2]The random error $v_i$ can be positive or negative and so the stochastic frontier outputs vary about the deterministic part of the model, exp ($x_i'\beta$).

Or $q_i = \exp\,(\beta_0 + \beta_1 ln x_i + v_i - u_i)$……………………………………………eqn (3)

Or $q_i = \underbrace{\exp\,(\beta_0 + \beta_1 ln x_i)}_{\text{Deterministic component}} \times \underbrace{\exp\,(v_i)}_{\text{Noise}} \times \underbrace{\exp\,(-u_i)}_{\text{Inefficiency}}$,………………………………eqn(4)

By taking an example of two firms (groundnut farmers) that is firm A and firm B it can be graphically illustrated below. Inputs and outputs for the two firms (A and B) are plotted. The deterministic component of the frontier model was drawn to show the existence of diminishing return to scale. Values of inputs used are represented along the horizontal axis and outputs are represented along the vertical axis. Firm A uses the input level $x_A$to produce the output $q_A$ and firm B uses the input level $x_B$ to produce the output $q_B$. Thus, if there is no inefficiency that is $u_A = 0$ and $u_B = 0$, then the frontier output would be $q_A^* \equiv \exp\,(\beta_0 + \beta_1 ln x_A + v_A)$ and $q_B^* \equiv \exp\,(\beta_0 + \beta_1 ln x_B + v_B)$ for firm A and B respectively. These frontier values are indicated by the points marked with x.

The frontier output for firm A lies above the deterministic part of the production frontier only because the noise effect is positive (i.e $v_A > 0$), while the frontier output for firm B lies below the deterministic part of the frontier because the noise effect is negative (i.e$v_B < 0$). It is observed that output for firm A lies below the deterministic part of the frontier because sum of the noise and inefficiency effects is negative $(v_A - u_A < 0)$. Unobserved or frontier output tend to be evenly distributed above and below the deterministic part of the frontier, however observed outputs tend to lie below the deterministic part of the frontier. Observed output can lie above the deterministic part of the frontier when the noise effect is positive and larger than the inefficiency effect (i.e$q_i^* > \exp(x_i'\beta)\ if\ \epsilon_i \equiv v_i - u_i > 0$).

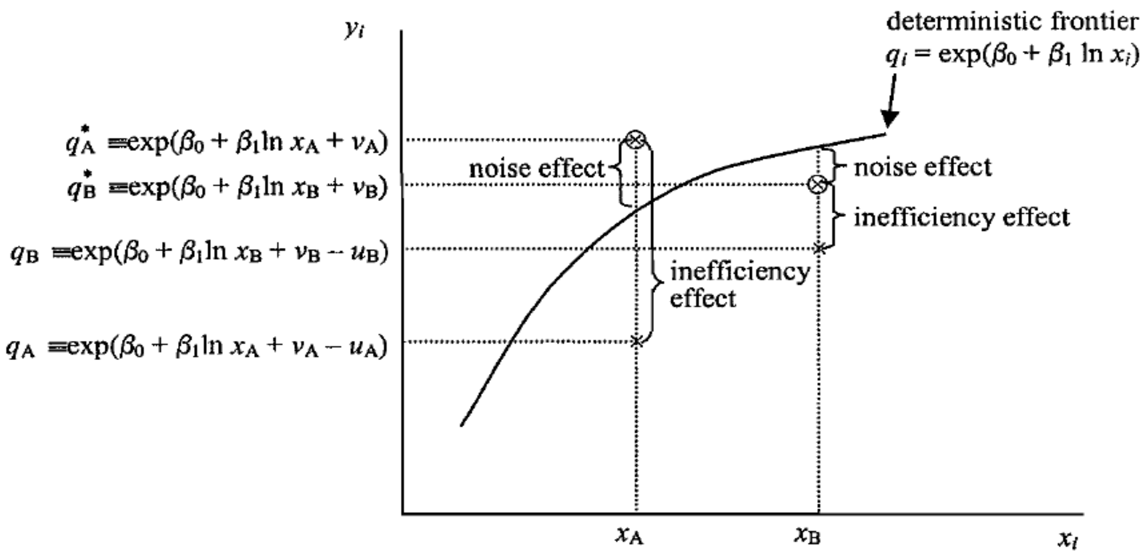


**Figure 6: Stochastic Production Frontier (Adopted from Battese *et al.*, 2005)**

Most of the stochastic frontier analysis are aimed at predicting the ineffciency effects thus output oriented measure of technical efficiency represents the ratio of observed output to the corresponding stochastic frontier output.

$$TE_i = \frac{q_i}{\exp(x_i'\beta_i + v_i)} = \frac{\exp(x_i'\beta + v_i - u_i)}{\exp(x_i'\beta + v_i)} = \exp(-u_i) \text{.........................................eqn (5)}$$

This measure of technical efficiency takes a value between zero and one. It measure the output of the i-th firm relative to the output that could be produced by a fully efficient firm using the same input vector. The first step in predicting $TE_i$, is estimating parameters of the stochastic frontier production model of equation (1).

## 2.6 Review of Gender Analytical Frameworks (GAF)

According to March *et al.* (2005), there are various gender analytical frameworks (GAF) that have been used to intergrate gender considerations into development initiatives. The word framework is used as a method of research and planning for assessing and promoting gender issues in institutions (March *et al.,* 2005). Gender frameworks can be used indepently or in combination based on the purpose of the study and the resources available to carry out the study.

### 2.6.1 Havard analytical framework

Havard analytical framework (HAF) is commonly used in analysing gender roles, it was the first analytical framework to be published, was published in 1985 (March *et al.,* 2005). The framework was designed purposely to demonstrate that there is economic case for allocating resource to women as well as men (Amoah, 2016; March *et al.,* 2005). The framework was designed to help planners to design more efficient project and improve overall productivity by mapping the work and resources of men and women in a community and highlighting the main differences (March *et al.,* 2005).

Harvard Analytical Framework was observed to have the following strength, it give clear picture on gender division of labor and it shows differences in workloads and in access to and control of resources (Amoah, 2016 and March *et al*., 2005). However, Havard analytical framework have the following weaknesses, it is silent on power relations, it does not transform gender relations, it assume that institutions have a neutral culture regarding gender power relations, it emphasizes separation rather than inter-relationships and it ignore changes over time (Amoah, 2016).

### 2.6.2 Moser analytical framework (MAF)

The MAF framework is underpinned by Gender and Development (GAD) approach that argue for an intergrated gender planning perspective in all development work, concentrating on power relations between men and women (Amoah, 2016; March *et al.*, 2005). Aim of Moser frame work was to set up "gender planning" as type of planning in its own right, goal of gender planning is the anticipation of women from their subordination and their achievements of equality, equity and empowerment (Amoah, 2016; March *et al.,* 2005).

Strength of Moser framwork includes the following, it is useful tool in accessing the impacts of intervention on gender relations, it question policy assumptions of projects (Amoah, 2016 and March *et al.,* 2005). However, Moser framework has the following weaknesses, it is silent in power relationships in tripple role, it ignores intersectionality, division between strategic and practical is artificial for example education, change over time is not examinable as a variable (Amoah, 2016).

### 2.6.3 Women's empowerment (Longwe framework)

The framework was developed by Sara Hlupekile Longwe, a consultant on gender and development based in Lusaka Zambia (March *et al.,* 2005). According to Longwe women's empowerement means enabling women to take an equal place with men, and to participate equally in development process in order to achieve control over the factors of production on an equal basis with men (Amoah, 2016; March *et al.,* 2005). The aim of Longwe framework was to assess the extent development intervention is supporting empowerement (Amoah, 2016). In Longwe framework, development means enabling people to take charge of their own lives and escape from poverty. Poverty is seen as arising not from lack of productivity, but from oppression and exploitation (March *et al.,* 2005). Strength of Longwe framework includes its usefulness in explaining empowerement, it identifies the gap between rhetoric and reality, potentially transfomatory (Amoah, 2016; March *et al.,* 2005). The weaknesses of Longwe framework is that, it ignores intersectionality, it is static and silent on change over time, focuses on the relationship between male and females only in terms of equality (Amoah, 2016).

### 2.6.4 Summary of gender analytical framworks

In summary Havard analytical framework aims at looking on gender roles for increased efficiency of the women in the productive activities. Moser framework looks at gender relation between men and women by anticipating the subordinate position of women and how they can achieve gender equality, equity and empowerement. Longwe framework looked at how women can be empowered through development interventions. Moser framework and Longwe framework have one thing in common, that is they both look at power relation between men and women aiming at empowring women. Therefore, an intergrated approach of looking at gender roles and gender relation based on power relation is helpful for increased efficiency on gender roles and empowerement as well to women by improving their subordinate position based on power relation.

## 2.7 Review of Gendered Economic Models of Household Behaviour

### 2.7.1 Unitary model of household behaviour

Unitatry model of household behaviour models households behaviour by assuming that there is the existences of household welfare function that aggregates the preferences of all members (Chiappori *et al.,* 1993). Maximizing household welfare function, subject to the approapriate budget constraints yields demands function for goods, broadly defined and leisure (Chiappori *et al.*, 1993). The unitary model is also known as "common preference model or altruism model or benovolent dictator model" (Chiappori *et al.,* 1993). It is called untiary model because it describes how households act as one (Chiappori *et al.*, 1993).

Unitary model of household behaviour has weaknesses following its assumptions of existence of household welfare function that reflects the preferences of all members, because individual household members are likely to have different preferences although according to this model individual preferences can be aggregated but social choice literature illustrates theoretical difficulties in aggregating individual preferences (Chiappori *et al.*, 1993; Maluccio and Quisumbing, 1999). The most important consequences of unitary model is the pooling of household resources (capital, labour and land), that requires at least one household member has the ability to monitor and to sanction those who fail to comply with the rule (Chiappori *et al.*, 1993).

Moreover, according to Maluccio and Quisumbing (1999), examples from Sub-Saharan Africa, have shown that targeting one individual, rather the other, has led to non-adoption of particular policies or unintended consequences of policies adopted. Also unitary model predicts that household behaviour can be changed only by changes in prices and household income unlike collective model that posits that a large range of policies can be used to affect household allocation outcomes such as changes in access to common property resources, credit, public work schemes and legal and institutional rights (Maluccio and Quisumbing, 1999).

### 2.7.2 Collective models of household behaviour

The model unlike unitary model considers the individuality of household members and possible differences in their preferences (Muluccio and Quisumbing, 1999). One class of the collective models is that they allow differing preferences and only assume that allocations are made in such a fashion that the outomes are Pareto optimal or Pareto efficient (Muluccio and Quisumbing, 1999).

### 2.7.3 Summary on unitary and collective model of household behaviour

Unitary model should be treated or regarded as a special sub set of collective model suitable when certain specified condition hold (Chiappori *et al.*, 1993). Economists should regard households as ‘collective’ rather than ‘unitary’ entitities as the theoretical foundation of the unitary model are weak and its assumptions are of questionable validity (Chiappori *et al.,* 1993). Therefore, with regard to yield gap analysis for groundnut production in Tanzania, intrahousehold inequality based on gender was assessed such that future policies and programs aiming at reducing the yield gap addresses gender inequality for reduced groundnut yield gap.

## 2.8 Review of Profitability Analysis

### 2.8.1 Measures of profitability analysis

There are many measures of profitability analysis, all of which relates to the return of the firms to its sales, assets or equity (Grebe *et al.,* 2015). Measures of profitability analysis allows the analyst to evaluate the effectiveness and efficiency of the firms management in generating the profit by means of sales and productive use of the assets and capital as well (Grebe *et al.,* 2015). The most common measures of profitability are gross margin analysis, net farm income technique and policy analysis matrix (PAM). Also there others like cost benefit analysis and linear programing.

Studies like that of Abba *et al.* (2006) on economic analysis of groundnut production in Biu Local Government Area of Borno State, Nigeria; Abdullahi *et al.*(2016) on gross margin analysis of modern groundnut oil extraction in Gombe Metropolis Gombe State, Nigera; and Giroh *et al*. (2015) on analysis of profitability of groundnut production in Northern part of Taraba State, Nigeria, used gross margin analysis for assessing the profitability of groundnut production.

### 2.8.2 Gross margin analysis

Gross margin is the differences between annual or seasonal gross income of farm enterprise and variable costs directly associated with an enterprise (Casement *et al.,* 2017, Leslie, 2013). Alternatively gross margin can be defined as the estimation of cost and returns of a particular enterprise (Musitini, 2012). Variable cost considered in gross margin analysis includes crop production operations, harvesting and marketings (Casement *et al*., 2017). Gross margin is useful in assessing the structure of the business in term of costs and returns, can be used to compare relative profitability between different farm enterprises, also it pin point high cost or low cost income areas in a specific farm enterprise (Leslie, 2013, Musitini *et al.,* 2012 and RMCG, 2011).

### 2.8.3 Limitations of gross margin analysis

The major limitations of gross margin analysis is that fixed or overhead[3] costs are ignored because it is assumed that firm or farmer incur costs regardless the level of enterprise. (Casement *et al.,* 2017; Leslie, 2013; Musitini, 2012). Gross margins of different enterprise can not be compared if they have different overhead costs, the crop might have the highest gross margin however it may be the most sensitive to variations due to commodity prices and seasonal variations (Casement *et al.,* 2017; Leslie, 2013; Musitini, 2012).

## 2.9 Conceptual Framework of the Study

Gendered factors in a household like resource ownership pattern, participation in production decision making, farmer education level, sex and age determine the farmers ability to transform inputs into output which finally also determine the groundnut yield gap. Also physical and institutional factors like access to market, access to extension services, agro ecological zone, distance to the farm, amount of labour, land, groundnut

[3]Fixed or overhead costs are not included in gross margin analysis because they are not directly associated with any crop in particular and they can be easily omitted so that comparison between crops grown by a farmer can be compared (RMCG, 2011). Examples of fixed or overhead costs are insurance, permanent labor charges and depreciation. (RMCG, 2011).

seeds also determine the ability of the farmer to transform input into output which ultimately affect the groundnut yield gap.

More jointly or collective ownership of the household resources relative to individual ownership of the resources results into increased production efficiency in a household as members of the household are not limited with the use of the resources thus they can increase groundnut yield from efficient utilization of the resources. Also, groundnut farmers having formal education have more ability to increase the groundnut yield in his or her plot because of being able to understand different technology packages and being able to use them in his or her groundnut field.

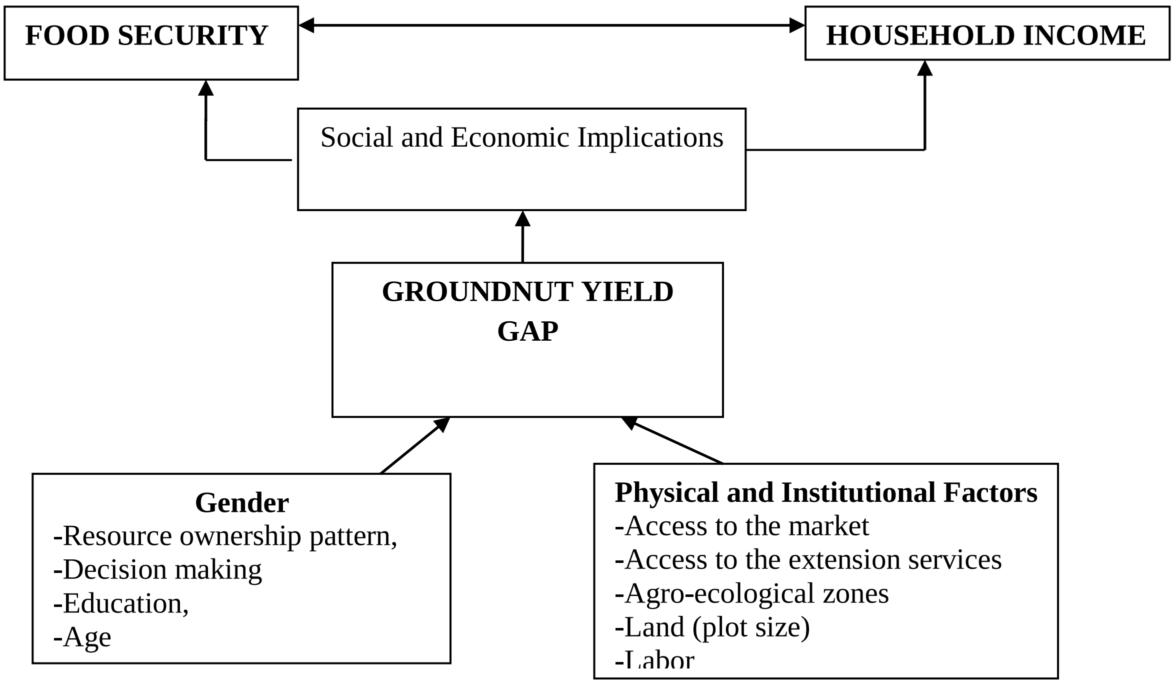


**Figure 7: Conceptual framework for groundnut yield gap**

A groundut farmer located in humid and sub humid agro-ecological zone will have more groudnut yield and lower yield gap relative to the groundnut farmer in arid and semi-arid agro-ecological zone. Also a groundnut farmer with more access to labour and groundnut seeds will have more groundnut yield in his or her groundnut plot relative to the groudnut farmer with limited supply of labour and limited accessibility to groundnut seeds. Groundnut yield gap being higher or lower have the social and economic implications on farmers food security status and household income. Thus, a lower groundnut yield gap have the implication of higher household income and improved food security status.

# CHAPTER THREE

## 3.0 METHODOLOGY

### 3.1 Study Location

The cross sectional data set for the 2015/2016 farming season was obtained from the International Crop and Research Institute for Semi Arid Tropics (ICRISAT). The data set involved nine regions of Tanzania namely Mwanza, Shinyanga and Geita under Lake agro-ecological zone, Dodoma under Central agro-ecological zone, Tabora under Western agro-ecological zone, Mbeya, Songwe and Rukwa under Southern highland agro ecological zone and Mtwara under Southern agro-ecological zone thus covering five agro ecological zones. The sample size was 938 groundnut farmers. The regions were purposively selected because represent more than 80% of the number of small holder farmers growing groundnut in Tanzania. Refer Fig. 7 and Appendix 4 for details on characteristics of agro-ecological zones.

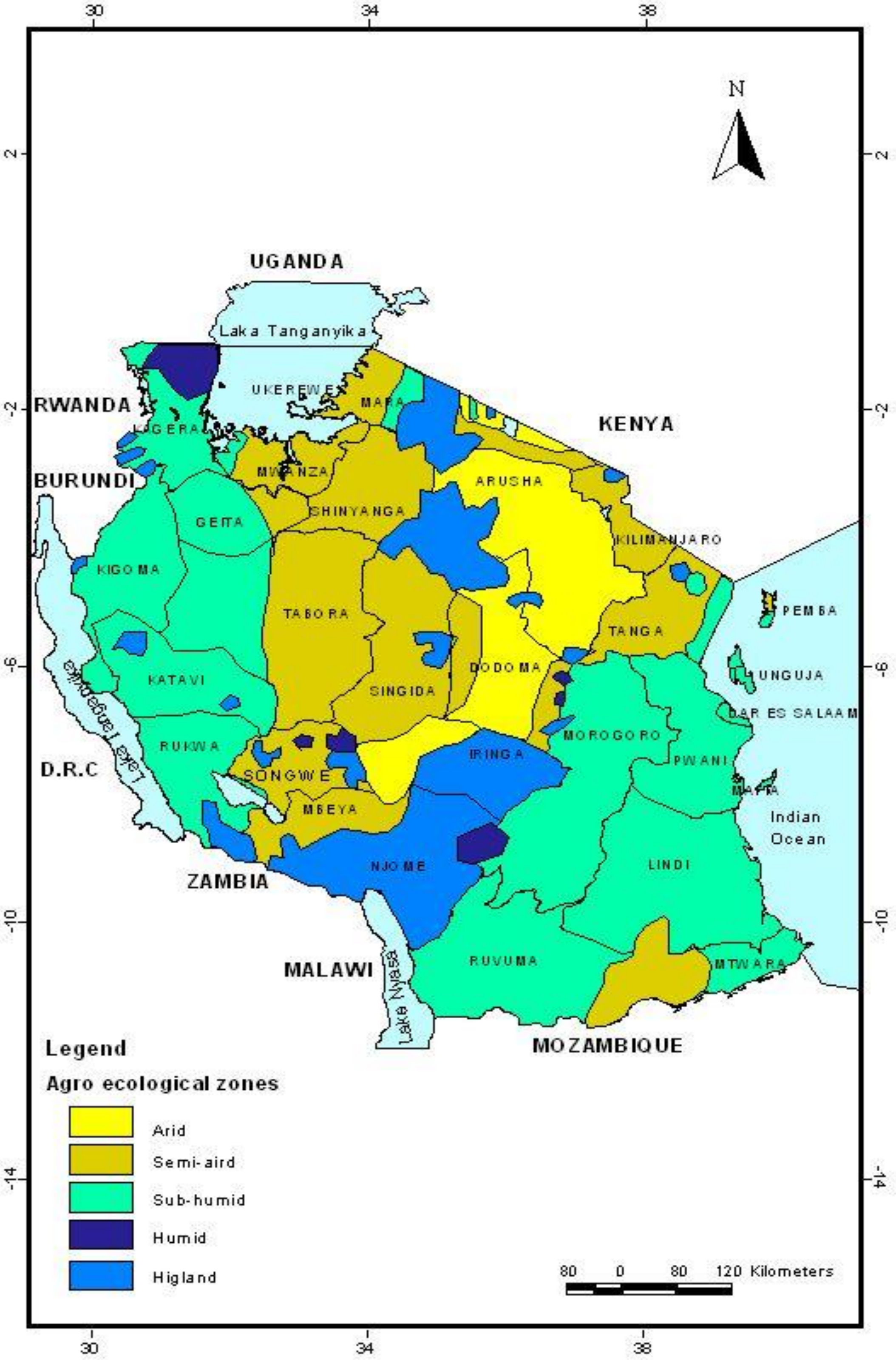


**Figure 8: Map of Tanzania showing agro-ecological zones (Source: FAO, 2005)**

## 3.2 Data Sources

Other secondary data were collected from different sources, including FAO statistics where information on groundnut yield for the past 20 years were collected such that it was helpful to know the trend of groundnut yield up to recent, library of International Crop and Research Institute for Semi-Arid Tropics (ICRISAT) provided conference papers that were reviewed such that data on groundnut production and yield as well in the world and Africa in general were obtained that was helpful to determine the position of Tanzania in terms of groundnut production in Africa and in the world.

## 3.3 Data Analysis

Information collected were first organized in such a way that they provide relevant information for the purpose of analysis for example kilograms were converted into metrics tons and acres were converted into hectares to be able to get the results for easy comparison with findings from other authors in the world. The study used the following statistical and econometric software during the analysis; Statistical Package for Social Science (SPSS) was used where descriptive statistics like frequencies, descriptive analysis and cross tabulations were computed. STATA program was used to do logit analysis for assessing socio-economic factors for the adoption of improved groundnut variety where marginal effects coefficients were easily computed to determine the likelihood ratio of adopting improved groundnut variety.

Stochastic frontier software program version 14 was also used to analyze the technical efficiencies of groundnut production such that from the technical efficiency coefficients potential yield and groundnut yield gap were easily computed using excel program and descriptive statistics.

## 3.4 Theoretical Framework of the Study

According to Perloff (2014) economists assume that firm's owners try to maximize profit by producing efficiently as possible. If a firm does not produce efficiently, it can not maximize profit thus efficient production is a necessary condition for maximizing profit (Perloff, 2014). Even though all firms in an industry may be producing efficiently, it is possible for some firms to be more productive than others by producing more output from a given bundle of inputs due to innovations such as technical progress and new methods of organizing production (Perloff, 2014).

Groundnut farmers are asssumed to produce a given level of output with limited inputs given existing knowledge about technology and organization of production. Fig. 8 below depitcts two yield levels. Point $F_1$ represent a female farmers actual groudnut yield ($Y_{af}$), which is determined by input level $X_a$. $F_1$ is located below the frontier, therefore a female groundnut farmer can increase the yield to the technical efficient yield at point $F_2$, using the same amount of inputs, thus the groundnut yield gap for a female groundnut farmer is represented by the distance from $F_1$ to $F_2$.

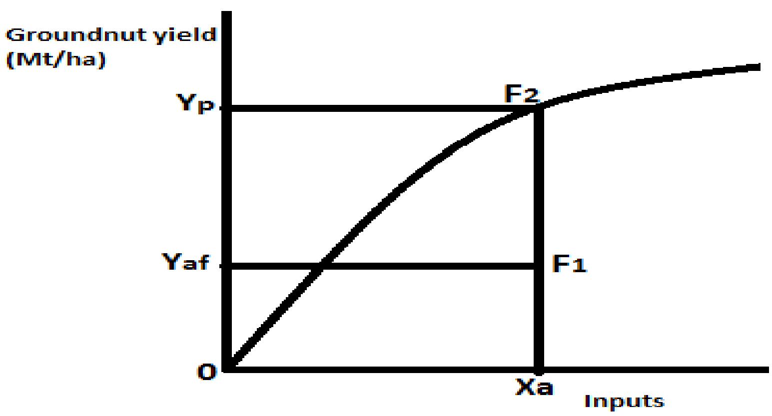


**Figure 9: Theoretic framework for groundnut yield gap for female groundnut farmers**

From Fig. 9; Point $F_3$ represent the male actual groundnut yield ($Y_{am}$), which is also determined by input level $X_b$. Point $F_3$ is also located below the frontier, therefore a male groudnut farmer can increase the groundnut yield to the technical efficient yield at point $F_4$ using the same input level. Thus a male groudnut farmer yield gap is represented by the distance from $F_3$ to $F_4$. For a male to reduce the groundut yield gap has to increase the groundnut yield from point $F_3$ to point $F_4$.

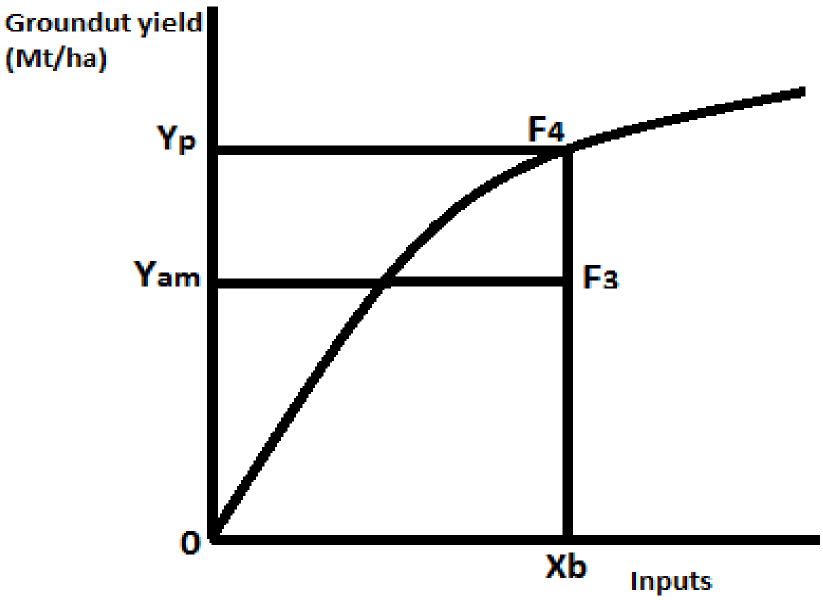


**Figure 10: Theoretical framework for groundnut yield gap for male groundnut farmer**

## 3.5 Analytical Framework

### 3.5.1 Characterization of household resource ownership structure based on gender in Tanzania

The empirical discussion of gender yield gap could not be complete achieved without first describing the gender relationships of households in terms of resource ownership structure and participation in household decisions as they determine the farmers' ability to reduce the groundnut yield gap by allocating their scarce resources efficiently. The collective model of household behaviour in decision making was regarded as a standard approach in explaining gender relation of the households. In this objective Moser framework was used for analyzing gender relationships of groundnut farmers in Tanzania. Tool number three of Moser framework is concerned with analysis of households' decisions and control over the resources was adopted.

This tool helped to determine the position of women in term of bargaining power in various household holds decision and control over the productive resources because decisions on production like what to produce (groundnut seed varieties) and how to produce (management practices) will determine the farmers' efficiency and yield gap as well.

### 3.5.2 Determination of groundnut yield gap based on gender in Tanzania

Determination of the groundnut yield gap comprised four stages; the first stage involved determination of the technical efficiency of groundnut production. Second stage involved computing the potential yield of each individual farmer. The third stage involved finding the yield gap of each individual farmer and the fourth step involved computing the mean groundnut yield gap of all the farmers based on sex, age and agro ecological zone as well.

#### 3.5.2.1 Determining technical efficiency of groundnut production

Stochastic production frontier estimation approach was used to estimate the technical efficiency in production of the groundnut farmers. There are two commonly used functional forms of stochastic frontier model which are Cobb Douglas and Translog. The advantage of Translog is that, it is flexible which means that it does not impose assumptions about constant elasticity of production nor elasticity of substitution between inputs; however the use of translog can cause multicollineality problems (Donkoh *et al*., 2011). The Cobb Douglas functional form is not only simple but it is self-dual and has been applied widely in agricultural production technologies in many developing countries (Donkoh *et al.*, 2011).

### 3.5.2.2 Empirical specification of the model

Cobb Douglas Stochastic frontier model was used to determine the relationship between groundnut output as a dependent or explained variable and farm inputs, as independent or explanatory variables as shown below.

$$lny_i = \beta_0 + \beta_1 lnx_1 + \beta_2 lnx_2 + \beta_3 lnx_3 + (v_i - u_i) \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where, $in$ stand for logarithm base e; $y_i$= groundnut yield of the i[th] farm in kilogram; $\beta_0$= constant term, $\beta_i$ = regression coefficient of the $i^{th}$ farm; $x_1$= plot size in acres; $x_2$= groundnut seed in kilograms; $x_3$= labour in man days.

Since groundnut output is also determined by the farmer efficiency ($u_i$) to transform input into output, thus inefficiency component can be expanded as shown in equation below.

$$u_i = \delta_0 + \delta_1 z_{i1} + \delta_2 z_{i2} + \delta_3 z_{i3} + \delta_4 z_{i4} + \delta_5 z_{i5} + \delta_6 z_{i6} + \delta_7 z_{i7} + \delta_8 z_{i8} \ldots\ldots\ldots \text{(2)}$$

Where, $u_i$ = technical inefficiency of the i[th] holding, $\delta_0$= constant term, $z_{i1}$= sex dummy variable (1 being male and 0 for female), $z_{i2}$ =age, $z_{i3}$=intercropping dummy variable (1 for intercropping and 0 otherwise), $z_{i4}$ =improved variety dummy variable (1 for improved variety and 0 for local variety), $z_{i5}$= Land tenure (1 for self owned land and 0 otherwise), $z_{i6}$= irrigation dummy variable (1 for irrigation and 0 otherwise), $z_{i7}$= plot distance, $z_{i8}$= marital status dummy variable (1 for being married and 0 otherwise). $\delta_0$, $\delta_1$ to $\delta_8$= coefficients of unknown parameters to be estimated and the variance parameters which are expressed as;

$\delta^2 = \delta_u^2 + \delta_v^2$ and $\gamma = {\delta_u^2}/{\delta^2}$

Where the $\gamma$-parameter has value between zero and one. The maximum likelihood method using computer program, FRONTIER version 4.1 was used to estimate the parameters of the stochastic frontier production function model.

#### 3.5.2.3 Determining the potential yield of each of the individual farmer

Potential yield of each individual farmer which was computed as a ratio of farmer's actual yield and technical efficiency

Since $TE_i = \frac{Y_i}{Y_i^*} = \frac{f(X_i;\beta)\exp(V_i - U_i)}{f(X_i;\beta)\exp(V_i)} = \exp(-U_i)$............................................................ (3)

Thus, $Y_i^* = \frac{Y_i}{TE_i} = f(X_i;\beta)\exp(V_i)$......................................................................... (4)

Where $TE_i$ =technical efficiency of the i$^{th}$ farmer in groundnut production

$Y_i^*$ = frontier/ potential output of the i$^{th}$ farmer in groundnut production

$Y_i$ = The actual/ observed output of the i$^{th}$ farmer in groundnut production

$V_i$= Random error term, $X_i$= Production inputs

$U_i$= Inefficiency component, $\beta$= Parameters to be estimated

#### 3.5.2.4 Computing the yield gap for each individual farmer

Yield gap which is the difference between farmer's actual yield and potential yield of groundnut production

$Y_g = Y_i^* - Y_i$ ................................................................................................................ (5)

Where $Y_g$ = Yield gap of the i$^{th}$ farmer

#### 3.5.2.5 Computing the mean yield gap for all the farmers

The mean yield gap is the summation of the individual farmers yield gaps divided by the number of farmers or sample size.

$$\omega_i = \frac{\sum_{i=1}^{n} Y_g}{n} \quad \text{..........} (6)$$

Where $\omega_i$= Is the mean yield gap of all the farmers and $n$= is the sample size.

### 3.5.3 Determining socioeconomic factors for the adoption of improved groundnut variety in Tanzania

Socio-economic factors determine farmers' decision to grow improved groundnut seed varieties as addressed by third objective, a binary logistic regression model through maximum likelihood estimation procedures was used. The dependent variable used was farmers' choice of improved groundnut seed variety. The probability of farmers decision growing improved groundnut seed variety was given a value of '1' while that of growing other varieties was given a value of '0'.

The model shows the probability of explanatory variables to the independent variables, in such a way that the probability lies between 0 and 1. The logistic cumulative probability function of the farmers' decision to grow improved groundnut seed varieties can be represented as simplified in the logit equations below.

$$\Pr(Y = 1) = \frac{e^{\beta' x}}{1 + e^{\beta' x}} \quad \text{..........} (1)$$

With the commutative distribution function given by

$$F(\beta' x) = \frac{1}{1 + e^{\beta' X}} \quad \text{..........} (2)$$

Whereby $\beta'$represents vector of parameters associated with the socio economic factors x

Assuming the probability that the farmer n will choose to produce groundnut using improved groundnut seed is equal to the proportion of groundnut farmers using improved groundnut seed.

$$GS_i = \beta_0 + \beta_1 DMARKET + \beta_2 DEXTOFFICER + \beta_3 LAKEZONE + \beta_4 CENTZONE + \beta_5 WESTZONE + \beta_6 SOUTHHZONE + \beta_7 GENDER + \varepsilon_i \quad (3)$$

### 3.5.4 Determining profitability differences between female and male groundnut farmers in Tanzania

In determining profitability difference in groundnut production between men and women the budget technique also known as net farm income technique was used. The budgetary technique is expressed as shown in equation 1 and 2 below. From the equations, gross margin of groundnut production was computed for farm plots owned by female farm managers and compared to gross margin of farm plots owned by male farm managers. The t-test was used to see if there was a statistical significance difference in the gross margin of female farm managers and male farm managers' plots.

$$GM_{fi} = \sum_i^n (TR_{fi} - TVC_{fi}) \quad (1)$$

$$GM_{mi} = \sum_i^k (TR_{mi} - TVC_{mi}) \quad (2)$$

Where, subscript *f and m* represents female producer and male producer respectively. *GM* represents the gross margin, *TR* and *TVC* represent total revenue and total variable cost[4] respectively while *n* and *k* represents number of females and number of males respectively. The formula for t-test which was used to compare the farm plots managed by females and farm plots managed by males is shown below

[4]Total variable cost (TVC) is the sum of variable costs incurred by the producer during the production process; variable costs included were costs of seeds, hired labour, pesticides, and transportation.

$$t = \frac{GM_f - GM_m}{\sqrt{\frac{(n-1)S_{GM_f}^2 + (k-1)S_{GM_m}^2}{n+k-2}} * \sqrt{\frac{S_{GM_f}^2 + S_{GM_m}^2}{2}}} \quad \text{......................................................................(3)}$$

Where, t represents t-score, $S_{GM_f}^2$ and $S_{GM_m}^2$ represents standard deviation of female and male *GM* respectively.

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSION

### 4.1 Groundnut Farmers Socio-economic Characteristics

#### 4.1.1 Sex of the respondents

Sixty percent of the studied groundnut farmers were males and forty percent were females. Results from Table 1, show that most of the farmers growing groundnut were males and from all of the five agro-ecological zones it was observed that males were major producers of groundnut with exception of central zone whereby females were major growers.

**Table 1: Sex of the respondents**

| Agro-ecological zone | Respondent sex | | | | | |
|---|---|---|---|---|---|---|
| | Female farmers | | Male farmers | | Total | |
| Lake zone | 116 | 35% | 211 | 65% | 327 | 100% |
| Central zone | 103 | 52% | 95 | 48% | 198 | 100% |
| Western zone | 101 | 45% | 121 | 55% | 222 | 100% |
| Southern highland zone | 25 | 23% | 82 | 77% | 107 | 100% |
| Southern zone | 31 | 37% | 53 | 63% | 84 | 100% |
| **Total** | **376** | **40%** | **562** | **60%** | **938** | **100%** |

Males being major producers of groundnut have the implication that groundnut is a profitable farming business. This is consistent with the observation of Anderson and Leavens (2011) that males tend to move to activities considered females when they become profitable. Groundnut being dominated by males is consistent with a situation in maize whereby although maize is a principal food crop in Tanzania and women were the primary producer of it, after the introduction of oxen-plow males became more engaged in producing maize (Anderson and Leavens, 2011). Greater gender diversity in groundnut production was observed in southern highland zone where 77% of the groundnut growers were males and 23% were females. Smaller gender diversity was observed in central zone where 52% of the groundnut farmers were females and 48% were males.

### 4.1.2 Age of the sampled groundnut farmers

Twenty two percent (22%) of the studied groundnut farmers were youth with the age group of 16 to 35 years, 61% were adult with the age group of 36 to 60 years and 17% were the elders with the age group of 61 years and above. According to results from Table 2, in all of the agro ecological zones adults were the major producers of groundnut. This has the implication that groundnut production is the activity dominated by farmers in the adult age group (that is between 36 to 60 years) in Tanzania.

**Table 2: Age of the groundnut farmers based on agro ecological zones**

| Agro ecological zone | Youth age group (16-35 Years) | | Adult age group (36-60 Years) | | Elder age group (≥61 Years) | | All age group | |
|---|---|---|---|---|---|---|---|---|
| Lake zone | 81 | 25% | 192 | 59% | 54 | 17% | 327 | 100% |
| Central zone | 44 | 22% | 114 | 58% | 40 | 20% | 198 | 100% |
| Western zone | 50 | 23% | 137 | 62% | 35 | 16% | 222 | 100% |
| Southern highland zone | 23 | 21% | 75 | 70% | 9 | 8% | 107 | 100% |
| Southern zone | 10 | 12% | 52 | 62% | 22 | 26% | 84 | 100% |
| **Total** | **208** | **22%** | **570** | **61%** | **160** | **17%** | **938** | **100%** |

Groundnut production in Tanzania being dominated by farmers in the adult age group is due to the nature of the crop having been labour intensive (Abubakari *et al.*, 2013 and Mazmvimavi, 2015). Adults have enough labour supply from the family compared to the youth and elders for undertaking different groundnut production activities like planting, weeding and harvesting. Southern highland was observed to have many adults (70%) followed by southern and western zone.

### 4.1.3 Plot size of the groundnut farmer

The mean plot size[5] of the farmers under groundnut production was 0.796 ha. Table 3 results show that farmers from central agro ecological zone had the highest plot size of 1.1 ha while farmers from southern highland agro-ecological zone had the smallest plot size of 0.483 ha. Central zone is characterized with semi-arid and arid features thus farmers tended to allocate more land growing groundnut for reducing the risk of crop failure due to drought, unlike southern highland zone with humid and sub-humid climatic features such that farmers received favourable rainfall where from a small plot of land farmers could harvest enough volume of groundnut. Furthermore, farmers as a firm owner had the objective of maximizing profit by producing efficiently as possible given the available resources (Perloff, 2014).

**Table 3: Plot size of the groundnut farmers based on agro ecological zone**

| Agro ecological zone | Youth age group (16-35 years) | Adult age group (36-60 Years) | Elders age group ((≥61 Years) | Mean plot size (All age group) |
|---|---|---|---|---|
| Lake zone | 0.757 | 0.940 | 1.004 | 0.905 |
| Central zone | 1.061 | 1.213 | 0.870 | 1.110 |
| Western zone | 0.494 | 0.621 | 0.554 | 0.582 |
| Southern highland zone | 0.600 | 0.451 | 0.456 | 0.483 |
| Southern zone | 0.520 | 0.480 | 0.905 | 0.596 |
| **Total** | **0.730** | **0.812** | **0.828** | **0.796** |

Among competing alternatives (crops) to growing groundnut in southern highland zone, farmers may have chose to allocate more land to crops with higher returns than groundnut in the southern highland zone, for example potatoes, vegetables and fruit crops. Groundnut being a crop which is drought resilient in semi arid regions compared to horticultural crops

[5] Plot sizes are in hectares (ha)

like fruits and vegetables and cereal crops like rice with higher economic returns (Kattumuri *et al*., 2015), farmers in central agro ecological zone which is semi arid in nature must have allocated more land for groundnut production for reducing the risk of crop failure or loss. The mean plot size cultivated by youth groundnut farmers was 0.730 hectares, adults were 0.812 hectares and elders were 0.828 hectares. The mean plot size cultivated for groundnut production for all age groups was 0.796 hectare. There is little variation in plot size cultivated based on age groups. However, it is observed that youth farmers were cultivating small plot size compared to other age groups, the reason could be young farmers have limited ownership of the land compared with adults and elderly farmers.

### 4.1.4 Farmers actual groundnut yield

According to the results from Table 4, the mean groundnut yield for all agro ecological zones was 0.386 Mt/ha. The mean groundnut yield was low compared with the mean Tanzanian actual groundnut yield from 1995 to 2014 which was 0.822 Mt/ha (FAOSTAT, 2017) and was low compared the African average groundnut yield of 1.02 Mt/ha (FAOSTAT, 2017) and World average groundnut yield of 1.4 Mt/ha (Katundu *et al*., 2014; Madhusudhana, 2013).

**Table 4: Actual groundnut yield in metric tons per hectare**

| **Agro ecological zone** | **Youth age group (16-35 years)** | **Adult age group (35-60 years)** | **Elders age group ((≥61 Years)** | **All age group** |
|---|---|---|---|---|
| Lake zone | 0.404 | 0.315 | 0.302 | 0.335 |
| Central zone | 0.669 | 0.323 | 0.293 | 0.394 |
| Western zone | 0.374 | 0.273 | 0.22 | 0.287 |
| Southern highland zone | 0.777 | 0.624 | 0.501 | 0.646 |
| Southern zone | 0.495 | 0.505 | 0.51 | 0.505 |
| **Total** | **0.498** | **0.364** | **0.322** | **0.387** |

Drought was the major reason reported by the farmers for the lower groundnut yield. Groundnut yield was observed to be higher in southern highland and southern zone with the mean groundnut yield of 0.646 and 0.505 metric tons per hectare. Reasons for the groundnut yield to be higher in southern highland and southern zone were part of these zones are sub-humid and humid in nature (Fig. 7) such that the zones receives more rainfall than other zones, also many farmers had formal education compared to other zones and more participation of adults in groundnut farming. Western and lake agro-ecological zones had the lowest groundnut yield compared to other agro ecological zones with the mean actual groundnut yield of 0.287 and 0.335 Mt/ha.

The major reason mentioned by the farmers was the lack of rainfall for long period of production (drought). Furthermore, part of lake and western agro-ecological zone are characterised with semi-arid climatic features (Fig. 7). Nevertheless, western, central and lake agro-ecological zones were the zones with many farmers participating in groundnut production and allocate more land for groundnut production than other agro-ecological zones, making them to be the major producers of groundnut in Tanzania (Table 2 and 3). Thus, it can be stated farmers in central, western and lake agro-ecological zones depend on extensive groundnut farming system (allocating more land for groundnut production) rather than increased yield for getting more groundnut volume. It is unlike southern highland and southern zone where farmers got more groundnut volume from higher groundnut yield (Table 3 and 4).

Increasing groundnut production from increased acreage or hectares allocated for groundnut production than increased yield in western, central and lake agro-ecological zones is consistent with the finding of Benfica *et al.* (2016) observed that in the period

2001 to 2008, 61% of the growth in agricultural output was more attributed by the expansion in land and not the increase in agricultural factor productivity.

Lower groundnut yield of 0.386 Mt/ha had the economic implications of low household income from groundnut production and increasing importation and reduced exportation of groundnut in the country (Fig. 10). Tanzania had been importing more groundnut from 2009 to 2013 than what it exported (Fig. 10). This could have resulted into unfavourable terms of trade in the groundnuts sub-sector.

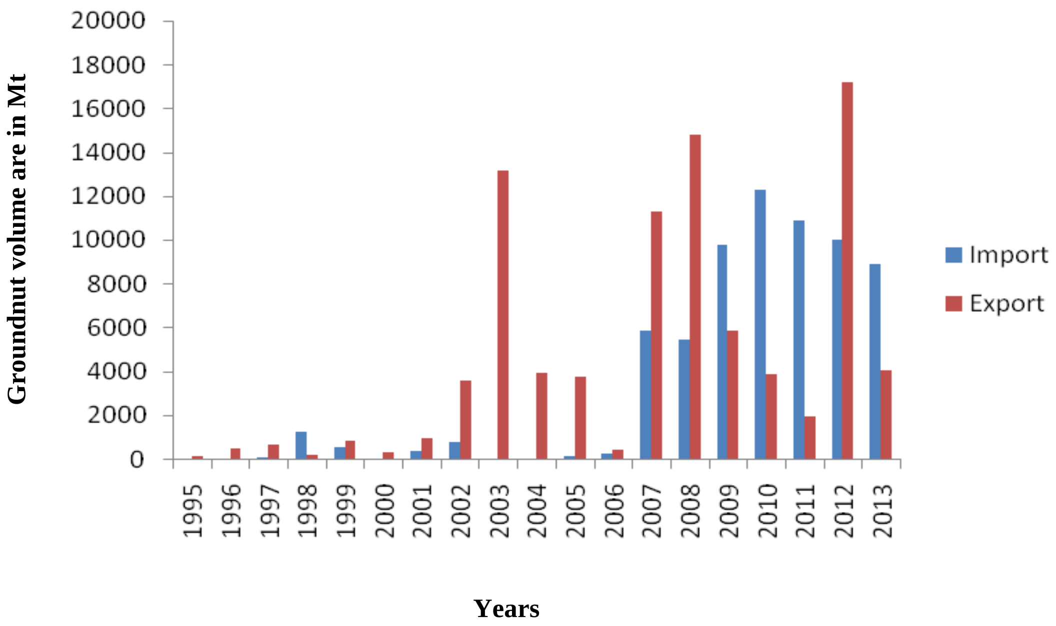


**Figure 11: Groundnut import and export volumes in Tanzania (Source: FAOSTAT, 2017)**

## 4.2 Resource Ownership Structure in Tanzania

Referring to Table 5, it shows that groundnut farming households own the following resources (capital items): agricultural land; houses; farm equipment; that is, non mechanized farming equipment (hand hoe, oxen plough), birds (chicken, duck, turkey, pigeons); cell phones; means of transportation (like bicycle, motorcycle, car); large livestock (oxen, cattle); radio and small livestock (goat, sheep, pigs).

However, 57.1% of the groundnut farming household own the mentioned capital items individually while 42.9% of the groundnut farming households own the capital items jointly. Capital items being more owned individually (exception of large consumer durables and farm mechanized equipment) than jointly ownership have the implication of weaker bargaining powers to some members of the household with regard to households' decision making (World Development Report, 2012).

**Table 5: Resource ownership structure**

| **Capital Items (Resources)** | **Ownership of capital item** | | |
|---|---|---|---|
| | **Individually** | **Jointly** | **Total** |
| Agricultural land (pieces/plots) | 637(59.4%) | 435(40.6%) | 1072(100%) |
| Large consumer durables (fridge, TV, sofa) | 43(29.9%) | 101(70.1%) | 144(100%) |
| Small consumer durables (radio, cookware) | 307(60.4%) | 201(39.6%) | 508(100%) |
| Cell phone | 568(68.2%) | 265(31.8%) | 833(100%) |
| Land not used for agricultural purposes | 51(57.3%) | 38(42.7%) | 89(100%) |
| Means of transportation (bicycle, motorcycle, car) | 494(61.7%) | 307(38.3%) | 801(100%) |
| Large livestock (oxen, cattle) | 299(57%) | 226(43%) | 525(100%) |
| Small livestock (goats, pigs, sheep) | 252(52.7%) | 226(47.3%) | 478(100%) |
| Chickens, Ducks, Turkeys, Pigeons | 446(52.4%) | 405(47.6%) | 851(100%) |
| Farm equipment (non-mechanized) | 435(52.1%) | 400(47.9%) | 835(100%) |
| Farm equipment (mechanized) | 16(28.6%) | 40(71.4%) | 56(100%) |
| Nonfarm business equipment | 14(77.8%) | 4(22.2%) | 18(100%) |
| House (and other structures) | 585(55.2%) | 475(44.8%) | 1060(100%) |
| Total | 4147 (57%) | 3123 (43%) | 7270(100%) |

Individual ownership of resources is consistent with the unitary model of household behavior, one household member who has ownership of the resources is capable of pooling all the resource and makes the household decisions and able to monitor and sanctions other household members who fail to comply with his decision (Chiapori *et al.,* 1993). This may lead to inefficient allocation of resources and poor production as well.

## 4.3 Groundnut Yield Gap

### 4.3.1 Groundnut yield gap in Tanzania

Results from Table 6 shows, the mean technical efficiency of the groundnut farmers was 42.94%, at this level of technical efficiency farmers were getting the actual groundnut yield of 0.3868 Mt/ha. If farmers could be able to increase their technical efficiency by 57.06% they would get the potential groundnut yield of 0.8271 Metric tons per hectare, thus the 0.4403 Metric tons per hectare were the yield gap of groundnut production in Tanzania. Achieving the potential yield of 0.827 Metric tons per hectare will enable farmers' to be near to the African continent average yield of 1.01 Metric tons per hectare (FAOSTAT, 2017). Based on sex for all age group of the groundnut farmers, male groundnut farmers were technically efficient at the level of 46.46% while female groundnut farmers were technically efficient at the level of 37.687%.

At the level of technical efficiency of 46.46% male groundnut farmers were getting the actual groundnut yield of 0.4205 Mt/ha while for female groundnut farmers at the level of technical efficiency of 37.68%, they were getting the actual yield of 0.3363 Mt/ha. The difference in actual groundnut yield between male and female groundnut farmers stood at 0.0842 Mt/ha, which was statistically significant at 5%. Furthermore, from Table 6, if male groundnut farmers could be able to improve their technical efficiency by 53.54%, they would be able to achieve the potential yield of 0.8284 Mt/ha. At the level of actual groundnut yield of 0.4205 Mt/ha and potential yield of 0.8284 Mt/ha, male groundnut farmers had yield gap of 0.4079 Mt/ha. If female groundnut farmers could be able to improve their technical efficiency by 62.32%, they would be able to achieve their potential yield of 0.825 Mt/ha. At the level of actual yield of 0.3363 Mt/ha and potential yield of 0.8252 Mt/ha, female groundnut farmers had the yield gap of 0.4889 Mt/ha. Thus, the difference of the yield gap for male and female groundnut farmers in Tanzania was 0.081 Mt/ha which is equivalent to 20% of the male yield gap. This difference was not statistically significant. Based on age group, youth groundnut farmers were more technically efficient than other age group. Youth groundnut farmers were technically efficient at the level of 49.51%. At this level of technical efficiency they had the actual groundnut yield of 0.4984 Mt/ha.

**Table 6: Tanzania gendered groundnut yield gap**

| Owner of capital items | **Sex** | **All age group** | **Youth (16-35 years)** | **Adult (36-60 years)** | **Elders (Above 60 years)** |
|---|---|---|---|---|---|
| Technical efficiency | Male | 0.4646 | 0.5414 | 0.4455 | 0.4281 |
| | Female | 0.3768 | 0.421 | 0.3721 | 0.341 |
| | Both | 0.4294 | 0.4951 | 0.4163 | 0.3905 |
| Actual yield per hectare | Male | 0.4205 | 0.5759 | 0.3884 | 0.3228 |
| | Female | 0.3363 | 0.3744 | 0.3278 | 0.32 |
| | Both | 0.3868 | 0.4984 | 0.3643 | 0.3216 |
| Potential yield per hectare | Male | 0.8284 | 0.9925 | 0.7978 | 0.7127 |
| | Female | 0.8252 | 0.8042 | 0.8229 | 0.8572 |
| | Both | 0.8271 | 0.9201 | 0.8078 | 0.775 |
| Yield gap per hectare | Male | 0.4079 | 0.4165 | 0.4094 | 0.3899 |
| | Female | 0.4889 | 0.4297 | 0.4951 | 0.5372 |
| | Both | 0.4403 | 0.4216 | 0.4435 | 0.4534 |

However, if youth groundnut farmers could increase their technical efficiency by 50.49%, they would get the potential yield of 0.9201 Mt/ha. Thus, the yield gap for youth age group was 0.4216 Mt/ha. Adult groundnut farmers had the yield gap of 0.4435 Mt/ha and elders' groundnut farmers had the yield gap of 0.4535 Mt/ha. Therefore, youth groundnut farmers had lower yield gap relative to other age group.

### 4.3.2 Groundnut gendered yield gap in lake agro-ecological zone

Referring to Table 7, in lake agro ecological zone groundnut farmers were technically efficient at the level of 37.1%, at this level of technical efficiency groundnut farmers were getting the actual groundnut yield of 0.335 Mt/ha. Thus, if the groundnut farmers could be able to increase their technical efficiency by 62.9%, they would be able to achieve the potential groundnut yield of 0.820 Mt/ha. Hence, the yield gap for groundnut production in lake agro ecological zone was 0.485 Mt/ha.

Based on sex male groundnut farmers were more technically efficient than female groundnut farmers. Female groundnut farmers in lake agro-ecological zone were technically efficient at the level of 33.2%. At this level of technical efficiency female groundnut farmers were getting the actual groundnut yield of 0.316 Mt/ha. If the female groundnut farmers could be able to increase their technical efficiency by 66.8%, they would be able to achieve the potential groundnut yield of 0.849 Mt/ha. Hence, the yield gap for female groundnut farmers in Lake agro ecological zone was 0.533 Mt/ha. Male groundnut farmers in lake agro-ecological zone were technically efficient at the level of 39.2%. At this level of technical efficiency male groundnut farmers were getting the actual groundnut yield of 0.345 Mt/ha. However, if the male groundnut farmers could be able to increase their technical efficiency by 60.8%, they would be able to achieve the potential groundnut yield of 0.798 Mt/ha. Hence, the groundnut yield gap for male groundnut farmers in lake agro ecological zone is 0.453 Mt/ha. Therefore, if the male groundnut farmers in lake agro-ecological zone will increase the efficient utilization of their existing resources they will be able to reduce or close the groundnut yield gap of 0.453 Mt/ha. Based on age group, youth groundnut farmers in the age group of 16 to 35 years were more technically efficient, had higher actual yield and potential yield than other age groups. For example the technical efficiency of the youth age group were 43.21%, while for adult age group and elderly age group were 35.53% and 33.58% respectively. Furthermore, the actual groundnut yields for farmers in youth age group were 0.3149 Mt/ha and the potential yield was 0.81 Mt/ha. Thus, making the yield gap of 0.4403 Mt/ha. Groundnut yield gap for youth farmers is observed to be less than the yield gap of farmers from adult and elderly farmers.

**Table 7: Groundnut gendered yield gap in lake agro-ecological zone**

| Variables | **Sex** | **All age group** | **Youth (16-35 years)** | **Adult (36-60 years)** | **Elders (Above 60 years)** |
|---|---|---|---|---|---|
| Technical efficiency | Male | 0.3921 | 0.4596 | 0.374 | 0.3597 |
| | Female | 0.3329 | 0.3876 | 0.3179 | 0.2982 |
| | Both | 0.3711 | 0.4321 | 0.3553 | 0.3358 |
| Actual yield per hectare | Male | 0.3453 | 0.4611 | 0.311 | 0.3035 |
| | Female | 0.3157 | 0.3116 | 0.3229 | 0.2995 |
| | Both | 0.3348 | 0.4039 | 0.3149 | 0.3019 |
| Potential yield per hectare | Male | 0.7985 | 0.9208 | 0.7602 | 0.7617 |
| | Female | 0.8597 | 0.7207 | 0.9099 | 0.9118 |
| | Both | 0.8202 | 0.8442 | 0.81 | 0.8201 |
| Yield gap per hectare | Male | 0.4532 | 0.4597 | 0.4493 | 0.4583 |
| | Female | 0.544 | 0.4091 | 0.587 | 0.6122 |
| | Both | 0.4854 | 0.4403 | 0.4952 | 0.5181 |

In summary, male groundnut farmers were more technically efficient and had higher actual groundnut yield and potential yield than female groundnut farmers. Furthermore, the yield gap for male groundnut farmers was low compared to female groundnut farmers because male groundnut farmers were more technically efficient than female groundnut farmers. Furthermore, results from Table 8 below show that more males had ownership of the land for cultivation than female groundnut farmers. Eighty nine percent (89%) of the male groundnut farmers had plot ownership unlike to 84% of the female groundnut farmers with plot ownership.

**Table 8: Farmers plot ownership in lake agro-ecological zone based on sex**

| | Sex of the respondent | | | | | |
|---|---|---|---|---|---|---|
| **Plot ownership** | **Female** | | **Male** | | **Total** | |
| Not owned | 18 | 16% | 24 | 11% | 42 | 13% |
| Owned | 98 | 84% | 187 | 89% | 285 | 87% |
| **Total** | **116** | **100%** | **211** | **100%** | **327** | **100%** |

### 4.3.3 Groundnut gendered yield gap in central zone

Results from Table 9 show that in Central Agro ecological zone groundnut farmers were technically efficient at the level of 40.6%. At this level of technical efficiency groundnut farmers were getting the actual groundnut yield of 0.394 Mt/ha. Thus, if groundnut farmers could be able to increase their technical efficiency by 59.4%, they would be able to achieve the potential groundnut yield of 0.886 Mt/ha. Hence, the yield gap for groundnut production in central agro ecological zone was 0.492 Mt/ha. Female groundnut farmers in central agro-ecological zone were technically efficient at the level of 37.0%. At this level of technical efficiency female groundnut farmers were able to get the actual yield of 0.354 Mt/ha. If the female groundnut farmers could be able to increase their technical efficiency by 63.0%, they would be able to achieve the potential groundnut yield of 0.887Mt/ha.

Hence, the yield gap for female groundnut farmers in central agro-ecological zone was 0.533Mt/ha. This yield gap requires 150% increase in actual groundnut yield to female groundnut farmers for closing actual groundnut yield gap. Male groundnut farmers in central agro ecological zone were technically efficient at the level of 44.6%. At this level of technical efficiency male groundnut farmers were getting the actual groundnut yield of 0.437Mt/ha.

**Table 9: Groundnut gendered yield gap in central agro-ecological zone**

| Variables | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Technical efficiency | Male | 0.4459 | 0.5412 | 0.4212 | 0.3785 |
| | Female | 0.3695 | 0.4647 | 0.3567 | 0.3299 |
| | Both | 0.4062 | 0.5116 | 0.3833 | 0.3554 |
| Actual yield per hectare | Male | 0.4373 | 0.7617 | 0.3014 | 0.3242 |
| | Female | 0.3537 | 0.5233 | 0.3377 | 0.2589 |
| | Both | 0.3938 | 0.6696 | 0.3227 | 0.2932 |
| Potential yield per hectare | Male | 0.8849 | 1.3023 | 0.6744 | 0.8196 |
| | Female | 0.8868 | 1.0962 | 0.8739 | 0.7452 |
| | Both | 0.8859 | 1.2227 | 0.7917 | 0.7842 |
| Yield gap per hectare | Male | 0.4477 | 0.5407 | 0.373 | 0.4954 |
| | Female | 0.5331 | 0.573 | 0.5362 | 0.4863 |
| | Both | 0.4921 | 0.5532 | 0.4689 | 0.4911 |

However, if male groundnut farmers could be able to increase their technical efficiency by 55.4%, they would be able to achieve the potential groundnut yield of 0.885Mt/ha. Hence, the groundnut yield gap for male groundnut farmers in Central Agro ecological zone was 0.448Mt/ha. This yield gap requires 102% increase in actual groundnut yield. Therefore, if male groundnut farmers in Central agro ecological will able to increase the efficient utilization of their existing resources they will be able to reduce or close the groundnut yield gap of 0.448Mt/ha. In summary, actual groundnut yield for female farmers in central agro-ecological zone was 0.354Mt/ha and actual yield for male groundnut farmers was

0.437Mt/ha, making a difference of 0.083Mt/ha. The yield gap for female groundnut farmers was 0.533Mt/ha and the yield gap for male groundnut farmers was 0.448Mt/ha, making a gendered yield gap of 0.085Mt/ha. However, the gendered yield gap was not statistically significant. Thus, concentration should be given on reducing the general groundnut yield gap in central agro ecological zone.

#### 4.3.4 Groundnut gendered yield gap in western agro ecological zone

Referring to Table 10, in western agro-ecological zone groundnut farmers were technically efficient at the level of 38.0%, at this level of technical efficiency groundnut farmers were getting the actual groundnut yield of 0.287Mt/ha. Thus, if groundnut farmers could be able to increase their technical efficiency by 62.0%, they would be able to achieve the potential groundnut yield of 0.717Mt/ha. Hence, the yield gap for groundnut production in western agro-ecological zone was 0.430 Mt/ha. Therefore, if the groundnut farmers in western agro-ecological zone will be able to improve the efficient utilization of their existing resources (land, labor and capital) they will be able to reduce or close the groundnut yield gap of 0.430Mt/ha. Furthermore, results of Table 10 show that, female groundnut farmers in Western agro ecological zone were technically efficient at the level of 34.6%. At this level of technical efficiency female groundnut farmers were able to get the actual groundnut yield of 0.270Mt/ha.

If female groundnut farmers could be able to increase their technical efficiency by making efficient utilization of their existing resources like land, capital and labor by 65.4%, they would be able to get the potential groundnut yield of 0.716Mt/ha. Hence, the yield gap for female groundnut farmers in western agro-ecological zone was 0.446Mt/ha. This yield gap require 165% increase in actual groundnut yield for female groundnut farmers to close the groundnut yield gap. Male groundnut farmers in western agro-ecological zone were technically efficient at the level of 40.7%. At this level of technical efficiency male groundnut farmers were getting the actual groundnut yield of 0.301Mt/ha. However, if the male groundnut farmers could be able to increase their technical efficiency by 59.3%, they would be able to achieve the potential groundnut yield of 0.717Mt/ha. Hence, the groundnut yield gap for male groundnut farmers in western agro-ecological zone was 0.416Mt/ha. This yield gap requires 138% increase in actual groundnut yield. Therefore, if male groundnut farmers in western agro-ecological zone will able to increase the efficient utilization of their existing resources they will be able to reduce or close the groundnut yield gap of 0.416Mt/ha.

**Table 10: Groundnut gendered yield gap in western agro-ecological zone**

| Variables | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Technical efficiency | Male | 0.4073 | 0.4813 | 0.4073 | 0.3858 |
| | Female | 0.3464 | 0.4046 | 0.3464 | 0.22 |
| | Both | 0.3796 | 0.4399 | 0.3796 | 0.3493 |
| Actual yield per hectare | Male | 0.3012 | 0.3723 | 0.3012 | 0.1931 |
| | Female | 0.2705 | 0.3751 | 0.2705 | 0.2398 |
| | Both | 0.2872 | 0.3738 | 0.2872 | 0.2198 |
| Potential yield per hectare | Male | 0.7175 | 0.7835 | 0.7175 | 0.4854 |
| | Female | 0.7163 | 0.7878 | 0.7163 | 0.7116 |
| | Both | 0.7169 | 0.7858 | 0.7169 | 0.6147 |
| Yield gap per hectare | Male | 0.4163 | 0.4113 | 0.4163 | 0.2924 |
| | Female | 0.4458 | 0.4127 | 0.4458 | 0.4718 |
| | Both | 0.4297 | 0.4121 | 0.4297 | 0.3949 |

In summary actual groundnut yield for female farmers in western agro-ecological zone was 0.270Mt/ha and actual yield for male groundnut farmers was 0.301Mt/ha, thus making a difference of 0.031Mt/ha. The yield gap for female groundnut farmers was 0.446Mt/ha and the yield gap for male groundnut farmers was 0.416Mt/ha, thus making a gendered yield gap of 0.03Mt/ha. However, the gendered yield gap was not statistically significant. Thus, concentration should be given at reducing the general groundnut yield gap in central agro ecological zone.

### 4.3.5 Groundnut gendered yield gap in southern highland agro ecological zone

Results of Table 11 representing southern highland agro ecological zone show that groundnut farmers were technically efficient at the level of 64.12%, at this level of technical efficiency groundnut farmers were getting the actual groundnut yield of 0.646Mt/ha. Thus, if groundnut farmers could be able to increase their technical efficiency that is making efficient utilization of their existing resources by 35.88%, they would be able to achieve the potential groundnut yield of 0.953Mt/ha.

Hence, the yield gap for groundnut production in southern highland agro ecological zone was 0.306Mt/ha. Therefore, if the groundnut farmers in southern highland agro-ecological zone could be able to improve the efficient utilization of their existing resources (land, labor, and capital) they would be able to reduce or close the groundnut yield gap of 0.306Mt/ha. This needs 47% increases in actual groundnut yield.

Moreover, Table 11 shows that female groundnut farmers in southern highland agro-ecological zone were technically efficient at the level of 55.0%. At this level of technical efficiency female groundnut farmers were able to get the actual yield of 0.386Mt/ha. If the female groundnut farmers could be able to increase their technical efficiency by 45.0%, they would be able to achieve the potential groundnut yield of 0.678Mt/ha. Hence, the yield gap for female groundnut farmers in southern highland agro-ecological zone was 0.292Mt/ha. This yield gap requires 75.6% increase in actual groundnut yield for female groundnut farmers for closing the yield gap.

**Table 11: Groundnut gendered yield gap in southern highland agro-ecological Zone**

| Variables | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Technical efficiency | Male | 0.6689 | 0.7468 | 0.6398 | 0.6598 |
| | Female | 0.5503 | 0.5449 | 0.5533 | 0.5232 |
| | Both | 0.6412 | 0.7293 | 0.6156 | 0.6294 |
| Actual yield per hectare | Male | 0.7254 | 0.8317 | 0.7094 | 0.5298 |
| | Female | 0.3863 | 0.1979 | 0.4030 | 0.4000 |
| | Both | 0.6462 | 0.7766 | 0.6236 | 0.5009 |
| Potential yield per hectare | Male | 1.0362 | 1.0622 | 1.0614 | 0.7636 |
| | Female | 0.6780 | 0.3223 | 0.7048 | 0.7525 |
| | Both | 0.9525 | 0.9979 | 0.9616 | 0.7611 |
| Yield gap per hectare | Male | 0.3109 | 0.2306 | 0.3521 | 0.2338 |
| | Female | 0.2917 | 0.1244 | 0.3018 | 0.3525 |
| | Both | 0.3064 | 0.2213 | 0.3380 | 0.2602 |

Male groundnut farmers in southern highland agro-ecological zone were technically efficient at the level of 66.9%. At this level of technical efficiency male groundnut farmers were getting the actual groundnut yield of 0.725Mt/ha. However, if the male groundnut farmers could be able to increase their technical efficiency by 33.1%, they would be able to achieve the potential groundnut yield of 1.036Mt/ha. Hence, the groundnut yield gap for male groundnut farmers in southern highland agro-ecological zone was 0.311Mt/ha. This yield gap requires 42.9% increase in actual groundnut yield. If male groundnut farmers in southern highland agro-ecological zone would be able to increase the efficient utilization of their existing resources they could be able to reduce the groundnut yield gap of 0.311Mt/ha.

In summary, actual groundnut yield for female farmers in southern highland agro-ecological zone was 0.386Mt/ha and actual yield for male groundnut farmers was 0.725Mt/ha, thus making a difference of 0.339Mt/ha which was statistically significant at the 5%. The yield gap for female groundnut farmers was 0.292Mt/ha and the yield gap for male groundnut farmers was 0.311Mt/ha, making a gendered yield gap of 0.019Mt/ha. However, the gendered yield gap was not statistically significant.

Thus, it can be observed that although male groundnut farmers in southern highland agro-ecological zone had higher actual groundnut yield of 0.725Mt/ha compared to female groundnut farmers with the actual yield of 0.386Mt/ha but the yield gap for male groundnut farmers of 0.311Mt/ha was higher than the yield gap of female groundnut farmers of 0.292Mt/ha. This was because the yield gaps were more attributed by the differences in potential yield of 0.358Mt/ha than the differences in actual groundnut yield of 0.339Mt/ha. Therefore, concentration should be given at leveraging actual groundnut yield for male and female groundnut farmers.

### 4.3.6 Groundnut gendered yield gap in southern agro-ecological zone

Referring Table 12 representing southern agro-ecological zone groundnut farmers were technically efficient at the level of 57.3%, at this level of technical efficiency groundnut farmers were getting the actual groundnut yield of 0.505Mt/ha. Thus, if groundnut farmers could be able to increase their technical efficiency that is making efficient utilization of their existing resources by 42.7%, they would be able to achieve the potential groundnut yield of 0.846Mt/ha. Hence, the yield gap for groundnut production in southern agro-ecological zone was 0.342Mt/ha. Therefore, if groundnut farmers in southern agro-ecological zone will be able to improve the efficient utilization of their existing resources they will be able to reduce or close the groundnut yield gap of 0.342Mt/ha.

Female groundnut farmers in southern agro-ecological zone were technically efficient at the level of 52.4%. At this level of technical efficiency female groundnut farmers were getting the actual yield of 0.530Mt/ha. If female groundnut farmers could be able to increase their technical efficiency by 47.6%, they would be able to achieve the potential groundnut yield of 0.846Mt/ha. Hence, the yield gap for female groundnut farmers in Southern agro ecological zone was 0.342Mt/ha. This yield gap requires 64.5% increase in actual yield for female groundnut farmers for closing the yield gap.

Male groundnut farmers in southern agro-ecological zone were technically efficient at the level of 60.1%. At this level of technical efficiency male groundnut farmers were getting the actual groundnut yield of 0.492Mt/ha. However, if male groundnut farmers could be able to increase their technical efficiency by 39.9%, they would be able to achieve the potential groundnut yield of 0.777Mt/ha.

Hence, the groundnut yield gap for male groundnut farmers in southern agro-ecological zone was 0.287Mt/ha. This yield gap requires 58.3% increase in actual groundnut yield. If male groundnut farmers in southern highland zone would be able to increase the efficient utilization of their existing resources they could be able to reduce the groundnut yield gap of 0.287Mt/ha. In summary actual groundnut yield for female farmers in southern agro-ecological zone was 0.530Mt/ha and actual yield for male groundnut farmers was

0.490Mt/ha, making a difference of 0.04Mt/ha which was not statistically significant. The yield gap for female groundnut farmers was 0.435Mt/ha and the yield gap for male groundnut farmers was 0.287Mt/ha, making a gendered yield gap of 0.148Mt/ha.

**Table 12: Groundnut gendered yield gap in southern agro-ecological zone**

| Variables | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Technical efficiency | Male | 0.6013 | 0.7079 | 0.5863 | 0.5824 |
| | Female | 0.5240 | 0.5841 | 0.5229 | 0.5017 |
| | Both | 0.5728 | 0.6798 | 0.5607 | 0.5567 |
| Actual yield per hectare | Male | 0.4906 | 0.5821 | 0.5154 | 0.3965 |
| | Female | 0.5298 | 0.2917 | 0.4893 | 0.7536 |
| | Both | 0.5051 | 0.495 | 0.5049 | 0.5101 |
| Potential yield per hectare | Male | 0.7774 | 0.7869 | 0.8327 | 0.5533 |
| | Female | 0.9646 | 0.4789 | 0.8744 | 0.9023 |
| | Both | 0.8465 | 0.6945 | 0.8495 | 0.9085 |
| Yield gap per hectare | Male | 0.2869 | 0.2047 | 0.3173 | 0.1937 |
| | Female | 0.4348 | 0.1872 | 0.3851 | 0.4170 |
| | Both | 0.3415 | 0.1995 | 0.3447 | 0.3984 |

The gendered yield gap was statistically significant at 5%. Thus, there is a need of leveraging gendered yield gap.

### 4.3.7 Socio-economic factors determining groundnut yield gap in Tanzania

According to the results from Stochastic Frontier Analysis (SFA) presented in Table 13, the mean technical efficiency of groundnut production was 43.0% in the groundnut model with a minimum of 16.5% and a maximum of 82.9%. On average, groundnut farmers produced 43% of groundnut output that is achievable with best management practices provided of their current level of production input and technology used. Thus, groundnut farmers could increase their output by 57% from a given mix of production input if farmers were technically efficient. This technical efficiency did not differ significantly with that of 50% of maize farmers in central province, Zambia (Chiona *et al.*, 2014) and that of 46.4% of agricultural farmers of central region of Uganda (Kalibwani *et al*., 2014).

The magnitude of the coefficient of plot size 0.302 is negative and statistically significant at 1 percent, therefore it can be estimated that one percent increase in land allocated for groundnut production as measured in hectare under ceteris paribus will reduce groundnut yield by 0.302 percent. Thus, allocating more land for groundnut production has the implication of reducing the groundnut yield and increasing the groundnut yield gap well. Therefore, there exists the inverse relationship between plot size and groundnut yield, this is consistent with the theory of farm size.

Seed coefficient was positive and statistically significant at one percent, thus it can be estimated that one percent increase in groundnut seeds as measured in kilograms under ceteris paribus increases the groundnut yield by 0.15%. This indicates that groundnut yield was relatively more responsive to the changes in the amount of groundnut seeds. Using more groundnut seeds in a groundnut plot will lead to increased groundnut yield resulting into the reduction of groundnut yield gap. This result is also consistent with the findings of Taphee and Jongur (2014) in their study of productivity and efficiency of groundnut farming in Northern Taraba State, Nigeria, they found the seed coefficient to have positive influence on increased groundnut yield.

Thus, farmers have to increase the use of groundnut seed for increased groundnut yield. Labour coefficient was positive and statistically significant at one percent. It can be estimated that one percent increase in labour as measured in man days under *ceteris paribus* will increase the groundnut yield by 0.188%.

**Table 13: Results from stochastic frontier analysis**

| Variable | Coefficient |
|---|---|
| Constant | 4.694*** |
| Plot size | -0.302*** |
| Seed | 0.15*** |
| Labor | 0.188*** |
| **Inefficiency model** | |
| Constant | 2.29 |
| Gender | -0.159** |
| Livestock production | -0.362 |
| Intercropping | 0.258*** |
| Tenure | -0.108 |
| Irrigate | -0.3009 |
| Plowing frequency | -0.822 |
| Formal education | -0.1406 |
| Youth age | -0.2436** |
| Plot distance | 0.153 |
| Road months | -0.161 |
| Presence in the household | -0.55 |
| Southern high and Southern zone | -0.466*** |
| Male decision | -0.245 |
| Jointly decision | -0.189 |
| Sigma squared | 0.8806 |
| Gamma | 0.422 |
| Mean T.E | 0.43 |
| Max T.E | 0.829 |
| Min T.E | 0.165 |

*** is for one 1% level of significance, ** is for 5% level of significance, and * is for 10% level of significance.

This indicates that allocating more labour input as measured in man days to groundnut plot will increase groundnut yield and reduce the groundnut yield gap as well. Application of pre-and post-emergence weedicides and introduction of small farm equipment's such as threshers (for stripping the pods of different sizes), shellers (for shelling the seeds) and seed graders will minimize labour use in especially in areas where availability of man power is a serious problem (Dwivedi and Upadhyaya, 2015). Thus, development and dissemination of labour intensive technologies will drive more production of groundnut for reduced yield gap in Tanzania. Given the specification of the Cobb-Douglas stochastic frontier model, the results show that the elasticity of the groundnut yield was estimated to be an increasing function of seed and labour but a decreasing function of land, however groundnut output or yield was observed to be more responsive to changes in land as measured in hectares. Therefore, groundnut farmers should concentrate on intensive system of farming for increased groundnut yield because extensive farming by allocating more hectares of land for groundnut production will lead to reduced groundnut yield.

In explaining the influences of the inefficiency variables it is important to note that in the inefficiency model the variables are included as inefficiency variables; thus a negative coefficient means that an increase in the efficiency or decrease in the inefficiency and a positive coefficient means a decrease in the efficiency or increase in the inefficiency. Beginning with sex ($\delta_1$), of the groundnut farmer, this variable was included to assess the direction of influence of sex on technical efficiency. The coefficient of sex in this study was estimated to be negative and statistically significant at 5 percent level for groundnut output; this indicates that being male under ceteris paribus increases the efficiency of producing groundnut by 15.9% relative to being female. This has the implication that male groundnut farmers are more efficient than female farmers.

Intercropping ($\delta_3$) coefficient was positive and statistically significant at one percent. This indicates that practicing intercropping under ceteris paribus increases the technical inefficiency of producing groundnut by 25.8% relative to the farmer who is not practicing intercropping. Thus, a farmer practicing intercropping reduces the groundnut yield and increases the groundnut yield gap as well because intercropping reduces the farmer efficiency of producing groundnut. Formal education ($\delta_7$) coefficient was negative and statistically significant at ten percent, this indicates that being a groundnut farmer with a formal education under ceteris paribus reduces the technical inefficiency by 14.0% relative to a groundnut farmer with no formal education. This has the implication that groundnut farmers with formal education were able to reduce the yield gap than groundnut farmers with no formal education.

Youth age group ($\delta_8$) coefficient, was negative and statistically significant at five percent. This indicates that being in the youth age group under ceteris paribus reduces the inefficiency of producing groundnut by 24.3% relative to other age group. Thus, groundnut farmers in youth age group have to be taken into consideration during policy design and program implementation for increased groundnut yield and reduced groundnut yield gap as well.

Southern highland and southern zone ($\delta_{11}$) coefficient was negative and statistically significant at one percent. This indicates that being in the southern highland and southern zone under ceteris paribus reduces the technical inefficiency of producing groundnut by 46.6% relative to a groundnut farmer in lake zone, central zone and western zone. This have the implication that a groundnut farmer in the southern highland and southern zone had the ability to reduce the groundnut yield gap than farmers of lake zone, central zone and western zone because of being more technically efficient.

### 4.4 Socio-Economic Factors Influencing Adoption of Improved Groundnut Variety

From Table 14, it can be observed that farmer distance to the market for accessing inputs and market for output, distance to the office of the extension officer and being in lake zone were the socio-economic and physical factors significantly explaining the adoption rate of improved groundnut variety. The magnitude of the coefficient of farmer distance to the market is negative and statistically significant at 5 percent, thus it can be estimated that one kilometer increase in the farmer distance to the market reduces the probability of adopting improved groundnut variety by 0.082 percentages other factors are kept constant (*ceteris paribus*).

The magnitude of the coefficient of farmer distance to the extension officer is negative and statistically significant at 5 percent. Thus, it can be estimated that one kilometer increase in farmer distance to the extension officer reduces the likelihood of adopting improved groundnut variety by 0.002 percent other things remain constant (*ceteris paribus*).

**Table 14: Socio-economic factors for the adoption of improved groundnut variety**

| **Logit regression variables** | **Coef.** | **Std. Err.** | **z** | **P>z** | **M.E (dy/dx)** | **Std. Error** | **P>z** |
|---|---|---|---|---|---|---|---|
| Distance market | -0.049 | 0.017 | -2.86 | 0.004 | -0.082 | 0.002 | 0.003 |
| Distance ext. Officer | -0.014 | 0.005 | -2.74 | 0.006 | -0.002 | 0.001 | 0.005 |
| Lake zone | -1.684 | 0.321 | -5.25 | 0.000 | -0.194 | 0.031 | 0.000 |
| Central zone | -0.354 | 0.303 | -1.17 | 0.243 | -0.044 | 0.035 | 0.211 |
| Western zone | -0.053 | 0.283 | -0.19 | 0.851 | -0.007 | 0.037 | 0.849 |
| Southern high zone | 0.479 | 0.35 | 1.37 | 0.171 | 0.056 | 0.036 | 0.118 |
| Sex | -0.056 | 0.179 | -0.31 | 0.755 | -0.007 | 0.024 | 0.756 |
| Cons | -0.627 | 0.267 | -2.35 | 0.019 | | | |

The magnitude of the coefficient of lake zone is negative and significant at one percent. Thus, it can be estimated that a groundnut farmer being in the lake zone reduces the probability of adopting improved groundnut variety by 0.194 percent relative to the farmer in southern zone other factors remain constant (*ceteris paribus*).

Referring Table 15 presented below; 19% of the interviewed groundnut farmers were using improved or modern groundnut variety, the result is consistent with the finding of Katundu *et al.* (2014) who stated that most of the groundnut farmers in Tanzania practices traditional kind of farming which have lower yields; low farm yields have the economic implications on food insecurity and poor household income.

**Table 15: Gender versus adoption of improved groundnut variety**

| Respondent sex | Was this an improved variety? | | |
|---|---|---|---|
| | No | Yes | Total |
| Female | 300 (80%) | 76 (20%) | 376 (100%) |
| Male | 460 (82%) | 102(18 %) | 562(100%) |
| **Total** | **760 (81%)** | **178 (19 %)** | **938(100%)** |

Nevertheless female groundnut farmers were observed to be less rigid in adopting improved groundnut variety relative to males because females groundnut farmers had 20% adoption rate improved groundnut variety unlike to that of 18% for male groundnut farmers although the 2 percent adoption differences between female and male groundnut farmers was not significant but in promoting the adoption of improved groundnut variety women should be considered as an important group in adopting the improved groundnut variety technology.

From Table 16, it is observed that there are 11 groundnut seed varieties; 10 are improved seed varieties developed by Naliendele Agricultural Research Institute (NARI). Unfortunately local variety was observed to be mostly grown by groundnut farmers by 81% relative to improved groundnut varieties with the adoption rate of 19%. Pendo 98 was the leading improved groundnut variety to be adopted by farmers followed by Johari, then Nachingwea 09.

"…..Pendo 98 was the leading adopted groundnut variety compared to other varieties. The reason is that, is it was developed in 1998 while Naliendele 09, Mangaka 09, Mnanje 09, Masasi 09 and Nachingwea 09 were developed in 2009, such that Pendo 98 had enough time to be disseminated and reach different parts of the country.

**Table 16: Groundnut varieties adoption across gender divides**

| Groundnut variety | Female | Male | Total |
|---|---|---|---|
| Local | 300 | 460 | 760 |
| Johari | 8 | 5 | 13 |
| Nyota | 3 | 3 | 6 |
| Red mwitunde | 2 | 3 | 5 |
| Dodoma bold | 2 | 3 | 5 |
| Pendo 98 | 13 | 18 | 31 |
| Naliendele 09 | 2 | 2 | 4 |
| Mangaka 09 | 3 | 3 | 6 |
| Mnanje 09 | 1 | 3 | 4 |
| Masasi 09 | 1 | 1 | 2 |
| Nachingwea 09 | 4 | 4 | 8 |
| Others | 37 | 57 | 94 |
| Total | 376 | 562 | 938 |

Furthermore, farmers had enough time to try the variety by cultivating it for making decision of whether to adopt or not compared to groundnut varieties developed in 2009…" (Mponda, personal communication, 2017).

## 4.5 Determining profitability differences in groundnut production

### 4.5.1 Profitability differences between male and female groundnut farmers in Tanzania

The mean groundnut gross margins for all agro-ecological zones was 251 803.00 Tanzanian shillings per hectare. Results from Table 17 show that the gross margin for male groundnut farmers was higher than the gross margin for female groundnut farmers. The mean gross margin for male groundnut farmers were 276 232.50 Tanzanian shillings per hectare, while the mean groundnut gross margin for female groundnut farmers were 215 288.70 Tanzania shillings per hectare. Thus, making a gendered groundnut gross margin gap of 60 943.80 Tanzanian shillings per hectare.

**Table 17: Gendered gross margin for all agro ecological zones**

| Variable | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Gross margin | Male | 276 232.50 | 401 030.00 | 249 954.30 | 199 741.90 |
| | Female | 215 288.70 | 246 765.90 | 203 959.80 | 216 063.90 |
| | Both | 251 803.00 | 341 697.60 | 231 637.20 | 206 780.80 |
| Gendered Gross margin gap | Count | 60 943.80 | 154 264.10 | 45 994.50 | (16 322.00) |
| | Gap in% | 28.308 | 62.514 | 22.551 | (7.554) |

This gendered groundnut gross margin gap is equivalent to 28.3%. This difference in gendered gross margin was more attributed by differences in technical efficiency and off course actual groundnut yield as well. Furthermore, results from the t-statistical tests revealed that groundnut gendered gross margin gap was significant at 1%, thus there is the need of doing intervention by increasing the technical efficiency of women groundnut farmers such that they can allocate their physical resources like land, labor and groundnut seed efficiently for increased groundnut yield and profit as well.

Hired labor was observed to be the major cost driver for groundnut production in Tanzania as shown in Table 18 below that it costs 25 700.00 Tanzanian shilling per hectare for male groundnut farmers and 13 000.00 Tanzania shillings per hectare for female groundnut farmers. Thus, making a gendered cost differences for hired labor of 12 700.00 Tanzania shillings per hectare. The difference in labor cost between male and female groundnut farmers was statistically significant at 1%.

**Table 18: Variable costs for groundnut production in Tanzania**

| Input | Sex | Cost in TShs. | Cost differences based on sex | % of Cost differences |
|---|---|---|---|---|
| Seed | Male | 9564.86 | | |
| | Female | 7 596.04 | | |
| | Both | 8775.65 | 1968.82 | 26 |
| Hired oxen | Male | 9065.00 | | |
| | Female | 10 900.00 | | |
| | Both | 9789.48 | (1835.00) | -17 |
| Hired labor | Male | 25 700.00 | | |
| | Female | 13 000.00 | | |
| | Both | 20 600.00 | 12 700.00 | 98 |
| Total cost | Male | 44 329.86 | | |
| | Female | 31 496.04 | | |
| | Both | 39 165.13 | 12 833.82 | 41 |

Male groundnut farmers having higher cost for hired labor relative female groundnut farmers means that they are less depending on their own labor or family labor for groundnut production. Therefore, supporting women groundnut farmers with technologies that can improve their labor productivity can increase the profitability of groundnut production from increased yield.

### 4.5.2 Profitability differences in the southern highland zone

Referring Table 19, the mean groundnut gross margin was observed to be higher in the southern highland zone with the mean gross margin of 426 917.00 Tanzanian shillings per hectare. Male farmers were observed to have higher groundnut gross margin than female farmers. The mean groundnut gross margin for male farmers were 485 956.80 Tanzanian shillings per hectare while the mean groundnut gross margin for female farmers were 233 266.50 Tanzanian shillings per hectare. Thus, making a gendered groundnut gross margin gap in the southern highland zone of 252 690.30 Tanzanian shillings per hectare which is equivalent to 108.33%. This result is consistent with the assertion of Anderson and Leavens (2011) who stated that men tend to move into activities that are profitable and marketable. The gendered gross margin gap was because male groundnut farmers were more technically efficient at the level of 66.9% in allocating their productive resources like land and labor than female groundnut farmers who were technically efficient at the level of 55.0%.

**Table 19: Groundnut gendered gross margin for southern highland zone**

| Variable | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Gross margin | Male | 485 956.80 | 573 000.00 | 469 954.50 | 348 273.80 |
| | Female | 233 266.50 | 120 833.30 | 240 476.00 | 270 000.00 |
| | Both | 426 917.00 | 533 681.20 | 405 700.50 | 330 879.60 |
| Gross margin gap | Count | 252 690.30 | 452 166.70 | 229 478.50 | 78 273.80 |
| | Percent | 108.33 | 374.21 | 95.43 | 28.99 |

A result from the t-statistical test for the gendered groundnut gross margin gap in the southern highland zone was observed to be significant at 5 percent. Thus, there is the need of leveraging the gendered groundnut gross margin gap by increasing the actual yield for female groundnut farmers, by allocating their resources more technically efficient.

Hired labor was observed to be the major cost driver for groundnut production in southern highland zone as shown in Table 20 below, that it costs 66 250.00 Tanzanian shilling per hectare for male groundnut farmers and 45 500.00 Tanzania shillings per hectare for female groundnut farmers. However, the difference in labor cost between male and female groundnut farmers was not statistically significant. Hired oxen were more costly to female groundnut farmers than to males, whereby the cost differences for hired oxen based on sex was statistically significant at 5%.

**Table 20: Variable costs for groundnut production in southern highland zone**

| Input | Sex | Cost in TShs. | Cost differences based on sex | % of cost differences |
|---|---|---|---|---|
| Seed | Male | 6 360.80 | | |
| | Female | 3 800.00 | | |
| | Both | 5 762.49 | 2 560.80 | 67 |
| Hired oxen | Male | 6 036.83 | | |
| | Female | 21 200.00 | | |
| | Both | 9 579.63 | (15 163.17) | -72 |
| Hired labor | Male | 26 500.00 | | |
| | Female | 18 200.00 | | |
| | Both | 24 600.00 | 8 300.00 | 46 |
| Total cost | Male | 38 897.63 | | |
| | Female | 43 200.00 | | |
| | Both | 39 942.12 | (4 302.37) | -10 |

Thus, reducing hired oxen cost to female groundnut farmers by enabling them to have ownership to oxen and their plough may significantly reduce the cost of groundnut production and increase the groundnut yield and profit as well.

### 4.5.3 Profitability differences in the southern zone

The Southern zone was the second with the highest groundnut profit margin after the southern highland zone with the mean gross margin of 341 261.80 Tanzanian shillings per hectare (Table 21). Unlike to other agro ecological zone, female groundnut farmers in Southern zone had higher groundnut gross margin than male groundnut farmers. Referring Table 21, the mean groundnut gross margin for female farmers was 368 725.80 Tanzanian shillings per hectare which was higher than the mean groundnut gross margin for male farmers which was 325 197.90 Tanzanian shillings per hectare.

Thus, making a gendered gross margin gap of 43 527.90 Tanzanian shillings per hectare which is equivalent to 11.8%. Female groundnut farmers had higher groundnut gross margin than male groundnut farmers because they were more technically efficient and had higher actual groundnut yield than male groundnut farmers. However, the gendered gross margin gap was not statistically significant.

**Table 21: Groundnut gendered gross margin for southern zone**

| Variable | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Gross margin | Male | 325 197.90 | 428 095.20 | 345 292.90 | 235 649.30 |
| | Female | 368 725.80 | 233 333.30 | 339 190.50 | 515 357.10 |
| | Both | 341 261.80 | 369 666.70 | 342 828.50 | 324 647.30 |
| Gross margin gap | Count | (43 527.90) | 194 761.90 | 6 102.40 | (279 707.80) |
| | Percent | (11.805) | 83.469 | 1.799 | (54.275) |

Hired labor was observed to be the major cost driver for groundnut production in southern zone as shown in Table 22 below that it costs 38 700.00 Tanzanian shilling per hectare for male groundnut farmers and 12 400.00 Tanzania shillings per hectare for female groundnut farmers. Female groundnut farmers having lower cost for producing groundnut relative to male means those female groundnut farmers were more depending on their own labor supply or family labor for undertaking groundnut production.

However, the difference in labor cost between male and female groundnut farmers was not statistically significant. The other cost driver after hired labor was seed costs whereby male groundnut farmers had higher cost of seed of 11 300.00 Tanzanian shillings per hectare and female groundnut farmers a seed cost of 8 577.42 Tanzanian shillings per hectare. However, the seed costs differences between male and female groundnut farmers were not statistically significantly different.

**Table 22: Variable costs for groundnut production in southern zone**

| Cost | Sex | Gross margin | Gender gross margin gap | Gender gross margin gap in % |
|---|---|---|---|---|
| Seed cost | Male | 11300.00 | | |
| | Female | 8 577.42 | | |
| | Both | 10 300.00 | 2722.58 | 32 |
| Cost of hired oxen | Male | - | - | - |
| | Female | - | - | - |
| | Both | - | - | - |
| Hired labor cost | Male | 38700.00 | | |
| | Female | 12 400.00 | | |
| | Both | 29000.00 | 26300.00 | 212 |
| Total cost | Male | 50 000.00 | | |
| | Female | 20 977.42 | | |
| | Both | 39 300.00 | 29022.58 | 138 |

### 4.5.4 Profitability differences in the central zone

Referring Table 23, in the Central zone the mean groundnut gross margin was 241 029.46 Tanzanian shillings per hectare. The mean groundnut gross margin was observed to be higher for male groundnut farmers than for female groundnut farmers.

**Table 23: Groundnut gendered gross margin for central zone**

| Variable | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Gross margin | Male | 273 712.70 | 559697.50 | 163 048.80 | 153 694.30 |
| | Female | 210 884.70 | 313 424.40 | 203768.70 | 144231.90 |
| | Both | 241 029.50 | 464 546.50 | 186980.70 | 149199.70 |
| Gross margin gap | Count | 62828.00 | 246 273.10 | (40 719.90) | 9462.40 |
| | Percent | 29.793 | 78.575 | (19.983) | 6.561 |

The mean groundnut gross margin for male groundnut farmers were 273 712.72 Tanzanian shillings per hectare and that for female groundnut farmers were 210 884.70 Tanzanian shillings per hectare. Thus, making a gendered gross margin gap of 62 828.00 Tanzanian shillings per hectare. Male groundnut farmers had higher gross margin than female groundnut farmers because of higher technical efficiency and higher actual yield than female groundnut farmers. However, the gendered gross margin gap was not statistically significant. Referring Table 24, hired labor was the major cost driver for groundnut production in the Central zone. Male groundnut farmer had the cost of 130 000.00 Tanzanian shillings per hectare which was higher than that of female groundnut farmers of 67 250.00 Tanzanian shillings per hectare. Thus, making the cost differences of 62 750.00 Tanzanian shillings per hectare. The second cost driver after hired labor was oxen plough whereby it was observed that there were slight differences in costs of hired oxen for male and female groundnut farmers.

**Table 24: Variable costs for groundnut production in central zone**

| Cost | Sex | Gross margin | Gender gross margin gap | Gender gross margin gap in % |
|---|---|---|---|---|
| Seed cost | Male | 7 842.11 | | |
| | Female | 7291.26 | | |
| | Both | 7 555.56 | 550.85 | 8 |
| Cost of hired oxen | Male | 25 200.00 | | |
| | Female | 24 300.00 | | |
| | Both | 24 700.00 | 900.00 | 4 |
| Hired labor cost | Male | 52 000.00 | | |
| | Female | 26 900.00 | | |
| | Both | 38 900.00 | 25 100.00 | 93 |
| Total cost | Male | 85 042.11 | | |
| | Female | 58 491.26 | | |
| | Both | 71 155.56 | 26 550.85 | 45 |

Male groundnut farmers had the cost of 63 000.00 Tanzanian shillings per hectare and for female groundnut farmers had the cost of 60 750.00 Tanzanian shillings per hectare making the cost differences of 2 250.00 Tanzanian shillings per hectare. However, this difference was not statistically significant. Slight difference in the cost for hired oxen plough between Male and Female groundnut farmers means that hired oxen is most important to both sexes for groundnut production in Central zone.

### 4.5.5 Profitability differences in the lake zone

In the Lake zone the mean groundnut gross margin was 231 226.44 Tanzanian shillings per hectare. Referring Table 25, the mean groundnut gross margin was observed to be higher for male groundnut farmers than for female groundnut farmers. The mean groundnut gross margin for male groundnut farmers was 238 599.60 Tanzanian shillings per hectare and that for female groundnut farmers was 217 815.00 Tanzanian shillings per hectare.

**Table 25: Groundnut gendered gross margin in lake agro-ecological zone**

| Variable | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Gross margin | Male | 238 599.60 | 309 857.50 | 213 482.60 | 228 056.50 |
| | Female | 217 815.00 | 218 487.80 | 219 178.30 | 212 666.70 |
| | Both | 231 226.40 | 274 888.90 | 215 381.20 | 222 071.50 |
| Gross margin gap | Count | 20 784.60 | 91 369.70 | (5 695.70) | 15 389.80 |
| | Percent | (9.542) | (41.82) | (2.599) | 7.24 |

Thus, making a gross margin gap of 20 784.60 Tanzanian shillings per hectare. Male groundnut farmers had higher gross margin than female groundnut farmers because of higher technical efficiency and higher actual yield than female groundnut farmers. However, the gendered gross margin gap was not statistically significant.

Referring Table 26, hired labor was the major cost driver for groundnut production in the Lake zone. Male groundnut farmer had the cost of 45 500.00 Tanzanian shillings per hectare and female groundnut farmers had the cost of hired labor of 15 148.73 Tanzanian shillings per hectare. Thus, making the cost differences of 30 351.28 Tanzanian shillings per hectare. The cost difference was statistically significant at 10%.

Female groundnut farmers having lower cost for hired labor compared to male have the implication that female groundnut farmers depend more on their own labor or family labor supply than hired labor due to budgetary constraints. Labor intensive technologies for increased labor productivity to women groundnut farmers would help to increase groundnut yield and profit as well.

**Table 26: Variable costs for groundnut production in the lake zone**

| Cost | Sex | Cost in TShs. | Cost differences based on sex | % of cost differences |
|---|---|---|---|---|
| Seed | Male | 11 400.00 | | |
| | Female | 5 956.98 | | |
| | Both | 9 441.62 | 5 443.02 | 91 |
| Hired oxen | Male | 4 194.31 | | |
| | Female | 5 948.28 | | |
| | Both | 4 816.51 | (1 753.97) | -29 |
| Hired labor | Male | 18 200.00 | | |
| | Female | 6 059.49 | | |
| | Both | 13 900.00 | 12 140.51 | 200 |
| Total cost | Male | 33 794.31 | | |
| | Female | 17 964.75 | | |
| | Both | 28 158.13 | 15 829.56 | 88 |

### 4.5.6 Profitability differences in the western zone

The mean groundnut gross margin was observed to be lower in the Western zone with the mean gross margin of 173 469.50 Tanzanian shillings per hectare. Referring Table 27, male farmers were observed to have higher groundnut gross margin than female farmers. The mean groundnut gross margin for male farmers were 180 260.40 Tanzanian shillings per hectare while the mean groundnut gross margin for female farmers were 165 333.90 Tanzanian shillings per hectare, thus making a gendered groundnut gross margin gap of 14 926.50 Tanzanian shillings per hectare which is equivalent to 9.03%.

Kuboja and Temu (2013) observed that groundnut in Tabora region which is in Western agro ecological zone had lower profit margin compared with Tobacco. Thus, there is the need of improving the profitability of groundnut production in the Western zone by increasing the actual groundnut yield through increasing the use of modern inputs like improved groundnut varieties.

**Table 27: Groundnut gendered gross margin for western zone**

| Variable | Sex | All age group | Youth (16-35 years) | Adult (36-60 years) | Elders (Above 60 years) |
|---|---|---|---|---|---|
| Gross margin | Male | 180 260.40 | 247 715.70 | 176 670.30 | 96 694.44 |
| | Female | 165 333.90 | 248 084.00 | 119 369.60 | 177 725.00 |
| | Both | 173 469.50 | 247 914.50 | 154 084.60 | 142 997.60 |
| Gross margin gap | Count | 14 926.50 | (368.30) | 57 300.70 | (81 030.56) |
| | Percent | 9.028 | (0.148) | 48.003 | (45.593) |

Groundnut seed and hired labor was the major cost driver for groundnut production in the Western zone. Referring Table 28, male groundnut farmers had the cost of 29 750.00 Tanzanian shillings per hectare for hired labor which was higher than that of female groundnut farmers of 14 430.98 Tanzanian shillings per hectare. Thus, making the cost differences of 15 319.03 Tanzanian shillings per hectare. The cost difference was statistically significant at 5%. Female groundnut farmers having lower cost compared to male have the implication that female groundnut farmers depend more on their own labor or family labor supply than hired labor due to budgetary constraints. Labor intensive technologies for increased labor productivity to women groundnut farmers would help to increase groundnut yield and profit as well in the Western zone.

**Table 28: Variable costs for groundnut production in the western zone**

| Cost | Sex | Gross margin | Gender gross margin gap | Gender gross margin gap in % |
|---|---|---|---|---|
| Seed cost | Male | 9 213.76 | | |
| | Female | 10 400.00 | | |
| | Both | 9 766.06 | (1 186.24) | -11 |
| Cost of hired oxen | Male | 10 900.00 | | |
| | Female | 3 574.26 | | |
| | Both | 7 590.09 | 7 325.74 | 205 |
| Hired labor cost | Male | 11 900.00 | | |
| | Female | 5772.39 | | |
| | Both | 9 110.45 | 6 127.61 | 106 |
| Total cost | Male | 32 013.76 | | |
| | Female | 19 746.65 | | |
| | Both | 26 466.60 | 12 267.11 | 62 |

Also male groundnut farmers were observed to have higher cost for groundnut seed relative to female. However, their difference were not statistically significant different. Groundnut seed being one of the major cost drivers for groundnut production in Western zone have the implication of farmers' willingness to buy improved groundnut seed. Oxen ploughs also were observed to be more costly to Male groundnut farmers than female groundnut farmers. The differences were statistically significant at 10%. This reveals that female groundnut farmers depend more on their own labor or family labor supply than from oxen plough and hired labor. Thus, improving the management skills for female groundnut farmers is important for increased groundnut yield and profitability as well in Western zone.

# CHAPTER FIVE

## 5.0 CONCLUSION AND RECOMMENDATIONS

### 5.1 Summary of Findings

Most of the households' productive resources were more individually owned rather than jointly owned which may lead to inefficient allocation of resources due to weak bargaining power. Resource ownership was stated in world development report (2012) to be one of the indicators of increased bargaining power in household decision making.

Groundnut farmers were technically efficient at an average of 42.94% of groundnut output that is achievable with best management practices provided of their current level of production input and technology used. This efficiency level has resulted into the mean actual groundnut yield of 0.3868 Mt/ha and the mean potential yield of 0.8271 Mt/ha; thus there is the mean groundnut yield gap of 0.4403 Mt/ha. Thus, when groundnut farmers will increase their technical efficiency by 57.06%, they will achieve a potential groundnut yield of 0.8271 Mt/ha. Groundnut yield gap was statistically significant at 5% while the groundnut yield gap based on sex was not statistically significant.

Based on sex Male groundnut farmers had higher actual groundnut yield and lower yield gap than female groundnut farmers. Male groundnut farmers had the technical efficiency of 46.46%, actual yield of 0.4205Mt/ha, potential yield of 0.8284Mt/ha and the yield gap 0.4079 Mt/ha while female groundnut farmers had the technical efficiency of 37.68%, actual yield of 0.3363 Mt/ha, potential yield of 0.8252 Mt/ht and the yield gap of 0.4889 Mt/ha. The difference in actual yield and yield gap between female and male groundnut farmers was because of the differences in actual groundnut yield, land ownership for groundnut production and formal education. 68% of the male groundnut farmers had formal education while 56% of the female groundnut farmers had formal education. 89% of the male groundnut farmers had ownership of farm plot for groundnut production while 84% of female groundnut farmers had ownership of farm plot for groundnut production.

However, in southern zone female groundnut had higher actual groundnut yield than male groundnut farmers. Female groundnut farmers had actual yield of 0.5298Mt/ha, potential yield of 0.9646Mt/ha while male groundnut farmers had the actual groundnut yield of 0.5298Mt/ha and potential yield of 0.7774Mt/ha. However, in Southern zone it was observed that male groundnut farmers had higher technical efficiency than female groundnut farmers. Elders female groundnut farmers were the drivers for groundnut yield in southern zone that is why the overall average yield for female groundnut farmers was observed to be high but in actual sense other age group like youth and adults female groundnut farmers had lower actual yield and potential yield relative to males.

Based on age, youth were the drivers of groundnut yield in Tanzania. Adults were more technically efficient, had higher actual yield and potential yield than other age groups. For example the technical efficiency of youth were 49.51%, actual yields were 0.4984Mt/ha, and potential yield of 0.9201Mt/ha. While adults technical efficiency were 41.63%, actual yield were 0.3643Mt/ha and potential yield were 0.8078Mt/ha and elders technical efficiency were 39.05%, actual yield were 0.3216Mt/ha and potential yield of 0.775Mt/ha. Furthermore, youth had lower yield relative to other age group. The yield gap for youth was 0.4216Mt/ha, for adults were 0.4435Mt/ha and elders 0.4534Mt/ha. Based on agro ecological zone southern highland and southern zone had higher technical efficiency, actual yield and potential yield relative to other agro ecological zone. Socio economic factors like literacy rate, use of improved groundnut varieties and physical factors like weather explained significantly the variations of actual yields, potential yields and yields gaps across agro ecological zones. Western zone and lake zone had lower actual yield and potential yield relative to other agro ecological zones the major reason was lower amount of rainfall received and limited access of improved groundnut varieties. Furthermore, literacy rate was observed to be very low in lake zone and western zone compared to other agro ecological zones. In Southern highland zone and southern zone literacy rate were 80% and 76% respectively unlike to lake zone and western zone with the literacy rate of 65% and 70% respectively.

Groundnut yield were observed to be an increasing function of groundnut seed and labour. Thus, more additional unit of groundnut seed as measured in kilograms and labour as measured in man days will lead to increased groundnut yield per unit hectare. However, groundnut yield was observed to be a decreasing function for plot size, hat is more additional unit of plot size as measured in hectares will lead to reduced groundnut yield.

Being male, undertaking livestock production, intercropping, being in youth age group and being in Southern highland and southern zone were the factors significantly influencing the technical efficiency of groundnut production. Being male, undertaking livestock production, being in youth age group and being in southern highland and southern zone had positive influence on the technical efficiency of groundnut production in Tanzania. Undertaking intercropping had negative influence on the technical efficiency of groundnut production in Tanzania.

Farmer distance to the market, farmer distance to the extension officer and farmer being in the lake zone were the physical and socio-economic factors significantly influencing the adoption of improved groundnut varieties although other factors like gender, southern zone, western zone, central zone also observed to have an influence on the adoption of improved groundnut variety but they were not statistically significantly influencing the adoption of improved groundnut variety.

Adoption of improved groundnut variety stood at 19 percent with female groundnut farmers being main adopters with the adoption rate of 20% followed by male groundnut farmers with the adoption rate of 18%. Groundnut adoption rate is still low relative to maize which stood at 30% however, groundnut adoption have improved much... (Mponda, personal communication, 2017).

Improved groundnut variety developed by Naliendele agricultural research institute were less adopted by 19 percent compared to local groundnut variety. For the improved or modern groundnut varieties Pendo 98 were mostly adopted, followed with Johari and then Nachingwea 09. The main reason for the Pendo 98 to be mostly adopted than other improved groundnut varieties is that Pendo was developed earlier 1998 compared to other varieties like Nachingwea 09 which was developed in 2009. Thus, farmers had enough time to share information and to test Pendo 98 in the field than Nachingwea 09.

Male groundnut farmers had higher gross margin compared to female groundnut farmers. The gross margin for male groundnut farmers was 276 232 Tanzanian shillings per hectare while for female groundnut farmers were 215 288 Tanzanian shillings per hectare. Thus, making a gross margin difference of 60 943.80 Tanzanian shillings per hectare. The difference is equivalent to 28.308%. The difference was attributed by large difference in actual groundnut yield because higher yield minimizes production cost. Actual groundnut yield for male groundnut farmers was 0.4205Mt/ha while actual yield for female groundnut farmers was 0.3363Mt/ht, thus making a difference of 0.0842Mt/ha which is equivalent with 25%.

## 5.2 Conclusion

Based on the results of this study, the null hypothesis which stated that there is no groundnut yield gap in Tanzania that is farmers were fully technically efficient was rejected in favor of the alternative hypothesis. Groundnut farmers in all of the studied agro-ecological zones were observed to be technically efficient at an average of 43%. At this level of technical efficiency, the mean actual groundnut yield for the farmers in Tanzania for 2016 was 0.387 Mt/ha and for the same period groundnut yield gap in Tanzania was 0.4403 Mt/ha. Actual groundnut yield was observed to be higher for youth and males groundnut farmers especially for southern highland and southern agro ecological zone. Groundnut yield gap was observed to be higher for females especially in western, lake and central agro-ecological zones.

Higher groundnut yield gap in Tanzania have the following economic implication, first farmers can get more income from increased efficient utilization of their existing resources. Furthermore, closing this yield gap will lead to increased employment in groundnut sub sector because of its labor intensive in nature. Also reducing the groundnut yield gap will lead to reduced importation of groundnut in Tanzania thus saving more foreign currency. Higher variation of actual groundnut yield and yield gap based on sex, age and agro-ecological zone will have the social implication of higher inequality in distribution of income, employment, access to nutritious food which ultimately will lead to differences in welfare status among the groundnut farmers in Tanzania.

## 5.3 Recommendations

The study recommends increased efficient utilization of the farmers existing resources regardless of their sex, age and agro ecological zone because their yield gap is very high. This can be done by improving their skills in better agricultural practices for increased efficient utilization of their existing resources. Furthermore, the study recommends increased youth participation in groundnut production and more support to women groundnut farmers for increased groundnut yield. Also it is recommended to increase the usage of groundnut seeds to farmers and use of labour intensive technologies for increased groundnut yield. Land intensification for increased land productivity and higher groundnut yield should be more encouraged rather than extensive system of farming because groundnut yield is inversely related to more acreage of land allocated for groundnut production. To address drought, pest and diseases problems the study recommends increased access of resilient groundnut varieties to the farmers.

Farmer distance to the market, distance to the extension officer and farmer being in lake zone should be considered as important physical and socio-economic factors negatively influencing the adoption of improved groundnut variety. Addressing these factors is a necessary condition for increased adoption of improved groundnut variety for increased groundnut yield and reduced groundnut yield gap as well.

Intervention aimed at reducing farm operational production costs of groundnut product and accessibility of good market for groundnut products for youth and female groundnut farmers are important for leveraging the gendered groundnut gross margin gap between female and male groundnut farmers. Technologies aiming at increasing labour productivity are important at reducing the dependence on hired labour which have significant share in the total cost of groundnut production.

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# APPENDICES

## Appendix 1: Groundnut yield in Africa

| **Groundnut yield in Africa** | |
|---|---|
| **Year** | **Mt/ha** |
| 2010 | 1.0229 |
| 2011 | 1.0232 |
| 2012 | 1.0096 |
| 2013 | 0.9957 |
| 2014 | 1.0375 |
| Average yield | 1.0178 |

Source: FAOSTAT (2017)

## Appendix 2: List of variables for estimating stochastic production frontier

| Variable | Description | Measurement unit | Expected sign |
|---|---|---|---|
| Yield (Y Dependent) | Quantity of groundnut yield | Metric tons/Hectare | +/- |
| Plot size ($X_1$) | Size of the land under groundnut cultivation | Hectares | +/- |
| Labor ($X_2$) | Labor used | Man days | + |
| Seeds ($X_2$) | Amount of groundnut seeds | Kilograms | +/- |

## Appendix 3: List of variables for estimating inefficiency model

| **Variable** | **Description** | **Measurement unit** | **Expected sign** |
|---|---|---|---|
| U (Dependent) | TE, of the $i^{th}$ farm | % | |
| Gender ($\delta_1$) | Sex of the farmer | 1=Male, 0=female | - |
| Livestock production ($\delta_2$) | If the farmer is keeping livestock | 1=Yes, 0=Otherwise | - |
| Intercropping ($\delta_3$) | If the farm has intercropped or not | 1=Intercropped, 0=Not intercropped | +/- |
| Tenure ($\delta_4$) | Land tenure of the groundnut farm | 1=Owned, 0=Otherwise | +/- |

| | | | |
|---|---|---|---|
| Irrigate ($\delta_5$) | If the farm is irrigated or not | 1= Irrigated, 0=Not irrigated | - |
| Plowing frequency ($\delta_6$) | Frequency of plowing the groundnut farm | Number plowing | +/- |
| Formal education ($\delta_7$) | If the farmer had formal education | 1= Yes, 0= Otherwise | - |
| Youth age group ($\delta_8$) | If the farmer is in the youth age group of 16 to 35 years | 1=Yes, 0=Otherwise | - |
| Plot distance ($\delta_9$) | Distance from home to the farm | Kilometers | + |
| Road months ($\delta_{10}$) | Number of months the road can be passed by cars | Number of months | - |
| Farmer presence in the household ($\delta_{11}$) | Months the groundnut farmer is in the household | Number of months | - |
| Southern highland and southern zone ($\delta_{12}$) | Farmer being in southern highland and southern zone | 1= Yes, 0= Otherwise | - |
| Male decision ($\delta_{13}$) | If decision made by male | 1= Yes, 0=No | +/- |
| Jointly decision ($\delta_{14}$) | If decision was made jointly | 1=Yes, 0=No | +/- |

## Appendix 4: Characteristics of Agro-ecological Zones

| ZONE | REGION | DISTRICT | CASH CROPS | FOOD CROPS | Altitude: meters<br>Rainfall: mm/Year<br>Temperature: $^{o}$C |
|---|---|---|---|---|---|
| LAKE ZONE | Mwanza | Misungwi | Cotton, Chick pea, Sunflower, Simsim (Sesame) | Rice, Maize, Cassava, Sorghum, Sweat potatoes | Altitude:1 000-1 800<br>Rainfall: 600-1 400<br>Temperature:15-30<br>Soil: pH 6.5-7, Mixture of Sand, Silt, and Clay soil |
| LAKE ZONE | Mwanza | Kwimba | Cotton, Chick pea, Cow pea | Rice, Maize, Cassava, Sorghum, Sweat potatoes | Altitude: 1 000- 1 500<br>Rainfall: 600-1 200<br>Temperature: 15-30<br>Soil: pH 5-7 Black clay soil and Silt soil |
| LAKE ZONE | Shinyanga | Shinyanga | Cotton, Chick pea, Rice, Sunflower, Simsim (Sesame) | Maize, Sweat potatoes, Sorghum | Altitude: 900-1 300<br>Rainfall: 600-1 000<br>Temperature: 15-30<br>Soil: pH 5-9, mixture of silt, sand and black clay, average soil fertility |

| | | | | | |
|---|---|---|---|---|---|
| LAKE ZONE | Shinyanga | Msalala | Cotton, Mung beans, Chick pea, Rice, Sunflower | Maize, sorghum, Rice, Wheat | Altitude: 800-1 300<br>Rainfall: 300-650<br>Temperature: 15-30<br>Soil: pH 5-8, Silt, Sand, Black clay, average soil fertility |
| LAKE ZONE | Shinyanga | Ushetu | Cotton, Rice, Sunflower, Horticultural crops | Maize, sorghum, Rice, Wheat | Altitude: 900-1 300<br>Rainfall: 900-1 300<br>Temperature: 15-30<br>Soil: pH 5->8.5, Silt, Sand, and Black clay, average soil fertility |
| LAKE ZONE | Geita | Bukombe | Cotton, Cow pea, Groundnut, Tobacco | Maize, Cassava, Sweat potatoes | Altitude: 900-1 700<br>Rainfall: 600-1 200<br>Temperature: 10-30<br>Soil: pH 4-8.5, Sand, Silt, Gravel, Clay soil |
| LAKE ZONE | Geita | Mbogwe | Cotton, Cow pea | Maize, Cassava, Sweat potatoes | Altitude: 1 200-1 300<br>Rainfall: 600-1 400<br>Temperature: 10-30<br>Soil: Black, Silt, Clay, and Gravel. |
| CENTRAL ZONE | Dodoma | Chamwino | Vine, Simsim (sesame), Sunflower, Groundnut | Sorghum, Chick pea, Rice, Sweat potatoes | Altitude: 500-1 400<br>Rainfall: 400-800<br>Soil: Red soil, and Sand soil |
| CENTRAL ZONE | Dodoma | Kondoa | Sunflower, Simsim (Sesame), Pigeon pea, Groundnut | Sorghum, Maize, Cassava, Sweat potato, cow pea | Altitude: 500-1400<br>Rainfall: 400-800<br>Temp: 15-30<br>Soil: Sand, Silt, Red |
| CENTRAL ZONE | Dodoma | Mpwapwa | Sunflower, Groudnut, Sesame (Simsim) | Sorghum, Bambara nut, Maize, Sweat potatoes, Cassava, Cow pea | Altitude: 500-2 300<br>Rainfall: 200-1 000<br>Temperature: 10-30<br>Soil: Average soil fertility |
| CENTRAL ZONE | Dodoma | Chemba | Sunflower, Sesame (Simsim), Vine, Groundnut | Sorghum, Cassava, Wheat, Sweat potatoes, Maize, Cow pea | Altitude: 500-1 400<br>Rainfall: 400-800 |
| CENTRAL ZONE | Dodoma | Kongwa | Sunflower, Groundnut, Maize | Sorghum, Njugumawe, Cassava, Pigeon pea, Cow pea | Altitude: 500-2 300<br>Rainfall: 800-1 000<br>Temperature: 15-30<br>Soil: Silt, Sand and Clay soil. Average soil fertility |
| CENTRAL ZONE | Dodoma | Bahi | Vine, Rice, Sunflower, Groundnut | Sorghum, Wheat, Rice, Sweat potatoes | Altitude: 500-1 400<br>Rainfall: 400-800 |
| WESTERN ZONE | Tabora | Urambo | Cotton, Tobacco, Sunflower | Rice, Maize, Sorghum | Altitude: 800-1 800<br>Rainfall: 600-1 000<br>Soil: pH 5->8.5, Gravel, Clay, Silt and Sand soil with average soil fertility |
| WESTERN ZONE | Tabora | Sikonge | Tobacco, Cotton, Groundnut, | Rice, Sweat potato, | Altitude: 900-1 400<br>Rainfall: 200-1 000<br>Temperature: 15-30 |

| | | | | | |
|---|---|---|---|---|---|
| | | | Sunflower | | Soil: pH 4->8.5, Mixture of red , Gravel, Clay, Silt and Sand with mixture soil fertility (Low, average and high soil fertility) |
| WESTERN ZONE | Tabora | Kaliua | Tobacco, Cotton, Sunflower, Groundnut, Paw paw | Rice, Sweat potatoes, Wheat | Altitude: 1 100-1 300<br>Rainfall: 600-1 000<br>Soil: pH 5->8.5, Red clay/black, Gravel, Clay, Silt and Sand with different fertilizer levels (Low, average and high). |
| WESTERN ZONE | Tabora | Nzega | Cotton, Sunflower, Sorghum | Rice, Maize, Sorghum, Sweat potatoes | Altitude: 1 000-1 300<br>Rainfall: 700-1 200<br>Temperature: 15-30<br>Soil: Ph 5->8.5, Mixture of Black, Gravel, Clay, Silt soil, Sand soil with different soil fertility (Low, medium, high). |
| WESTERN ZONE | Tabora | Igunga | Cotton, Sunflower | Rice, Maize, | Altitude: 900-1 300<br>Rainfall: 700- 1 200<br>Soil: pH 5-9. Mixture of Black, Gravel, Clay, Silt, and Sand with different fertilizer levels. |
| SOUTHERN HIGHLAND ZONE | Mbeya | Mbarali | Rice, Sunflower, Simsim, garden crops | Rice, Cow pea, Pigeon pea, Sweat potatoes | Altitude: 800-1 500<br>Rainfall: 200-1 400<br>Temperature: 15-30<br>Soil: pH 5-7, Sand, Black clay and Silt soil |
| SOUTHERN HIGHLAND ZONE | Mbeya | Chunya | Tobacco, Sunflower, Sim sim ( sesame), horticultural crops | Rice, Maize, Sorghum, Wheat | Altitude: 800-1 800<br>Rainfall: 200-1 400<br>Temperature: 15-30<br>Soil: Ph 5-7, Mixture of sand, and clay soil, Gravel. |
| SOUTHERN HIGHLAND ZONE | Songwe | Ileje | Cocoa, Coffee, Groundnut, Sunflower, Soya, Garden crops, Paddy | Maize, Beans, Beans, Sweat potatoes | Altitude: 500-2 400<br>Rainfall: 1 000-2 400<br>Temperature: 5-25<br>Soil: pH 5-7, Clay, silt, plain |
| SOUTHERN HIGHLAND ZONE | Songwe | Mbozi | Coffee, Avocado, Sunflower, Maize, Beans, Soya bean, Simsim (Sesame) | Maize, Beans, Groundnut, Sorghum, Wheat | Altitude: 800-2 400<br>Rainfall: 1 000-2 400<br>Temperature: 5-25<br>Soil: Ph 4-8, Red Clay, Silt with enough soil fertility |
| SOUTHERN HIGHLAND ZONE | Songwe | Momba | Coffee, Maize, Simsim (Sesame), Sunflower, Cow pea | Maize, Rice, Beans, Garden crops, Sorghum, Wheat, Sweat potatoes | Altitude: 800-2 300<br>Rainfall: 1 000-2 400<br>Temperature: 10-25<br>Soil: Ph 5-7, Silt soil with enough fertilizer, Red clay soil |

| | | | | | |
|---|---|---|---|---|---|
| SOUTHERN HIGHLAND ZONE | Rukwa | Nkasi | Maize, Sunflower, Ngano, Wheat, Rice, Soya bean, Sweat potatoes | Maize, Rice, Beans, Sorghum, Wheat, Pigeon pea. | Altitude: 800-2 300<br>Rainfall: 1 000-1 400<br>Temperature: 10-30<br>Soil: pH 5-7 Silt soil, Mixture of Clay and Sand soil with enough soil fertility |
| SOUTHERN HIGHLAND ZONE | Rukwa | Sumbawang a | Maize, Sunflower, Rice, Wheat, Soya bean, round potatoes | Maize, Beans, Wheat, Sorghum, Pigeon pea | Altitude: 800-2 300<br>Rainfall: 1 000-1 400<br>Temperature: 10-30<br>Soil: pH 5-7, Silt soil, Clay soil, Sand soil. Enough Soil fertility |
| SOUTHERN HIGHLAND ZONE | Rukwa | Kalambo | Maize, Sunflower, Ngano, Round potatoes, Soya beans, Common beans | Maize, common beans, Wheat, Sorghum | Altitude: 800-2 300<br>Rainfall: 1 000-1 400<br>Temperature: 10-28<br>Soil: pH 5-7, Silt soil and Clay soil with enough fertility |
| SOUTHERN ZONE | Mtwara | Tandahimba | Cashew nut, Simsim (Sesame), Sunflower, Soya beans | Cassava, Sorghum, Pigeon pea, Maize, Rice | Altitude: 200-500<br>Rainfall: 800-1 000<br>Temperature: 12-35<br>Soil: pH 5-7, Silt soil, Sand soil and Clay soil |
| SOUTHERN ZONE | Mtwara | Nanyumbu | Cashew nut, Groundnut, Bambara nut, Simsim (Sesame), Coconut | Cassava, Pigeon pea, Maize, Rice | Altitude: 200-500<br>Rainfall: 800-1 000<br>Temperature: 12-35<br>Soil: pH 5-7, Silt soil, Sand soil and Clay soil |
| SOUTHERN ZONE | Mtwara | Mtwara | Cashew nut, Simsim (Sesame), Garden crops | Cassava, Rice, Maize, Cow pea | Altitude: 0-300<br>Rainfall: 800-1 000<br>Temperature: 12-35<br>Soil: pH 5-7, Silt soil, Sand soil and Clay soil |
| SOUTHERN ZONE | Mtwara | Masasi | Cashew nut, Simsim (Sesame), Garden crops | Cassava, Pigeon pea, Rice | Altitude: 200-500<br>Rainfall: 800-1 000<br>Temperature: 12-35<br>Soil: pH 5-7, Silt soil, Sand soil and Clay soil |

Source: MALF (2017)

## Appendix 5: Groundnut Production Procedures

| Altitude (meters from sea level) | Plant spacing $(m \times m)$ | Inputs needed | | Plant population per hectare | Number of months to maturity |
|---|---|---|---|---|---|
| | | Seeds | Fertilizer | | |
| 100-2 000 | $0.5 \times 0.15$<br>$0.9 \times 0.15$ | 68<br>90 | 75-125 TSP | 133 000 to<br>200 000 | 4-6 |

Source: MALF (2017)

**Appendix 6: Groundnut Production Calendar**

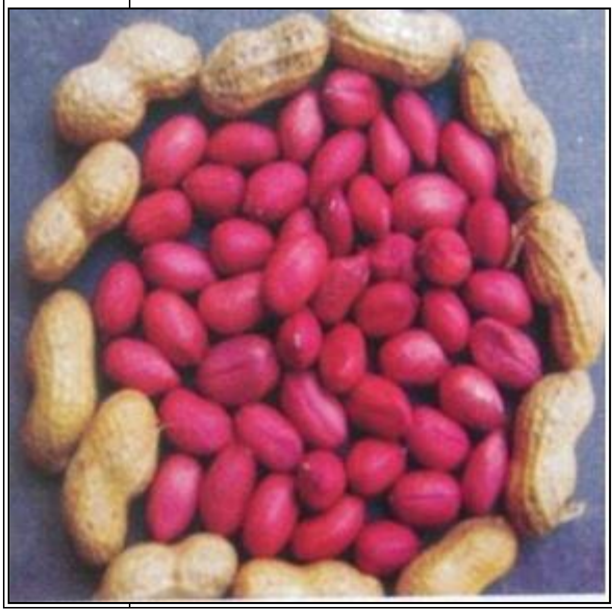
| ACTIVITY | JAN | FEB | MACH | APR | MAY | JUN | JUL | AG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Planting | | | | | | | | | | | | |
| Weeding | | | | | | | | | | | | |
| Harvesting | | | | | | | | | | | | |
| Storing | | | | | | | | | | | | |
| Marketing | | | | | | | | | | | | |

Source: MALF (2017)

**Appendix 7: Groundnut varieties**

| | VARIETY NAME | CHARACTERISTICS |
|---|---|---|
| 1. | NYOTA 1983 | |
| | | • Proposed elevation 0-1500m asl<br>• Mode of pollination: Self pollinated<br>• Number of days to 75% flowering: 26-30<br>• Number of days to maturity: 90-100<br>• Leaf colour/size: light green/medium<br>• Branching: Upright bunches<br>• Pod size: medium<br>• Number Kernels/Pods: 2-3<br>• Seed colour: tan<br>• Reaction to diseases: Tolerant to leaf spots and rosette<br>• Optimum Yield: over 1-1.5t/ha<br>• Seed dormancy: Not present<br>• 100 seed weight (gms):35-40 |
| 2. | JOHARI 1985 | |

| | | |
|---|---|---|
| | | • Proposed elevation 0-1500m asl<br>• Mode of pollination : Self pollinated<br>• Number of days to 75% flowering: 35-40<br>• Number of days to maturity: 110-115<br>• Leaf colour/size: Dark green/small<br>• Branching: Alternate, semi spreading<br>• Pod size: medium<br>• Number Kernels/Pods: 2<br>• Seed colour: Tan<br>• Reaction to diseases: Tolerant to leaf spots<br>• Optimum Yield: over 1-1.2t/ha<br>• Seed dormancy: Present<br>• 100 seed weight (gms):35-40 |
| 3. | SAWIA 1998 | |
| | | • Proposed elevation 0-1500m asl<br>• Mode of pollination : Self pollinated<br>• Number of days to 75% flowering: 30-40<br>• Number of days to maturity: 110-115<br>• Leaf colour/size: Dark green/small<br>• Branching: Alternate, semi spreading<br>• Pod size: medium<br>• Number Kernels/Pods: 2-3<br>• Seed colour: tan<br>• Reaction to diseases: Tolerant to leaf spots<br>• Optimum Yield: over 1-1.2t/ha<br>• Seed dormancy: Present<br>• 100 seed weight (gms):35-40 |
| 4. | PENDO 1998 | CHARACTERISTICS |
|  | | • Proposed elevation 0-1500m asl<br>• Mode of pollination : Self pollinated<br>• Number of days to 75% flowering: 25-30<br>• Number of days to maturity: 90-100<br>• Leaf colour/size: light green/medium<br>• Branching: Upright bunches<br>• Pod size: medium<br>• Number Kernels/Pods: 2-3<br>• Seed colour: tan<br>• Reaction to diseases: Tolerant to leaf spots<br>• Optimum Yield: over 1-1.5t/ha |

| | | |
|---|---|---|
| | | • Seed dormancy: Not present<br>• 100 seed weight (gms):35-40 |
| 5. | MANGAKA 2009 | |
|  | | • Proposed elevation 0-1500m asl<br>• Mode of pollination : Self pollinated<br>• Number of days to 75% flowering: 26-30<br>• Number of days to maturity: 90-100<br>• Leaf colour/size: light green/medium<br>• Branching: Upright bunches<br>• Pod size: medium<br>• Number Kernels/Pods: 2-3<br>• Seed colour: tan<br>• Reaction to diseases: Tolerant to leaf spots and rosette<br>• Optimum Yield: over 1-1.5t/ha<br>• Seed dormancy: Not present<br>• 100 seed weight (gms):35-40 |
| 6. | MNANJE 2009 | |
|  | | • Proposed elevation 0-1500m asl<br>• Mode of pollination : Self pollinated<br>• Number of days to 75% flowering: 35-40<br>• Number of days to maturity: 110-115<br>• Leaf colour/size: Dark green/small<br>• Branching: alternate, semi spreading<br>• Pod size: Medium<br>• Number Kernels/Pods: 2-3<br>• Seed colour: Red<br>• Reaction to diseases: Tolerant to leaf spots and rosette<br>• Optimum Yield: over 1-1.5t/ha<br>• Seed dormancy: Present<br>• 100 seed weight (gms):40-50 |

Source: NARI (2017)