PROFIT EFFICIENCY OF SMALLHOLDER WINE GRAPE FARMERS IN DODOMA CITY AND CHAMWINO DISTRICT IN DODOMA REGION, TANZANIA

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ABSTRACT

Grape is one of the most important economic fruits crop grown in Dodoma Region - Tanzania. However, grape production faces challenge of low yield of 5.6 t/ha compared to the established yield potential of 25 t/ha under irrigation and 17.3 t/ha under rain-fed in Tanzania. This low productivity was mainly due to rising cost of production, which is coupled with low output prices and an unreliable market. The most cost effective way to improve farm productivity is through efficient use of available scarce resources and technology. This study was conducted to analyse farm level profitability, profit efficiency and identify specific factors that account for variation in efficiency among farmers. The study also analysed farmer`s factor demand response due to changes in input prices. Multi-stage, stratification and random sampling techniques were used to select 176 farmers from irrigation and 183 farmers from rain-fed production systems. A structured questionnaire was used to collect data. Descriptive statistic, farm budgeting technique and a stochastic profit frontier were used to analyse the data. The results revealed that irrigated farms were more profitable compared to rain-fed farms. The findings show further that wine grape farmers are not fully profit efficient, implying that an opportunity exists to increase profit efficiency through better use of available resources. On average irrigated farms are more efficient (69%) compared to their rain-fed counterparts (63%). A farmer`s experience, group membership, access to extension and credit service are key factors that significantly influence profit efficiency among farmers. In the short-run the coefficients for own price of labour, manure and agrochemical are inelastic. Policy measures directed at providing credit and extension service to enhance the farm`s profit efficiencies are recommended. In addition, any support to facilitate formation of farmers` association is very important because membership in such groups can benefit farmers through economies of scale, thereby reducing each member’s production cost. Reducing the cost of labour and agrochemical can significantly increase the farmers’ profit level. Moreover, agricultural policies directed at developing irrigation schemes to enhance grape productivity in order to improve farm income and profit is recommended.

DECLARATION

I, ***Natalia Naftali Kalimang`asi***, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my own original work done within the period of registration and that it has neither been submitted nor-concurrently being submitted in any other institution.

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Amen!

DEDICATION

This thesis is dedicated to my beloved husband Dr. Gaspar Mwanachipeta Peter Mwembezi and our children Kenedy, Norbert and Ingrid. Let, God the most high continue to bless them forever. Amen!

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LIST OF ABBREVIATIONS AND SYMBOLS

AMCOs	Agricultural Marketing and Cooperative societies
CD	Cobb-Douglas
CDC	Chamwino District
DC	District Council
DCC	Dodoma City
DEA	Data Envelope Analysis
DPRTC	Directorate of Postgraduate Studies, Research, Technology Transfer and Consultancy
e.g.	For example
EACs	The East African Countries
FAO	Food and Agriculture organisation
FAO-OIV	Food and Agriculture organisation and International Organisation of Vine and Wine
FAOSTAT	Food and Agriculture organisation Statistics
g	gram
GoT	Government of Tanzania
ha	Hectares
i.e.	That is
Kg	Kilogram
LGAs	Local Government Authorities
LWR	Lutheran World Relief
Max	Maximum
Min	Minimum
MLE	Maximum likelihood estimation

°C	Degree Celsius
OIV	International Organisation of Vine and Wine
RCM	Roman Catholic Mission
SFA	Stochastic Frontier Approach
SURE	Seemingly Unrelated Regression Estimation
t	tonne
TZS	Tanzania Shillings
UNCCD	United Nations Convention to Combat Desertification
UNESCO	United Nations Educational, Scientific and Cultural Organization
URSA	United Republic of South Africa
URT	United Republic of Tanzania
VinPro	Vines production

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Grape is a fruit of vine from common known species *Vitis Vinifera* (FAO, 2009; Khair *et al.,* 2009). It is one of the world's largest economic fruits, with approximately 75.8 million tonnes produced each year (FAO-OIV, 2016; OIV, 2017a). At the global level grape is the second most produced fruit after banana in terms of net edible quantity (FAO-OIV, 2016). Being a fruit, grapes can be consumed either as fresh or as processed products such as wine, juice, dried grapes, jam and vinegar. Around 50% of grapes are used for making wine, 36% are consumed as fresh fruits, 6% are used for making juice and 8% are dried to make raisins (FAO-OIV, 2016). Hence, grape cultivation plays an important role globally in terms of food consumption and in the global economy in general.

Grape cultivation is one of the most profitable farming businesses in the world and it is a major source of income for millions of people in the world (Punjabi and Mukherjee, 2015). Grapes and grape products are sold to provide cash income for individual farmers. It is also a significant source of foreign exchange for many countries. The global grapes trade stands at USD 1.5 billion, while the trade for grape products such as wine stand at USD 32.6 billion in 2016 (Punjabi and Mukherjee, 2015; OIV, 2017b). As such grapes play a significant role in the national income of producing countries. Although the exact contribution of grape to the national income in Tanzania is not known, but it is well-documented that grape cultivation contributes about 36% of household income among grape producing farmers particularly in Dodoma city (Lwelamira *et al.,* 2015a).

Likewise, grape cultivation provides direct employment to about 1700 households and the crop also benefits indirectly the livelihood of about 7800 beneficiaries at the farm level

(UNCCD, 2013; Robbins, 2016). This figure does not include the number of service providers who are involved in the value chain such as trading, transporting, processing and packaging. Not only that, grape cultivation is probably most important now when the main agenda of the government in Tanzania is to guide the national economy from a low to a middle income economy through industrialization. Grape cultivation provides raw material for many processing industries such as wine, juice, jam and vinegar, hence it is particularly poised to contribute to the contemporary national agenda.

In addition to numerous economic benefits, grape also has numerous nutritional and health benefits to the human body. If grapes are eaten as fresh fruits, they provide the richest source of carbohydrates (15 to 18g per 100g serving) and one with a relatively high calorific content. The glycaemic index of grapes is very low (51g per 100g serving), falling at the low end of the range, it is therefore considered appropriate for inclusion in diets for diabetic individuals (FAO-OIV, 2016). According to the literature low glycaemic index varies from one to 55 g, medium varies between 56 and 69 g, while high glycaemic index starts at 70 g and above[1]. Grapes also provide an important source of vitamins and minerals such as Vitamins B6, thiamine (Vitamin B1), vitamin C (citrus Acid), vitamin E, potassium and manganese. These minerals and vitamins are very important for strengthening body immunity and prevent human body from infectious diseases. Moreover, grapes contain an antioxidant compound (*polyphenols*), which help the body function, it reduces risk of heart diseases and prevents the development of obesity and type 2 diabetes as well as processing *cardio-protective, neuro-protective*, antimicrobial and anti-aging properties (FAO-OIV, 2016; OIV, 2017b).

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[1] The glycaemic index range were taken from various sources including the International Table of Glycaemic Index and Glycaemic index food guide available at www.glycemicindex.com and www.google.com respective on 22nd April, 2020

Although grape cultivation is the most remunerative farming business worldwide and it has numerous economic, nutritional and health benefits, grape farming in Tanzania is not fully exploited, mainly due to heavy initial investment cost for preparing a vineyard and supporting farm infrastructure which is associated with high annual maintenance cost (UNCCD, 2013). Grape like any other agricultural crop in Tanzania is dominated by smallholder farmers, with average farm size of 0.9 ha which are under irrigation or rain-fed production technology (Azalia, 1992; Hussein, 2010). Accordingly, it is estimated that there were about 1 924 ha under grape cultivation in the Dodoma region, producing only 10 000 tonnes of grapes per year, with relatively low farm level productivity (UNCCD, 2013; Robbins, 2016). In addition, the grape subsector faces challenge of high input cost and unreliable market or limited access to market, while output prices remained relatively low (Lwelamira *et al.,* 2015a; Kulwijila *et al.,* 2018). In recent years (2010 - 2016) the cost of grape production per unit of output rose while grape farm gate prices remained relatively low (Hussein, 2010; LWR, 2016).

Such an increase in production cost and low farm gate prices affect farmer’s net income leading to low profit and profitability, hence leading to increased poverty among smallholder farmers. Profit is the difference between money that comes in to farm business from the sales of a product and the money that goes out to produce it, whereas profitability is a measure of performance that shows how well the resources available to the farmer are used to generate income and profit (Kanan, 2010). Thus, reducing production costs and securing better prices should be pursued in order to improve farmer’s profit and hence reduce income poverty. But this may not be feasible when farmers are price takers operating in a competitive market environment. The best solution for raising profit and profitability lies on increasing farm productivity through efficient use of available resources and developing higher yielding grape varieties.

It is widely recognized that efficient use of resources is the most cost-effective measure to enhance farm productivity in developing countries like Tanzania because resources are scarce and opportunities for developing and adopting new technology are limited (Dziwornu and Sarpong, 2014; Samarpitha *et al.,* 2016). Efficient use of available resource is the ability of a farmer to produce maximum output at the lowest possible cost (Abu and Kirsten, 2009; Chikobola, 2016). This means, grape farmers are not only required to be efficient in their farm operations, but they should also be responsive to factor and output prices, so that the existing scarce resources are allocated efficiently to improve productivity but also increase farm profitability.

A factor price response measures the extent to which farmers vary their input purchases as the factor price changes (Ullah *et al.,* 2012; Junaid *et al.,* 2014). As such, rising inputs price reduces farmer`s purchasing power, consequently less input can be used, which leads to low productivity and low total farm production. To address the problem of low productivity and exploit market opportunities, the government of Tanzania (GoT) and development partners have made several interventions such as (i) developing higher yielding varieties, which include Makutupora red and white, (ii) establishing irrigation schemes at Chinangali II, Gawaye and Lamaiti, (iii) establishing processing firms such as CETAWICO, ALKO VINTAGE as well as (iv) providing of technical assistance to farmers in order to improve grape productivity and hence increase farmer’s income and profit (UNCCD, 2013; URT, 2017). Unfortunately, these efforts have not improved grape productivity which is an important factor to ensure farmers` high profit (UNCCD, 2013).

1.2 Problem Statement and Justification for the Study

Despite all the efforts made by the GoT and development partners to improve grape productivity, there have been persistent low yield of 5.6 t/ha compared to the established yield potential in Tanzania, ranging from 17.3 t/ha under rain-fed to 25 t/ha under irrigation production system (UNCCD, 2013; Robbins, 2016). Besides, this yield level is low compared to the world average yield of 20 t/ha under good climatic condition and standard viticulture practices (FAO, 2009). Likewise, the yield is even lower than the average yield recorded in other countries such as South Africa (17.5 t/ha), 22.1 t/ha in Egypt, 8.3 t/ha in Morocco, 8.1 t/ha in Zimbabwe and 7.8 t/ha in Algeria (VinPro, 2014; URSA, 2016; FAOSTAT, 2017), although farmers operate in different climatic condition.

Such low productivity in Tanzania was mainly due to the rising cost of production. For example, between 2010 and 2016, the cost of production rose from 290 000 to 730 000 TZS/tonne of grapes, while farm gate prices remained relatively low, ranging from 500 to 1200 TZS/kg of grapes (Hussein, 2010; Lwelamira *et al.*, 2015a; LWR, 2016). This affected farmer's income, which led to low profit. In a competitive market environment, high farm profit reflects high productivity and efficient use of resource (Mlote *et al.*, 2013). Thus, enhancing efficient use of resource is the most cost-effective way to increase farm productivity, leading to increased profit and profit efficiency, which is an economic indicator for measuring farm performance. Profit is a wage to the farmer as return to management for taking the risk to make the investment while profit efficiency refers to the ability of a firm to achieve the highest possible profit, given the factor and output prices and levels of fixed factors of production for that firm (Ali and Flinn, 1989; Kanan, 2010; Trong and Napasintuwong, 2015).

Many studies have been conducted to assess the efficiency of grape farms worldwide (Carvalho *et al.*, 2008; Henrique *et al.*, 2009; Moreira *et al.*, 2011; Guesmi *et al.*, 2012; Ma *et al.*, 2012, Manevska, 2012). Most of these studies focused on technical, allocative and economic efficiency. These efficiency components have been measured using production frontier. However, Yotopoulos and Lau (1973) argue that the use of production function to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments. Similarly, Ali and Flinn (1989) argued that the production function framework fails to capture inefficiencies due to differences in factor endowments as well as input and output prices across different farms. This led to application of a stochastic profit frontier to estimate farm specific efficiency directly (Rahman, 2003; Dziwornu and Sarpong, 2014; Adam and Bakari, 2015; Sadiq and Singh, 2015).

Only a few studies on grape farming in Tanzania have been conducted with a multidimensional focus (Hussein, 2010; Lwelamira *et al.*, 2015a, b; Kulwijila *et al.*, 2018; Njovu, 2018). For example, Hussein (2010) and Kulwijila *et al.* (2018) focused on grape value chain analysis. The two studies by Lwelamira and others focused on technical efficiency of grape farmers as well as grapevine farming and its contribution to household income in Dodoma Municipality in Tanzania, while Njovu (2018) focused on crop water requirements as well as response in terms of grape yield and quality to different irrigation regimes.

None of these studies focused on the profit efficiency of wine grape farms comparing between irrigated and rain-fed farming system in Dodoma Region, but these studies also failed to capture factors explaining farm profit efficiency. Globally, results of efficiency studies on grape production vary across geographical location and time. Hence, the application of these findings is quite limited to specific farmer locations due to their geographical diversity, different socio-economic factors as well as institutional arrangement and resource endowments. Hence, the assessment of profit efficiency and factors influencing efficiency provides valuable information for improving farm management practices and the economic performance of smallholder farmers, which may lead to higher productivity and hence increase farmers' income and profit levels. Not only that, the assessment of factor demand response due to changes in factor prices is also important for providing valuable information for formulating appropriate agricultural policy for reducing production cost and improving grape productivity.

The factor demand elasticity is also an economic indicator for measuring the degree of responsiveness of input use due to changes in own factor price and the price of other input as well as the output price (Ullah *et al.,* 2012; Junaid *et al.,* 2014). However, there is limited information about factor demand response especially on perennial crops such as grape. None of the studies within and across Africa focused on factor demand response on grape farming due to changes in factor prices. Only a few studies have been conducted on grape farming focused on production and scale elasticities (Guesmi *et al.,* 2012; Ma *et al.,* 2012). This study therefore, attempted to fill the existing knowledge gap by analysing profitability and profit efficiency of wine grape farms comparing between irrigated and rain-fed farming system in the study area as well as identifying factors accounting for differences in profit inefficiency among farmers in Dodoma city (DCC) and Chamwino district (CDC). This study further attempted to fill the existing knowledge gap by analysing factor demand response due to change in factor prices in order to provide valuable information which may help to make good strategies that can reduce production cost and hence increase farm productivity.

1.3 Overall Objective of the Study

The overall objective of this study is to establish farmers` level of profit efficiency and identify specific factors that account for variation among wine grape farming in order to improve farm productivity in the study area.

1.3.1 Specific objectives

In order to achieve the overall objective, four specific objectives were pursued as listed below;-

i. To compare wine grape profitability between irrigated and rain-fed farmers
ii. To analyse the profit efficiency of smallholder wine grape farmers under irrigation and rain-fed farming
iii. To determine factors influencing profit inefficiency among wine grape farmers; and
iv. To analyse factor demand response due to changes in own factor price and the price of other inputs

1.3.2 Research Hypotheses

Each of the above specific objectives was subject to testable null hypotheses as presented below:

i. The first null hypothesis corresponding to the first specific objective, states that there is no significant difference in profit levels attained by farmers comparing between irrigated and rain-fed

   $H_{01}: \beta_1 = \beta_2$

   The alternative hypothesis states that there is a significant difference in profit levels attained by farmers comparing between irrigated and rain-fed

   $H_{a1}: \beta_1 \neq \beta_2$

ii. The second null hypothesis corresponding to the second specific objective, specifies that smallholder wine grape farmers operate on the profit frontier such that the inefficiency effect is equal to zero

   $H_{02}: \mu_i = 0$

   Where μ_i - stand for inefficiency effects

   $i = 1,2,3,....n$ Profit efficiency of i^{th} farmers

   The alternative hypothesis states that at least one of smallholder wine grape farmer operates below the profit frontier such that inefficiency effect is significantly different from zero

$H_{a2}: \mu_i \neq 0$

iii. The third null hypothesis states that socio-economic and institutional variables (such as extension services, access to credit, sex, education levels and farmer`s experience) do not account for variation of inefficiency levels among smallholder farmers

$H_{03}: \gamma = \delta_1 = \delta_2 = ... = \delta_7 = 0$

Where δ_i - stand for socio-economic and institutional factors

The alternative hypothesis states that some socio-economic and institutional variables do account for variation of inefficiency level among smallholder farmers

$H_{a3}: \gamma \neq \delta_1 \neq \delta_2 \neq ... \neq \delta_7 \neq 0$

iv. The fourth null hypothesis state that changes in the price of labour, manure and agrochemical do not influence the demand for corresponding own inputs and other related inputs

$H_{04}: \partial X_i^* / \partial p_i = \partial X_i^* / \partial P_j = 0$

Where:

$\partial X_i^* / \partial p_i$ = change in factor demand due to change in own factor price

$\partial X_i^* / \partial P_j$ = change in factor demand due to change in price of other factors

$i \neq j =$Represents number of inputs

The alternative hypothesis states that changes in the price of labour, manure and agrochemical influence the demand for corresponding own inputs and other related inputs

$H_{a4}: \partial X_i^* / \partial p_i \neq \partial X_i^* / \partial P_j \neq 0$

1.4 Significance of the Study

The empirical evidence from this study provides essential information to agricultural extension agents and private sector who wish to promote sustainable wine grape subsector and improve economic performance of smallholder farmers for the purpose of improving productivity and increases farmers` income. Identified key factors accounting for profit efficiency variation would assist smallholder farmers to maximise profit in wine grape production. This does not only benefit smallholder farmers to increase net farm income in grape production, but also reduce the wide spread income poverty among households in the study area and for the rest country wide. The study also provides valuable information to planners and policy makers for formulating appropriate agricultural policy that help to improve grape productivity, increase farm income and profit levels, consequently enhance the achievement of the national goals of reducing poverty and improving rural income. The study also bridge the existing knowledge gap on profitability, profit efficiency and factors influencing profit efficiency among farmers as well as factor demand response due to changes in factor prices.

1.5 Organisation of the Thesis

This thesis is organized in five chapters including this introductory chapter, which highlighted key issues regarding the grape subsector such as economic, nutritional and health benefits, problem statement and justification of the study, research objectives, hypotheses and significance of the study. Chapter two covers the literature review beginning with an overview of the grape subsector, theoretical framework and empirical studies covering profit efficiency, factor demand response, the concept of efficiency, measurement of efficiency and determinants of profit inefficiency.

Chapter three presents a detailed description of the study area, research design, sampling procedure, data collection methods and data analysis. This chapter also presents procedures and various models for analysing profitability, factor demand response analysis, profit efficiency and inefficiency as well as limitation of the study. Chapter four presents results and discussions of the study findings. Specifically, this chapter presents results and discussions on socio-economic and institutional factors, farm level profitability, profit efficiency, factor demand response as well as specific factors that account for variation of profit inefficiency. Chapter five presents conclusions, recommendations and areas for further research.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 An Overview of Global Grape Production

Worldwide, grape is grown in more than 100 different countries, in almost all the tropical and subtropical regions of the world (UNCCD, 2013; KOK, 2014). Grape cultivation covers 75.1millions ha of land (FAO-OIV, 2016; OIV, 2017a). According to OIV (2017a), China is the largest global grape producer representing 14.5% of global production in 2016, followed by Italy, USA, France and Spain making the top five grape producing countries in the world. In China, about 83% of grapes are used as table grapes while it is estimated that more than 85% of grapes produced in Italy, France and Spain are used for marking wine.

South Africa is the largest producer among African countries, producing around 95% of grapes in the continent and 1.9% of the global grape production (OIV, 2017a; UNCCD, 2013). Egypt ranks second, producing about 1.6% of the global grape production. South Africa is known to dominate wine grapes while Egypt dominates table grapes production (FAO-OIV, 2016; OIV, 2017a). Among East African Countries (EACs), Tanzania is the most significant player in the grape sub sector, producing about 0.03% of global grape production and 0.42% of Africa grape production (FAO, 2012; UNCCD, 2013). There is a wide range of factors that influence grape production in Africa, which include the historical production pattern and the presence of Roman Catholic Missionaries (Robbins, 2016). The next section presents a historical overview of grape production in Tanzania.

2.1.1 Grape production in Tanzania

In Tanzania, commercial grape production is only found in Dodoma region. The history of planting vines and grape production is traced back to the 19th century when early missionaries settled at different Roman Catholic Missions (RCM) in Dodoma region. Robbins (2016) claimed that, the first grapevines were introduced at Hombolo RCM in 1938. These grapevines were established in order to meet demands of the church. This means, there have been some wine grape farming and wine making in Dodoma region for over a century. Having been impressed with grape production at the mission, the government requested the church to introduce the same to smallholder farmers (Azalia, 1992; Hussein, 2010). Through support from the government and development partners` efforts during the 1960s, many people in the villages surrounding Hombolo and Bihawana RCM acquired knowledge and skills on developing and maintaining vineyards. These in turn transferred the knowledge and skills to more farmers around Dodoma city and Dodoma rural district (currently known as Chamwino and Bahi district) (Hussein, 2010;

UNCCD, 2013; Robbins, 2016). This marked the beginning of commercial grape production in Dodoma Region.

As described in the previous paragraph (section 2.1.1), the first grapevines were introduced to meet the demand for church purpose (for making Altar wine). Recently, it is estimated that about 90% of grape grown are wine grapes produced by smallholder farmers (Njovu, 2018). According to FAO, smallholder farmer refers to a farmer who is working on a land plot less than 2 ha (Rapsomanikis, 2015). The present study defined smallholder farmer as a farmer who cultivates grapes on a piece of land less than 3.0 ha. The farmers who own farms above 3.0 ha are considered medium or large scales. Since a large proportion (*i.e.,* 90%) of grape producers are smallholder farmers, this study focused on smallholder farmers who produce grapes under irrigation and others using rain-fed production technology.

More than 90% of grapes produced in Dodoma Region belonged to the local cultivars Makutupora red and white (UNCCD, 2013; Robbins, 2016; Njovu, 2018). These varieties are primarily meant for wine making, but not to be consumed as fresh grapes or table grapes. However, some of street vendors and traders in urban centres sell these varieties as table grapes (fresh fruits) because there are very few actual table grapes. The sellers therefore take advantage of consumer’s ignorance for not making the distinction between table grapes and wine grapes (UNCCD, 2013). It is worth noting that, table grapes usually have larger berries and firm pulp, making them more resistant to wilting and crushing. In addition, table grapes have loose bunches and a thicker skin which make them easy to eat (FAO-OIV, 2016). Meanwhile, wine grapes have small berries that are compacted together and easy to crush. Since the majority of smallholder farmers cultivate wine grape varieties, this study focused only on smallholder wine grape farmers. As such, in this study the term grape refers to wine grape, while a grape farmer or a farmer refers to a smallholder wine grape farmer.

2.1.2 Conditions for grape production

Grapevine is well adapted to a wide range of climates, but it is best grown in regions which have a reasonably long growing season (150-180 days of rainfall) with relatively low humidity (less than 800mm per year) and optimum temperature ranging from 25^{o}C to 30^{o}C for good development and ripening of the fruits (FAO, 2009). Geographically, grapes grow well in the temperate regions located between latitudes 40^{0} and 50^{0} in the Northern hemisphere and between 30^{0} and 40^{0} in the Southern hemisphere, but there are also tropical regions which lie between 23^{0} North and South of the Equator (KOK, 2014; Mariappan *et al.*, 2017). Due to variation in the temperature, sunshine, rainfall and altitude, grapevines grown in tropical regions usually have two or three distinct growing seasons per year, while grapes grown in temperate regions usually have only one growing seasons.

In addition, grapes grown in hot regions have an early first harvest (18 months after planting) compared to 3 or 4 years after planting in temperate regions (Khair *et al.*, 2009; KOK, 2014). The hot tropical temperature accelerates growth and development of the grapevines (KOK, 2014; Njovu, 2018). Apart from good climatic condition, grape cultivation also requires continuous care and input application throughout the year in order to ensure a good harvest. Hence, good viticulture practices are of paramount importance for realizing high grape productivity. The research indicates that if the vineyard is subjected to similar farm management and field conditions, grape yields remain stable from 5 to 35 years old grapevines (Mrosso, 2007; UNCCD, 2013). However, Azalia (1992) established that the economic life span for a vineyard is 20 years, thereafter all plants should be uprooted and threshed out and a vineyard is replaced with new vines.

Ingels *et al.* (2013) claimed economic life span of grapevines is 20 years, which was used to spread initial establishment cost in order to compute annual capital recovery cost. Based on this, the present study established that the average economic life span for the grapevine is 20 years.

2.1.3 Grape yield

Grape yield is a ratio of the amount of grape fruits per unit area of land (Liverpool *et al.*, 2011). The literature shows that, grape yield varies depending on climatic condition and viticulture practices and soil type (FAO, 2009). According to FAO (2009) under good climatic condition and standard viticulture practices grape yield varies from 5 to 20 t/ha. Grape yields also vary with other factors such as the amount of water supplied to the farm and soil type. Clay loam soil and good drainage are the most desirable parameters for grape production (FAO, 2009). Njovu (2018) established that a vineyard with a full drip water irrigation regime (100% water supply) produces higher grape yield compared to the regime with deficit irrigation (65% water supply). But, the farm yield is only a partial measure of farm`s performance. Other performance measures include profitability and profit efficiency. Profitability amongst others, is an economic indicators for measuring farm`s performance. Profitability is a measure that attempt to answer the question, how well does the farm business uses available resources to generate income and profit (Kanan, 2010)

2.2 Profitability Analysis

Many studies have assessed farm performance using profitability analysis for grape and other perennial cash crops (Khair *et al.*, 2009; Pappalardo *et al.*, 2013; Wangnaa and Awunyo, 2013; Appasmandri *et al.*, 2017). The literature review revealed that investment in perennial crop such as grapes or in orchards of the same nature has two important periods; the (i) establishment period and (ii) economic period. The former starts from land preparation, layout, planting until the crop starts bearing fruit during the 2 or 3 years after planting, while the latter starts from the stage of bearing fruits onwards (Khair *et al.*, 2009; Mohammed *et al.*, 2013; Sain *et al.*, 2013; Wangnaa and Awunyo, 2013). Usually, during the establishment period, a farmer incurs only the cost of activities such as land preparation, layout, digging and filling pits or trenches, planting materials and planting, laying the irrigation system, crop protection and training, manures/fertilizer applications as well as setting supporting infrastructure. During, the economic period, a farmer generates income and at the same time incurs some expenses, related to annual maintenance activities such as weeding, pruning, insecticide and fungicide application, manure application as well as other farm management practices.

Under such type of investment, two different approaches have been used to assess farm profitability. The first approach is to use capital budgeting techniques such as computing the benefit cost ratio, net present value and internal rate of returns, the second is the use of farm budgeting techniques to compute the gross margin or net farm income to assess farm profitability. Khair *et al.* (2009) in Pakistani used capital budgeting techniques while studying the profitability of grape orchard (an Ex-Post analysis). They found that, grape farming is profitable venture with high rate of returns (38%). They also computed positive net present value and benefit cost ratio that was greater than one. A similar methodology was used by Wangnaa and Awunyo (2013) while studying profitability analysis of cashew production in Ghana. Conversely, other researchers used farm budgeting technique to assess farm performance (Mohammed *et al.*, 2013; Andrew and Philip, 2014; Oladejo, 2015; Aheisibwe *et al.*, 2017). These studies computed either the gross margin or the net farm income and then analysed return on investment. However, the use of gross margin has been criticized by several researchers because it does not cover fixed costs, therefore a net farm income is argued to be the best (Mohammed *et al.*, 2013; Andrew and Philip, 2014).

In the current study, a farm budgeting technique was used to compute the net farm income and assess wine grape profitability for farmers in sample representing others in the study area. Fixed cost was computed as annual amortization of the initial investment made for wine grape farming. The annual amortization or annual capital recovery cost is equivalent to the annual payment on loans for the initial investment made to establish vineyard with the down payment equal to the discounted salvage value (McGourty *et al.*, 2012; Ingels *et al.*, 2013). As described in previous paragraph in section 2.2, initial establishment cost was estimated from preparatory farm activities such as land preparation, layout, digging and filling pits or trenches, planting materials and planting. According to LWR (2016), initial establishment cost of an irrigated farm is about 16.3 million TZS/ha, and about 7.5 million TZS/ha for a farm under rain-fed condition. Annual amortization was computed using the annual capital recovery formula, which was added to the annual maintenance cost to obtain annual total cost of respective farmers. Sain *et al.* (2013) used this method to compute annual fixed cost of guava in India. Similarly, the methodology was used by Lawal (2012) while studying the economic analysis of guava in Nigeria. The annual capital recovery cost formula is specified under the methodology in chapter three of this study (section 3.6.2.2). Apart from profitability analysis, the present study also analysed profit efficiency of smallholder farmers under irrigation and rain-fed farming. The theoretical framework for profit efficiency analysis is presented in the next section 2.3.

2.3 Theoretical Framework of Profit efficiency

This study is based on the Neo-classical producer theory, which assumes that a farmer is a rational economic agent who seeks to maximize profit. Although each farmer may struggle to achieve such an objective some farmers may succeed and some farmer may not due to the technical and allocative inefficiency they attain. Production inefficiency is either analysed separately or combined into a single system using a profit function (Dziwornu and Sarpong, 2014; Kaka *et al.,* 2016). Unlike the using separate production or cost function, the profit function combines technical and allocative efficiency in a profit relationship and any error in production decision is assumed to be translated into lower profits or net revenue for the producer (Wang *et al.,* 1996). Profit efficiency therefore refers to the ability of a firm to achieve the highest possible profit, given the factor and output prices and levels of fixed factors of production for that firm (profit frontier), while profit inefficiency is defined as the profit-loss from not operating on the profit frontier, given farm specific prices and the resource endowment (Ali and Flinn, 1989). The highest possible profit that a farmer can achieve is referred to as the profit frontier (Dwi *et al.,* 2014).

Usually, this profit efficiency has been measured using stochastic profit frontier or deterministic. Deterministic profit frontier explains that all deviations from the frontier are attributed to inefficiency, whereas in stochastic profit frontier, it is possible to discriminate between random errors and differences in efficiency (Sadiq and Singh, 2015; Kuboja *et al.,* 2017). The present study used stochastic profit frontier to measure profit efficiency among farmers. Hence, the study adopted Rahman (2003) model to specify a stochastic grape profit frontier as well as Battese and Coelli (1996) model to specify an inefficiency model, which can be expressed as a linear function of some socio-economic and institutional variables. The advantage of the inefficiency model proposed by Battese and Coelli (1995) is that it allows estimation of a farms efficiency scores and factors explaining efficiency variation among farmers in a single-step estimation procedure. Assuming that a farmer maximizes profit given farm specific prices and fixed factors, the wine grape farm profit (π_i) is determined as the difference between total revenue and total cost, as presented in equation 1.

$$\pi_i = y_i p_y - \sum_{i=1}^{n} v_i x_i - TFC_i \text{..}$$

Where

$\pi_i =$ is profit of i^th farmer;

$y_i =$Total output of i^th farmer;

$P_y =$ Average price of output of i^th farmer;

$y_i p_{yi} =$Total revenue;

$v_i x_i =$Total variable cost (labour cost computed based annual farm management activities, insecticides, fungicide and manure);

$v_i =$Price of variable input x_i;

$x_i =$Variable input;- and

$TFC_i =$Total fixed cost of i^th farmers (including annual capital recovery cost plus depreciation of farm tools).

The normalized profit function is given as

$$\pi_i^* = \frac{\pi}{P_y} = y_i - \frac{\sum_{i=1}^{n} v_i x_i - TFC}{P_y} = f(X_i, Z) - \sum_{i=1}^{n} P_i X_i - Z_i \text{..}$$

Where

$\pi^* = \pi / p_y$ Represents the normalized profit of i^th farmer;

$P_y =$ Output prices used to normalize variables in the equation 1;

$X_i =$ Represents optimal quantity of input;

$Z =$Represent fixed factor;

$P_i = v_i / P_y =$ Normalized price of input X_i;

$f(X, Z) =$ Production function and other variables are as defined earlier.

According to Rahman (2003) a stochastic profit frontier is defined as given in equation 3;-

$$\pi^{\bullet} = f(P_i, Z_i)\exp \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where; ε_i is a composite error consisting of two independent elements (v_i) and (μ_i), and $i = 1,2 \ldots n$ number of farms in the sample.

$$\varepsilon_i = v_i - \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

The first component of the error term (v_i) captures random variations in profit attributed to factors outside the control of the farmer. This component of the error term is assumed to be an independent and identically distributed random error, having normal distribution $N(0, \sigma^2)$, independent of μ_i. The second term (μ_i) captures inefficiency effects, which is assumed to be truncated or have a half normal distribution $N(\mu, \sigma^2)$ (Gebregziabher, 2012; Chikobola, 2016). According to Battese and Coelli (1995), the inefficiency effect is expressed as shown in equation 5.

$$\mu_i = \delta_0 + \sum_{i=1}^{d} \delta_i w_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where w_i - number of dth explanatory variables associated with inefficiency of the ith farm, δ_0 and δ_i are unknown parameter to be estimated (Adam and Bakari, 2015; Chikobola, 2016). The individual farm profit efficiency (PE) is derived as a ratio of the observed or actual profit to the corresponding predicted maximum profit of the best performing farmer (profit frontier), given the price of variable inputs and fixed factor(s) of that farmer. This can be expressed mathematically as presented in equation 6.

$$PE = \frac{actual.profit}{Frontier.profit} = \frac{f(P_i, Z)\exp(v_i - \mu_i)}{f(P_i, Z)\exp v_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

A one-sided component $\mu_i \geq 0$ reflects profit efficiency relative to the frontier. Thus, when $\mu_i = 0,$ implies that farm profit lies on the profit frontier (*i.e.*, 100% profit efficiency) and the firm is obtaining potential maximum profit given the prices of variable input and the level of fixed factors. When $\mu_i > 0,$ farm profit lies below the profit frontier, therefore a farmer is inefficient and loses profit because of inefficient (Sadiq and Singh, 2015; Chikobola, 2016; Kuboja *et al.*, 2017). The farm specific efficiency is again the mean of the conditional distribution of μ_i given by PE and is defined as

$$PE = \exp(-\mu) = E[\exp(-\mu) \mid \varepsilon_i] = E\left[\exp(-\delta_0 - \sum_{i=1}^{d} \delta_i w_i) \mid \varepsilon_i\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

PE takes the value between 0 and 1, and it is inversely related to the level of inefficiency. E is the expectation operator (Chikobola, 2016; Kuboja *et al.*, 2017). According to Coelli (1996) the maximum likelihood method simultaneously estimates unknown parameters, the stochastic frontier and inefficiency effect functions. The likelihood function is expressed in terms of variance such that $\sigma^2 = \sigma_\mu^2 + \sigma_v^2$ and $\gamma = \sigma_\mu^2 / \sigma^2$ (Battese and Coelli, 1995). Where, σ_v^2 is the constant variance for the symmetric error term (v_i) and σ_μ^2 is variance for the half normal error term (μ_i). The total variance of the composite error (σ^2) measures the overall fit and correctness of the specified distribution of the composite error term while the indicator Gamma (γ) test whether inefficiency exists and is bounded between 0 and 1. When $\gamma = 0,$ implies that deviations from the frontier are entirely due to random error; as such there is no evidence for the presence of inefficiency. If the value of $\gamma = 1$, then all deviations from the frontier are due to inefficiency (Galawat and Yabe, 2012; Adam and Bakari, 2015; Chikobola, 2016). Apart from discussion regarding the theoretical framework, the present study also discussed key concept of efficiency, which are presented in the next subsection.

2.3.1 The concept of efficiency

The history of efficiency analysis dates back to 1950s, when rigorous analytical approaches originated (Zainal and Ismail, 2010; Sadiq and Singh, 2015). The work of Koopmans (1951) and Debreu (1951) forms the basis of measuring efficiency. Koopmans provided a definition of technical efficiency while Debreu introduced the first measure of coefficient or resource utilization. Later on, Farrell (1957) drawing upon the work of Debreu (1951) and Koopmans (1951), provided a definition of production frontier, which represents the maximum possible output that can be produced if resources were optimally utilized (Sadiq and Singh, 2015). Farrell defined efficiency as the ability of a firm to produce the maximum possible output at the lowest possible cost (Abu and Kirsten, 2009; Sadiq and Singh, 2015; Chikobola, 2016).

The concept of efficiency has three distinguished components; technical, allocative and economic efficiency (Coelli *et al.,* 2005; Zainal and Ismail, 2010; Ogunniyi, 2011 and Quattara, 2012). Technical efficiency (TE) reflects the ability of a firm to obtain the maximum output from a given set of inputs. Alternatively, technical efficiency reflects the degree to which a firm could minimise the inputs used to produce a given level of output (Coelli *et al.,* 2005; Mokhtar *et al.,* 2006). The highest possible output that a farmer can obtain is referred to as the production frontier. Thus, a firm is said to be technically efficiency if its output lies on the production frontier, which implies that there is no wastage of inputs in the production process (Ali and Byerlee, 1991). Conversely, a firm is technically inefficiency if its output level lies below the production frontier.

According to Coelli *et al.* (2005) allocative efficiency reflects the ability of a firm to use inputs in optimal proportions, given their respective prices and the production technology. Thus, in a competitive market where a producer is a price taker, a firm is said to be allocatively efficient if it equates the marginal physical products of inputs to the ratio of market prices of the input and output. Alternatively, firms equate their firm value marginal product to the corresponding factor cost of that firm (Sibiko *et al.*, 2013). This can be achieved by taking the first derivative of equation 1 when output (y_i) is expressed as a function of input $y = f(x_i)$, which can imputed in the profit function as;-

$$\pi_i = P_y f(x_i) - \sum_{i=1}^{n} v_i x_i - TFC_i \text{...}$$

Therefore,

$$\frac{\partial \pi_i}{\partial x_i} = P_y MPP_{xi} - v_i \text{...}$$

Or

$$P_y MPP_{xi} = v_i \text{...}$$

Where

$P_y MPP_{xi}$ - Value marginal product (VMP) and other variables are as previously defined.

Economic theory states that a firm maximizes profit with respect to variable input if the ratio of its VMP to the corresponding marginal factor cost is equal to 1, as presented in equation 11.

$$\frac{VMP}{v_i} = 1 \text{...}$$

A ratio of less than one implies over utilization of resource and profit would rise by reducing the quantity of input used. Underutilization of these resources is indicated by a ratio greater than one, profit would rise by increasing the quantity of inputs used (Oluyole *et al.,* 2013; Kadiri *et al.,* 2014). As such, both overutilization and underutilization of the resources represent allocative inefficiency. Thus, a profit maximising firm always allocates inputs such that they produce at the profit frontier. As described in the previous section 2.3, the profit function has the ability to combine technical and allocative efficiency in a profit relationship and any error in production decision is translated into low profit, the use of a profit function to measure farm level efficiency cannot be overemphasized. Grape is a cash crop, as such, the main objective of a farmer is to maximise profit given the resource available, hence profit function is the best. Thus, the present study used a profit function to analyse farm level profit efficiency. Empirical measurement of profit efficiency is described in the next section.

2.3.2 Measuring profit efficiency

Many studies have examined efficiency in agricultural production by applying two main approaches; (i) the parametric Stochastic Frontier Analysis (SFA) (Ansah *et al.,* 2014; Bidzakin *et al.,* 2014; Dziwornu and Sarpong, 2014; Bahta and Baker, 2015; Kaka *et al.,* 2016; Kuboja *et al.,* 2017) and (ii) the non-parametric Data Envelop Analysis (DEA) (Geta *et al.,* 2013; Manevska, 2012; Urso *et al.,* 2018). Both methods estimate the efficiency frontier and calculate the firm`s technical, allocative and profit efficiency relative to the best performing firms (Chikobola, 2016). The main difference between the two measures lie on first, whether or not the functional form is specified, and second whether or not the random effect is taken on board in that specific technique (Zainal and Ismail, 2010). The parametric SFA requires that a functional form be specified for the production, cost or profit function while the non-parametric DEA approach does not requires functional form specification, but it just uses linear programming to construct a piece wise frontier that envelops the observations for all firms (Guesmi *et al.,* 2012; Chikobola, 2016).

The major strengths of DEA method include, (i) its ability to handle large data sets with multiple inputs and outputs simultaneously having different input and output measurement units; (ii), DEA allows the computation of scale efficiency; and (iii) the DEA does not impose distributional assumptions on the inefficiencies (Ray, 2012; Bidzakin *et al.,* 2014). Despite of these strengths, the DEA approach is more sensitive to outliers and does not separate inefficiency effect from random error hence it tends to overestimate inefficiency effects (Guesmi *et al.,* 2012).

Meanwhile, the main strength of SFA, in comparison to DEA, is that it takes into account measurement error and statistical noise in the data (Bidzakin *et al.*, 2014). This is a very important factors for studies using farm level data, especially in developing countries such as Tanzania where production outcomes are highly influenced by environmental factors especially weather conditions and sometimes there are measurement errors especially when farmers are required to state what they consumed, no one meet answer (Guesmi *et al.*, 2012; Chikobola, 2016). Moreover, the SFA allows the researcher to undertake statistical testing regarding the functional forms, significance of estimated coefficients and existence of inefficiency (Guesmi *et al.*, 2012; Bidzakin *et al.*, 2014; Chikobola, 2016; Kaka *et al.*, 2016). However, the SFA is not free from weakness, the SFA method imposes distributional assumption for inefficiency effects and random factors as such it is susceptible to misspecification error (Bidzakin *et al.*, 2014). Notwithstanding this weakness, the SFA method is still the most suitable for the present study because grape production like any agricultural crop is very sensitive to random factors such as weather, humidity, pest and diseases as well as measurement error, which are well addressed when SFA is used.

2.3.3 Empirical studies on stochastic frontier approach

Many studies have been carried out to assess farm profit efficiency specifically for annual crops such as maize, rice and groundnuts using a stochastic profit frontier (Galawat and Yabe, 2012; Adam and Bakari, 2015; Sadiq and Singh, 2015; Chikobola, 2016; Kaka 2016). However, there is a limited number of empirical studies on profit efficiency among farmers for perennial crops like grape. Most of the profit efficiency studies for different crops used either a Cobb-Douglas (CD) profit function or a Transcendental (Translog) profit function. The CD function specification is simple and requires estimation of a few parameters. However, the CD function is very restrictive because it imposes strong assumptions about constant elasticity of substitution (Chikobola, 2016). Despite its weaknesses, the CD functional form is popular and widely used to estimate farm efficiency (Moreira *et al.*, 2011; Adam and Bakari, 2015; Bahta and Baker, 2015; Lwelamira *et al.*, 2015b; Kaka *et al.*, 2016).

Meanwhile, the translog functional form is flexible and frequently used to estimate profit efficiency in agricultural crop (Ogunniyi, 2011; Galawat and Yabe, 2012; Maganga *et al.*, 2012; Chikobola, 2016; Kuboja *et al.*, 2017). However, the translog function suffers from multicollinearity problem due to inclusion of quadratic and interaction terms (Ogunniyi, 2011; Hussain *et al.*, 2012; Chikobola, 2016). Despite their weakness, both the CD and Translog functions are commonly employed in studies. The maximum Likelihood Estimation (MLE) is the most used method for analysis. However, choice of the best functional form is made using generalized Log-likelihood ratio test. Most studies have used the generalized Log-likelihood ratio test to choose functional forms and test the existence of profit inefficiency in production system (Dwi *et al.*, 2014; Dziwornu and Sarpong, 2014; Chikobola, 2016; Kaka *et al.*, 2016; Saysay *et al.*, 2016). The current study adopted this method to select the best functional form that suits the given data set and test the existence of inefficiency. The selected functional form has often been used to estimate profit efficiency and factors explaining profit inefficiency. The maximum Likelihood Method has the ability to estimate simultaneously both profit efficiency and determinants of profit inefficiency. The empirical studies on inefficiency are presented in the next subsection.

2.3.4 Empirical studies on factors influencing efficiency

Several studies have been carried out to determine factors that influence efficiency among farmers in crop production (Guesmi *et al.*, 2012; Ma *et al.*, 2012; Ansah *et al.*, 2014; Dwi *et al.*, 2014; Dziwornu and Sarpong, 2014; Lwelamira *et al.*, 2015b). These studies identified demographic, socio-economic, institutional and environmental factors as the main variables explaining efficiency differences among farmers. For instance, Moreira *et al.* (2011) confirmed that the efficiency of wine grape producers was positively influenced by labour cost and farm size. Lwelamira *et al.* (2015b) argue that grape efficiency was positively influenced by education level, farming experience, household size and access to extension services. In addition, the study found that farm size coupled with optimal use of organic fertilizer and pesticides had a significant effect on technical efficiency. Meanwhile, Ma *et al.* (2012) argue that farm efficiency was significantly affected by material cost, labour and vineyard cost. Guesmi *et al.* (2012) confirmed that efficiency was positively influenced by factors such as capital, farm size, experience, environmental preservation preferences and agronomic techniques.

Moreover, Dziwornu and Sarpong (2014) affirmed that extension service and access to credit were the main factors affecting profit efficiency in broiler production. Furthermore, Saysay *et al.* (2016) claim that farming experience, household size, access to market information, group membership, access to extension service and credit had a positive influence on rice profit efficiency. Other studies (Galawat and Yabe, 2012; Dwi *et al.*, 2014; Kaka *et al.,* 2016) argue that education of the household head, farming experience, group membership, access to extension service and credit had a positive influence on profit efficiency. Based on the literature, the current study made a priori expectation that the farmer`s educational level, sex, farming experience, extension service, access to credit and extension services would have positive effects on grape profit efficiency. Unlike the theoretical framework of profit efficiency, the present study also presented a theoretical framework for factor demand response, as explained in the next subsection.

2.4 Theoretical Framework for Factor Demand Response

Microeconomic theory suggests that major determinants of output supply and factors demand include its own prices, price of close substitute products or inputs and complementary input/output. An output supply function describes how the quantity of produce offered for sale varies due to variation in own price and price of related commodities, while a factor demand function describes how demand for an input varies due to change in its own factor price and the price of related inputs (Junaid *et al.,* 2012). Under the profit maximization assumption in a competitive market structure, factor demand and output supply function can be derived directly from a profit function using Hotelling`s lemma, according to which, the first derivative of a profit function with respect to input and output prices give the profit maximising level of output supply and factor demand functions, which are expressed in terms of input and output prices (Debertin, 2012; Thakare *et al.,* 2012; Mailena *et al.,* 2013).

The properties of such a profit function includes (i) non-decreasing in output price and non-increasing in input prices for given fixed factors; (ii) homogenous[2] of degree one in fixed factor for given input and output prices (Trong and Napasintuwong, 2015). Such

[2] Homogeneous of degree 1 was imposed by normalizing profit and input prices by output price

farm profit (π_i) is determined as the difference between total revenue and total cost, whereas total cost involve total variable cost and total fixed cost as presented in equation 1 (section 2.3 of this study). The input demand functions can be obtained by taking the first derivative of the profit function (equation 3) using Hotelling`s lemma, which gives the equation twelve (12).

$$\frac{\partial \pi_i^*}{\partial P_i} = \frac{\partial \pi(P_i, Z_i)}{\partial P_i} = X_i(P_i, Z_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1$$

Or

$$X_i^{\bullet} = X_i(P_i, P_j, Z_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where

π_i^* = The normalized profit of i^th farmer as described in page 20 of this study;

$X_i^{\bullet}$ =Represents the quantity of i^th input demanded in kilogram;

P_i =Price of input x_i divided by price of output in TZS;

P_j = Price of input x_j divided by price of output in TZS;

Z_i =is vector of fixed inputs; and

$i \neq j$ =Represents number of inputs

This derivative provides a system of factor demand equations with respects to factor prices. Since a profit function is homogeneous of degree one, these demand equations are homogeneous of degree zero[3] in input prices. Assuming that a profit function is convex, the proposition of profit maximization behaviour can be derived as follows;-

[3] Because profit function is continuously differentiable and homogenous of degree one, then its first derivative is homogenous of degree c-1.

$$- \frac{\partial X_i}{\partial P_i} = \frac{\partial}{\partial P_i}\left[\frac{\partial \pi(P_i, Z_i)}{\partial P_i}\right] = - \frac{\partial^2 \pi(P_i, Z_i)}{\partial p_i^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

This gives the input's own factor demand price elasticity, which is always negative, economic interpretation is that, if the absolute value of an input`s own price elasticity is less than unit $\left(\frac{\partial X_i}{\partial P_i} = |\ell_p| < 1\right)$, it implies that the factor demand is inelastic, while if the value is greater than unit $\left(\frac{\partial X_i}{\partial P_i} = |\ell_p| > 1\right)$, that factor demand is elastic.

Moreover, the derivative of the input demand function with respects to price of other related inputs provide cross-factor price elasticities. The cross-factor price elasticity is described in equation 15.

$$\frac{\partial X_i(P_i, Z_i)}{\partial P_j} = \frac{\partial}{\partial P_j}\left[\frac{-\partial \pi(P_i, Z_i)}{\partial P_i}\right] = \frac{\partial}{\partial P_i}\left[\frac{-\partial \pi(P_i, Z_i)}{\partial P_j}\right] = \frac{\partial X_i(P_i, Z_i)}{\partial P_j} \ldots\ldots\ldots\ldots\ldots\ldots$$

The economic interpretation is that if the value of the cross-factor price elasticity is less than zero $\left(\frac{\partial X_i}{\partial P_j} < 0\right)$, then the demand for two inputs X_i and X_j is said to be complementary, but if the value of the cross-factor price elasticity is positive $\left(\frac{\partial X_i}{\partial P_j} > 0\right)$, then the demand for two inputs X_i and X_j is said to be substitutes.

2.4.1 Empirical studies on factor demand response

Several studies have been conducted to analyse factor demand and output response in annual crops such as cotton, rice, wheat and maize (Kumar *et al.,* 2010; Thakare *et al.,* 2012; Mailena *et al.,* 2013; Rahman *et al.,* 2016). However, there is a limited number of studies on factor demand response for perennial crop such as rubber, cocoa and grape (Mustafa *et al.,* 2016). Most of the factor demand response studies addressed either cost minimization or profit maximisation problems (Kumar *et al.,* 2010; Suriagandhi, 2011; Thakare *et al.,* 2012; Mailena *et al.,* 2013). A cost minimization problem uses a cost function to derive conditional input demand functions, while a profit maximisation problem uses a profit function to derive both indirect factor demand and output supply functions and then factor and output price elasticities are estimated from factor demand and output supply functions (Kumar *et al.,* 2010; Thakare *et al.,* 2012; Mailena *et al.,* 2013). The profit function is most widely used in the literature because it permits straight forward derivation of output and input demand function and own-price and cross price elasticities (Suriagandhi, 2011; Junaid *et al.,* 2012; Thakare *et al.,* 2012; Ullah *et al.*, 2012; Mailena *et al.,* 2013; Sadiq and Singh, 2015; Rahman *et al.,* 2016). Hence, this study adopted a profit function to estimate factor demand functions in order to analyse factor demand response due to changes in factor prices.

Recent work which applied a profit function to estimate factor demand response used the Seemingly Unrelated Regression Estimation (SURE) include those of Kumar *et al.* (2010); Suriagandhi (2011); Thakare *et al.* (2012); and Mailena *et al.* (2013). The SURE method requires that profit functions and the system of demand functions to be jointly estimated using the Zellner (1962) estimation method (Kumar *et al.,* 2010; Thakare *et al.,* 2012; Mailena *et al.,* 2013; Rahman *et al.,* 2016). The SURE method is asymptotically equivalent to the Maximum Likelihood Method when iterated to convergence (Mailena *et al.,* 2013). The present study therefore used the Maximum Likelihood Estimation and regression model to estimate factor demand functions in order to obtain factor price elasticities with respect to variable input prices. The empirical studies on factor price elasticities are presented in subsection 2.4.2.

2.4.2 Factor price elasticities

Many studies on factor demand response identified that there is either a negative relationship between factor demand and its factor price while there is complementary or substitution relationship between factor demand and the price of other inputs (Suriagandhi, 2011; Thakare *et al.,* 2012; Ullah *et al.,* 2012; Mailena *et al.*, 2013; Rahman and Kazal, 2016). Applying SURE, Suriagandhi (2011) while studying input demand for banana, argues that a unit percent increase in the price of variable inputs such as labour, fertilizer and irrigation resulted into a decrease in demand for respective input. Likewise, the study identified that cross price elasticities of variable inputs were negative, implying that the demand for the pair of inputs (*i.e.,* labour and Fertilizer) was complementary rather than substitutes. Mailena *et al.* (2013) used a similar method to analyse input demand and output supply response of rice production in Malaysia. They identified that own price elasticities for labour demand, herbicides and seed had a negative relationship with its factor prices, while the cross-factor price elasticities of herbicides and seed had a negative sign, indicating these inputs are complements.

Several other studies used a similar methodology to analyse input demand and output supply response of various crop across the world (Suriagandhi, 2011; Thakare *et al.,* 2012; Rahman and Kazal, 2016). For example, Rahman and Kazal (2016) argue that all own price elasticities of variable inputs except labour had a negative sign which are consistent with demand theory. However, the absolute value was less than one, implying that factor demand is inelastic. Similar results were obtained by Mailena *et al.* (2013) while studying input demand and supply response of rice production in Malaysia. In the contrary, Suriagandhi (2011) found that demand for variable inputs with respect to their own prices were elastic while studying supply response of banana and input demand. There are reasons for inelastic factor demand for rice and maize production, while factor demand for banana is elastic. (i) Maize and rice are the main staple food for a large section of the population in the world; consequently factor price changes may not have substantial influence on the decision of farmers on either to buy or not to buy the input, (ii) Banana is a fruit or supplement food with many alternative, as such if the price of inputs required for banana production changes, there is high degree of responsiveness for input demand because farmers can switch from growing banana and hence grow an alternative fruit crops which appears to be cheaper. Based on the literature review, the present study hypothesized that factor demand response for grapes due to changes in own factor price is elastic because grape is a fruit. In the next subsection, the study presents the conceptual framework to guide analysis.

2.5 The Conceptual Framework

The conceptual framework for this study draws from the Neo-classical producer theory, which describes the behaviour of a firm, which seeks to achieve profit maximization. The possibility of achieving profit maximization depends on the efficient use of available resources and the cost of inputs. The efficient use of resources is a key factor for improving farm productivity and hence increasing farm profit and profitability. Given this fact, the present study assessed the performance of farmers using profitability and profit efficiency. The assessment was made in order to provide a clear picture regarding the performance of wine grape subsector and identify key factors that account for poor performance among farmers in order to address them and improve farm productivity and hence increase farmer`s income and profit. Farmer`s profit efficiency and profitability are influenced by the cost of production and farm level specific characteristics (Mohammed *et al.*, 2013; Saysay *et al.*, 2016). Not only that, external factors that a farmer cannot control and viticulture practices are likely to cause either an upward or a downward swing of productivity and hence profitability and profit efficiency. For example, good weather conditions would result in higher farm productivity, which in turn will lead to increased farm profit and profitability (Fig.1).

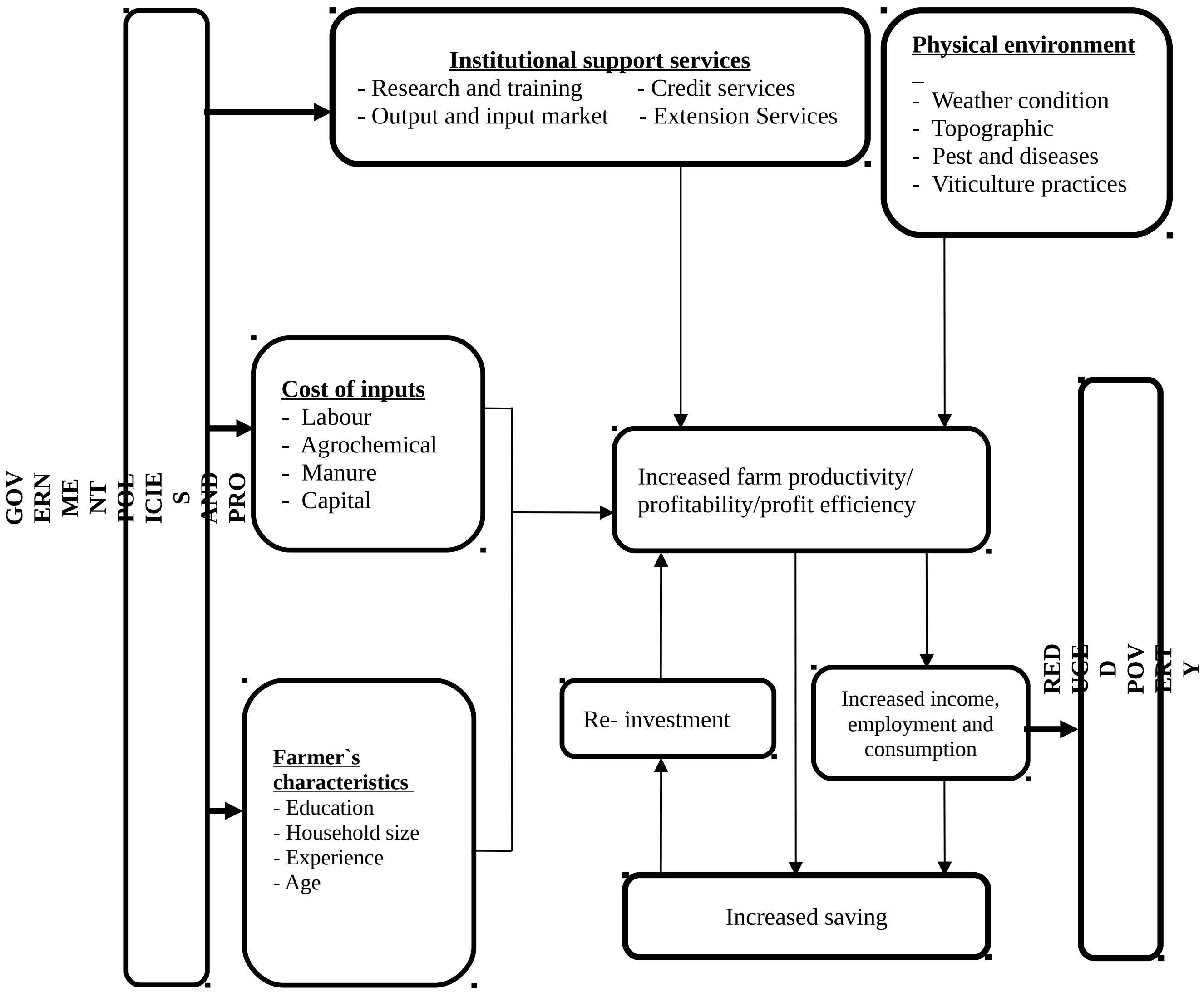

Figure 1: Conceptual framework

Source: Modified from Philip (2007)

In addition to the cost of production, farm specific factors and the physical environment, prevailing government policies and programmes may directly influence institutional support services such as credit and extension services, the cost of production and farmer`s behaviour. For example, if agricultural policies through research and development promote the use of improved technologies such as high yielding varieties, the ultimate outcomes will be increased productivity, higher income and profitability as well as more employment opportunities. The increased income and employment are likely to pull out farmers from wide spread income poverty.

Although this conceptual framework presents various causal relationships, this study focused on cost of the inputs, farmer`s characteristic and institutional support services such as credit and extension services that influence farmer`s performance at the farm level. Factor prices determine the quantity of inputs used in a farm, while output prices among others determine gross income received by farmers. The present study therefore collected data on the quantity of input usage, input and output prices as well as farmer`s specific characteristics. These data will facilitate the analysis of profitability, profit efficiency and factor demand price elasticities as well as identifying factors that account for profit efficiency. The findings of this study are expected to draw lessons for improving wine grape performance in the study area. The procedures for data collection are described in the methodology chapter three.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Study Area and Characteristics

The study was conducted in Dodoma city and Chamwino district, which were chosen purposively because they are leading in commercial grape production in Dodoma region. Moreover, Dodoma city and Chamwino district have that benefited from various interventions for grape expansion and productivity improvement. The study area is located between latitudes 4º and 8º South of the Equator and between longitudes 35º and 37º East of the prime meridian (Greenwich). Specifically, Dodoma City between latitude 5.50^0 and 6.30^0 South of the Equator and Longitude 35.30^0 and 36.02^0 East of Greenwich, while Chamwino district is located at 4.0^0 and 8.0^0 Latitude South of the Equator and between 35^0 and 37^0 Longitude East of the Greenwich (Fig. 2) (URT, 2015b; URT, 2015c)

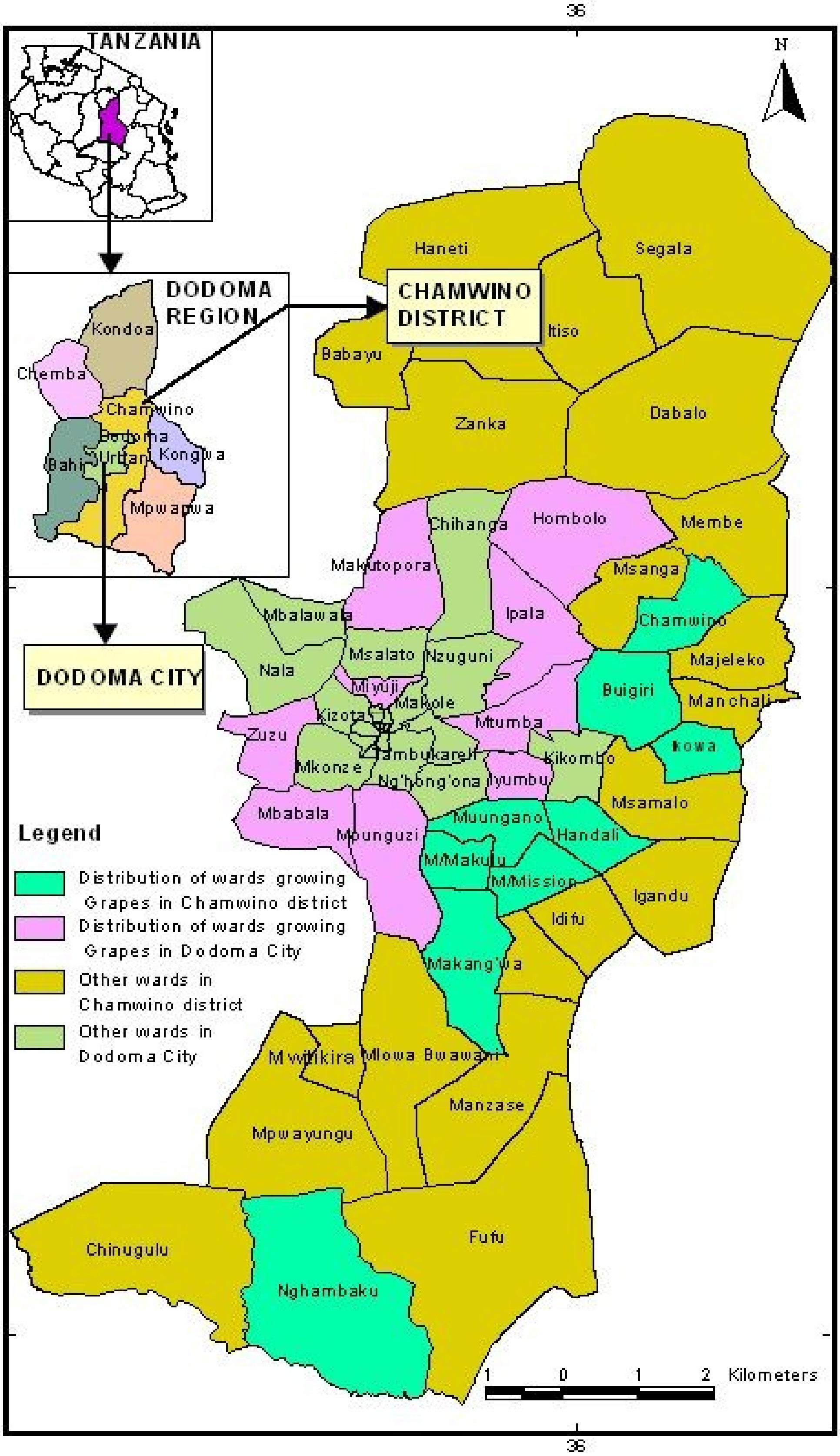

Figure 2: A map of the study area (Chamwino District and Dodoma City)

Both districts receive on average 570 mm of rainfall per annum, having two seasons namely; a short wet season, which lasts from December to mid-April and a long dry season, which lasts from late April and early December. The average annual temperature varies between 20ºC in July and 30ºC in November (UNCCD, 2013; URT, 2015b; URT, 2015c). The study area is found 1100m above the sea level with low levels of humidity and cool breezes (Robbins, 2016). These are pre-requisite climatic conditions for grape production.

Dodoma city is characterized by urban and rural qualities, which is surrounded by scattered stony hills among them being Mlimwa, Isanga, Mkalama and Imagi. It covers 2769 km^2 of land, of which 625 km^2 are within the urban boundary. The current population of Dodoma city is projected to be 482 190 people of whom 234 066 are male (49%) and 248 125 (51%) are female, with average household size of about 4.4 (URT, 2013). While, Chamwino district is characterized by Savannah type of climate with a long dry season and a short wet season. It covers about 8056 km^2 of land, which is surrounded by a number of mountains and a chain of hills from the Northwest to the Southwest. The current population is projected to be 363 572 people of whom 178 150 are male (49%) and 185 422 are female (51%). The average household size is about 4.5 (URT, 2013). In both districts, agriculture is the predominant economic activity employing about 90% of the active working population (URT, 2015a; URT, 2015b). Both districts have a total of 768 820 ha which are suitable for agricultural production and about 442 821 ha are used for crop production. This implies that, there is a potential for agricultural expansion since only 58% of the arable land is currently being used[4].

[4] Unpublished materials extracted from Dodoma city and Chamwino district profiles

3.2 Administrative Permits in the Study Area

Administrative procedures demanded that, the researcher should obtain necessary official authorisation to carry out research in the selected districts. Ethical permission for the study was obtained from Sokoine University of Agriculture (SUA) through the Directorate of Postgraduate Studies, Research, Technology Transfer and Consultancy (DPRTC) and submitted to the Regional Administrative Secretary, Dodoma required. Due to technical and administrative challenges, the period stipulated in first letter elapsed before the approval of the proposal (Appendix No.1). Hence, the DPRTC re-issued another two letters directly to each selected council to seek for an official permit in order to undertake the research in their respective areas (Appendix 2 and 3). Both letters explicitly stipulated the title of the study and the period for data collection. Both local government authorities (LGAs) in turn issued letters of no objection, enabling the researcher to access data at all levels within the study area; from grape farmers as well as other stakeholders within their jurisdictions as per schedule (Appendix 4, 5 and 6).

3.3 Research Design

A research design is an arrangement of conditions for data collection and analysis in a manner that aims at combining relevance of the research purpose with the economy (Kothari, 2004). This study used a cross-sectional data set that was collected from a sample of grape farmers between 15 March and 15 September, 2016. A cross sectional research has a high degree of accuracy and precision because a researcher collects variable of interest within a short time, hence it saves time and resources (Zangirolami-Raimundo *et al.,* 2018).

3.3.1 Sampling procedures

A sampling procedure is referred to a technique that a researcher adopts in selecting some sampling units from which inferences about the population is drawn (Kothari, 2004). For this study the sampling frame was defined as all smallholder wine grape farmers in the study area. Sampling was done at different levels starting at the region, going to districts, wards and respondents from each selected village or street. Hence, a multi-stage sampling technique with stratification was employed. In the first stage, purposive sampling was used to select Dodoma region, Chamwino district and Dodoma city based on their relatively high volume of commercial grape production. In the second stage, simple random sampling was used to select wards from each district.

Simple random sampling was also used to select villages or Mitaa (in Dodoma City) from each ward. Then, the grape farmers were purposely stratified into two strata differentiating farmers using irrigated farms and from those under rain-fed production technology. Further, sample frame from each stratum were ordered in a random manner to ensure representative of the total population. Finally, the farmers were selected using a systematic sampling procedure from each stratum because it is easy and cost effective to implement compared to simple random sampling. Moreover, systematic sampling procedure is more practical because it ensures more even distribution of the sample over the entire population. However, systematic sampling is not free from weakness; this method is proved to be in efficient if there is a hidden periodicity in the sampling frame (Kothari, 2004).

3.3.2 Sample *s*ize determination

The population of interest for this study comprised of all wine grape farmers in the study area. As pointed out in the introduction section 1.1, there are 1700 households that produce grapes in Dodoma Region, of which 833 households produce grapes under irrigation while 867 households produce grapes under rain-fed production technology. These strata formed two sampling lists. The minimum sample size for this study was computed by adopting Cochran`s formula for a finite population, the simplified formula is presented in equation 16 (Cochran, 1977).

$$n = \frac{n_0}{1 + (n_0 - 1)/N} \text{..}$$

Where

$n_0 =$ is the minimum sample size for an infinite population computed by a formula $(z^2 pq)/e^2$;

$Z = 1.96$;

$p =$ is the sample proportion in the study area which is assumed to be $p = 0.5$;

$e =$ is the maximum acceptable error which is assumed to be 0.05; and

N is total number of grape growers (1700 household).

$$n_0 = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2} = 385 \, farmers \text{..}$$

Thus

$$n = \frac{385}{1 + (385 - 1)/1700} = 314 \, farmers \text{..(18)}$$

The minimum sample size was determined to be 314 farmers, but the study used a systematic sampling procedure to draw an individual farmer from each of the stratum. Proportionate sampling was used to select 176 farmers from the list of irrigated farms and 183 farmers from the list of rain-fed farms to make a total sample size of 359 farmers. The two sample sizes were determined using equation 19.

$$n_i = \frac{nN_1}{N} = \frac{nN_1}{N_1 + N_2 + N_m} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where

n_i =Sample size of i[th] stratum

n =Proposed sample size of the study

$N_1, N_2 \ldots N_m$ =Sampling lists of m[th] stratum; and

$i = 1,2,3 \ldots m$ =Number of strata

$N = N_1 + N_2 + N_m$ =Population size in study area

The sample size for irrigated farmers was obtained as follows;-

$$n_i = \frac{359 \times (833)}{1700} = 175.9 \approx 176 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

The proportional sample size for rain-fed farmers was obtained as follows:-

$$n_i = \frac{359 \times (867)}{1700} = 183.09 \approx 183 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Since systematic sampling was used to draw the sample, the first farmer from each stratum was selected randomly; thereafter every 5[k] farmer was selected until each list was exhausted. The selection interval of five was obtained by dividing the total number of farmers in the respective farming system over the sample size, as presented in equation 22 and 23 hereunder.

$$k = \frac{N}{n} = \frac{833}{176} = 4.7 \approx 5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

or

$$k = \frac{N}{n} = \frac{867}{183} = 4.7 \approx 5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Table 1 shows the composition of farmers from each stratum.

Table 1: Sample distribution (%)

Farming System	Sex	Dodoma City N=193	Chamwino District N=166	Whole sample N=359
Irrigated	Male	46.5	53.5	100
	Female	38.2	61.8	100
	Total	**44.9**	**55.1**	**100**
Rain -fed	Male	60.8	39.2	100
	Female	70	30	100
	Total	**62.3**	**37.7**	**100**
Whole Sample	Male	53.9	46.1	100
	Female	53.1	46.9	100
	Total	**53.8**	**46.2**	**100**

Source: Survey data (2016)

3.4 Type of Data and Instrument for Data Collection

Primary data for the 2015 cropping season were collected between 15 March and 15 September, 2016 using a structured questionnaire. Prior to the main field survey, the structured questionnaire was pre-tested for relevance and consistency and updated by addressing problem identified during pretesting. The corrected version of the questionnaire was used for interviewing farmers. Six enumerators who had good communication ability in ‘Kiswahili’ and ‘*Chigogo’* (the local vernacular language) and had good experience in administering the questionnaire were hired. A five-day training session was given to the enumerators to ensure they understood the instrument.

The instrument included questions on farming operation such as land area cultivated, number of people, hours and days used to perform farm operations, quantity of manure, agro-chemicals (insecticides, pesticides and fungicides) and total output produced. Additional information included the cost of labour, manure, agro-chemicals as well as output price (Appendix 7). The questionnaire also contained information on socio-economic, demographic and institutional factors such as age, sex, years of schooling, farming experience, access to extension services and credit facilities.

During the data collection, regular cross checking was done for completed questionnaires for consistency of responses. Incomplete questionnaires were identified and follow up visits were made to the respondent. Verification regarding information on inputs such as input prices and input usage were obtained from local area extension officer and input stockists. Secondary data such as total number of grape farmers, total suitable land available for grape production, amount of rainfall and temperature were obtained from the District Council office as as well as Sokoine National Agricultural Library. This information was used to describe characteristics of the study area and various interventions, which were made for grape production.

3.5 Measurements of Variables

Inputs that were used included the quantity of pesticides, insecticides and fungicides. These were all collected either in litres, kilogram or grams. In the end, all agro-chemicals, which were measured in litres such attacan, gammalin 20 and duduba were all transformed into kilogram by the conversion factor of $1\,litre = 0.95945946$ kg in order to have the same standard unit. The quantity of output was measured in kilogram. However, the quantity of manure (cow dung) was collected in tonnes/truck or tonnes/ox-cart and then transformed into kilogram.

The quantity of labour included family and hired labour. Computation of labour was based on annual farm management activities such as weeding, spraying, repair and maintenance, irrigation, pruning, training, manure, insecticide and fungicide application. The number of people (labour units) who performed a particular piece of work, the number of days and average hours spent on doing that task were collected in order to compute the quantity of labour. Quantification of labour was based on labour hours whereby working hours of a woman were weighted by 0.75 and for children below 15 years were weighted by 0.5 in accordance to the Food and Agricultural Organization (FAO) (Nchare, 2007; Nyagaka, 2009). Finally, the sum of total working hours (for children, family and hired labour) were divided by eight hours (one man-day is equal to 8 working hours) to determine number of man-days.

Both hired and family labour was valued at the prevailing local wage rate to obtained total labour cost per ha. Family labour was valued on the basis of opportunity cost of the man-day therefore the prevailing local wage rate paid to a hired labour was used to value family labour. Opportunity cost is the amount of income a family member would earn if they were hired at someone else`s farm activity, instead they opted doing the same activity on their own farm.

Other inputs such as agrochemical and manure were valued at their market prices. The land area under wine grape production (ha) was used to normalize the quantity of inputs and respective cost so that each of them was considered as the quantity of inputs or cost of input per ha. The total fixed cost included depreciation of productive tools and annual payment on initial investment (annual capital recovery cost). The annual recovery cost was computed from the initial establishment cost using annual capital recovery formula equation 25 (section 3.6.2.2 of this thesis). The analytical framework is presented in subsection 3.6.

3.6 Analytical Framework

As described in subsection 3.4, primary data were collected between March and September, 2016. The analysis included descriptive and an empirical model analyses to assess the performance of wine grape farmers in the study area, as described in forthcoming sections.

3.6.1 Descriptive analysis

Descriptive analysis was used to summarize important characteristics of the grape farmers. The frequency distribution was used to characterise the sample by age group, marital status, sex, group membership, access to credit and extension services. Other variables such as input usage, output, farm size, profit and cost of inputs between the two production technologies were summarised using mean and standard deviation. Comparison of the mean differences was computed using an independent sample Z-test, while the comparison of variances was done using Chi-square tests at 5% level of significance. All these were computed using MS excel and compared to critical values obtained from relevant statistical table. Apart from descriptive statistics regarding farm specific characteristic, the present study also conducted profitability analysis, as described in subsection 3.6.2.

3.6.2 Farm profitability analysis

Profitability analysis was carried out to evaluate the performance of grape farmers during the year 2015. The analysis was based on farm size measured in ha. The profit of each farm was computed by subtracting total cost, from total revenue of respective farm. Total cost comprises total variable cost and total fixed cost. Total variable cost (TVC) was computed based on farm management activities performed in two cropping seasons of 2015, which included the cost of labour, manure and agro-chemicals. Fixed cost included depreciation cost on productive tools and annual capital recovery cost. Detailed information about total variable cost and fixed cost are presented in the forthcoming sections.

3.6.2.1 Depreciation cost

Wine grape farmers in the study area did not have any machinery or buildings as a specific asset for grape production, but most farmers possess small productive tools and equipment such as hand hoes, machetes, scissors, watering can/irrigation pumps and sprayers which are used to perform various activities in grape production and other crops. The study used a straight line method to compute the depreciation of shared and non-shared productive tools. Depreciation of shared productive tools was apportioned by the number of crops grown during 2015, to obtain estimated value that was used in grape production. This value was added to the depreciation of unshared tools to get the total depreciation value for each farmer. The study used equation 24 to compute depreciation cost of the productive tools.

$$\sum_{i=1}^{n} d = \frac{(p - s)}{n} \quad \text{...(2}$$

Where

d_i =Annual depreciation of the productive tools for i[th] farmer;

P =Purchase price;

s =Salvage value; and

n =Years of economic life

$i = 1,2,3...$ number of productive tools

Purchase price (P) corresponds to the observed market prices of the productive tools. As described in the previous paragraph, smallholder farmers in the study area possess only hand tools as fixed assets and which are practically used until the end of their life time, as such a final value (s) for such type of hand tools is equal to zero (Matus and Paloma, 2014).

3.6.2.2 Annual capital recovery cost

The second part of fixed cost comprises of annual capital recovery. As described in subsection 2.1.2 the first two or three years of grapevine growing involves only costs and no returns. The initial investment cost was established from year zero up to third year of planting. Hence, annual capital recovery cost was computed using capital recovery cost formula, established economic life of vineyard is 20 years as described in subsection 2.1.3 and the commercial interest rate on the borrowed fund is 18%. The annual capital recovery cost formula is presented in equation 25.

$$A_i = \left| (p - s) * f + (s + i) \right| \ldots\ldots (25)$$

Where

A_i =Annual capital recovery cost for the i[th] farmer

f =Capital recovery factor obtained from amortization Table of value[5]

i =Market interest rate (18% per annum[6])

P =Purchase price (corresponds to initial investment cost made to establish a vineyard);

s =Salvage value

The computed annual capital recovery cost (equation 25) was added to the computed depreciation cost (equation 24) to obtain the total fixed cost as presented in equation 26.

$$TFC_i = d_i + A_i \ldots\ldots$$

Where;

TFC_i =Total fixed cost for i^{th} farm

d_i =Annual depreciation of small productive tools

A_i =Annual capital recovery cost;

This worked out total fixed cost was added to maintenance cost to obtain annual production cost for respective farmer, as presented in equation 27.

$$TC_i = mc_i + TFC_i \ldots\ldots$$

[5] Capital recovery factor was obtained from Amortization Table at the interest rate of 18% and 20 years

[6] Source: Commercial lending rate is 18% in 2016 available at www.bot.go.tz: Bank of Tanzania (BOT)

TC_i = Annual total cost for i^th farmer,

mc_i = Annual maintenance cost for i^th farmer

The annual maintenance cost is the total variable cost (TVC) per ha and this was computed as described hereunder and presented in equation 28.

$$TVC = lab_i * P_w + manu_i * P_m + chem_i * P_c \text{..(2}$$

lab_i =Quantity of labour used by i^th household man day/ha

$manu_i$ =Quantity of manure used by *i*^th household in kg/ha

$chem_i$ =Quantity of agro-chemical used by i^th household in kg/ha

P_w =Price of labour (TZS/man-day)

P_c =Price of agro-chemicals (TZS/kg)

P_m =Price of manures (TZS/kg)

Total cost is one part of farm profitability analysis. The second part comprises of farm revenue, which is the amount of money that a farmer receives from the sales of wine grape outputs. As described in section 2.1.2, grape yield of 5 to 35 years old vines remain the same if the vines are subjected to similar management and field conditions. Thus, only vineyards with 5 years and above were included in the analysis. Further, the study assumed that 2015 was a typical production year and the decision to maintain a vineyard or grow other annual crops is based on annual income received. Consequently, only two cropping seasons were used to analyse profit and profitability.

As described in subsection 2.1.1, wine grapes are primarily produced for wine making; as such almost all grapes are sold either to wine processors or other traders from within or outside the country for the same purpose. Hence, gross return from wine grape production is the sum of returns from sale of wine grapes that were sold at different market points, including those consumed as fresh fruits during harvest and sale of stem cuttings for planting. However, it was difficult to accurately establish the amount of grapes that were consumed at the farm level (normally the amount consumed at farm gate is very small) and sale of stem cuttings for planting, hence only the value generated from the sale of grapes was used to compute total revenue for this study. Thus, total revenue (TR) from wine grape production was obtained by multiplying the quantity of wine grapes sold either to wine processors or other traders and the farm gate price, as presented in equation 29.

$$TR_i = \sum y_i p_y \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where

p_y =Output price of grape produces by i^{th} farmer for $i = 1,2,3 \ldots n$

y_i =Quantity of wine grape sold by i^{th} farmer for $i = 1,2,3 \ldots n$

TR_i =Total revenue i^{th} farmer for $i = 1,2,3 \ldots n$

$\sum$ =Symbol for summation

Thus, farm profit from grape production was determined using equation 30.

$$\pi_i = \sum y_i p_y - \sum (TVC_i + TFC) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (30)$$

π_i =Farm profit for i^{th} farmer; and other variables as previous defined.

3.6.2.3 Profitability analysis

The farm profitability was analysed using Return on Investment (ROI), which was computed as a ratio of Net Farm Income (NFI) to Total Cost (TC) per ha, as presented in equation 31.

$$ROI = NFI / TC \ldots$$

The study also analysed profit efficiency using a stochastic profit frontier. The empirical model for a stochastic frontier analysis is presented in subsection 3.6.3.

3.6.3 Empirical model for profit frontier

As pointed out in subsection 2.3.3, most of profit efficiency studies used either a Cobb-Douglas or Translog profit functions. The present study specified both Cobb-Douglas and Translog profit functions because profit function for the current data set was not known in advance. Assuming that the profit function is of Cobb-Douglas type, hence the Cobb-Douglas profit frontier is specified as follows;-

$$\pi_i^* = AP_{1i}^{\beta_1} P_{2i}^{\beta_2} P_{3i}^{\beta_3} P_{4i}^{\beta_4} e^{\varepsilon_i} \ldots$$

Where

π_i^* =Profit of i^th^ farmers for $i = 1,2,3,\ldots 359;$

$A =$ Constant terms

$P_1 =$ Cost of labour (TZS/ha) of the i^{th} farmer;

$P_2 =$ Cost of manure (TZS/ha) of the i^{th} farmer;

$P_3 =$ Cost agro-chemicals (TZS/ha) of the i^{th} farmer;

$P_4 =$ Number of plant in a farm of i^{th} farmer

$\beta_i =$ are the parameters to be estimated; and

ε_i =Composite error term as previous defined in section 2.3 of this study

The linearized Cobb-Douglas profit frontier is presented in equation 33.

$$\ln \pi_i^* = \beta_o + \beta_1 \ln P_{1i} + \beta_2 \ln P_{2i} + \beta_3 \ln P_{3i} + \beta_4 \ln P_{4i} + v_i - \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(33)$$

Where,

$\ln$ =denotes Natural logarithms

v_i and μ_i are as defined earlier

Assuming further that the profit function is transcendental; the transcendental stochastic profit frontier is specified in equation 34.

$$\pi_i^* = AP_{1i}^{\beta_1} P_{2i}^{\beta_2} P_{3i}^{\beta_3} P_{4i}^{\beta_4} e^{\sum_{i=1}^{2} \frac{\beta_{ii}}{2} \ln P_i \ln P_i + \sum_{j=1}^{2} \beta_{ij} \ln P_i \ln P_j + v - \mu} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots($$

The linearized translog profit function can be specified as follows (equation 35).

$$\ln \pi_i^* = \beta_o + \sum_{i=1}^{4} \beta_i \ln P_i + 0.5\beta_{22} (\ln P_{2i})^2 + 0.5\beta_{33} (\ln P_{3i})^2 + \beta_{24} \ln P_{2i} \ln P_{4i} +$$
$$+ V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

The translog profit function (equation 35) contained linear components for all cost components and number of plants, interaction term and quadratic terms for cost of manure and agrochemicals, which were thought to relate with profit in a non –linear manner. Both equations 33 and 35 were estimated using the Maximum Likelihood Method, which creates consistent estimators $(\beta, \lambda$ and $\sigma^2)$. The Maximum Likelihood Method simultaneously estimated parameters of the stochastic profit frontier as well as parameters of profit inefficiency function. The Log Likelihood function and its partial derivatives with respect to parameters are consistent with the model used by Battese and Coelli (1993) such that $\gamma = \sigma_\mu^2 / \sigma^2$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$. The value of Gamma (γ) indicates the level of inefficiency as described in the theoretical framework in subsection 2.3 of this study.

Both equations 33 and 35 were estimated using the Frontier Statistical Package Version 4.1 (Coelli, 1996), which uses a single step estimation procedure which produces maximum likelihood estimates of the stochastic profit frontier (Saysay *et al.,* 2016). The single step procedure is considered superior to two-stage procedures, which are employed in STATA software because it does not violate the classical assumption that the inefficiency effects are independently and identically distributed (Kumbhakar *et al.,* 2015). The single step procedure estimates simultaneously parameters of the profit efficiency model and the model for source of inefficiency in the production system. The generalized log-Likelihood test ratio was used to select appropriate functional forms as well as testing the presence of inefficiency effects and random error.

3.6.3.1 Choice of functional forms

The present study tested the adequacy of the restricted Cobb-Douglas function against the flexible translog function forms prior to further analysis. The null hypothesis which tested the two models stated that the Cobb-Douglas functional form was the best for representing the wine grape data set, while the alternative hypothesis stated that the translog functional form provided an adequate representation of wine grape data set. The choice of the best functional form was made using generalized likelihood ratio (LR) test (Green, 2012). The formula for Log Likelihood ratio (LR) test is presented in equation 36.

$$LR...(\lambda) = -2*\ln\left[\frac{L_R}{L_U}\right] = -2*(\ln L_R - \ln L_U)..(36$$

Where

L_R = The values of Log Likelihood function under the restricted Cobb-Doulas model

L_u = The value of Log Likelihood function under the unrestricted flexible Translog

But, the test statistic (λ) follows a chi-square χ^2 distribution with degree of freedom equal to the number of restrictions imposed by the null hypothesis (Khan *et al.,* 2010; Chikobola, 2016). Computed values of lambda (λ) were compared with outcomes values provided in Kodde and Palm (1986).

The Log Likelihood ratio test results indicated that the null hypothesis could not be rejected because the value of λ for profit function were less than the critical value of mixed chi-square distribution at the $\alpha = 0.05$ level of significance with 4 degree of freedom. This means, the Cobb-Douglas profit functional form is an adequate representation of the data set. Thus, the present study used the Cobb-Douglas model to compute profit efficiency of wine grape farmers. However, computation of profit efficiency does not account for socioeconomic, demographic and institutional factors, which are known to influence profit efficiency. Hence, the study proceeded to determine factors influencing profit efficiency among farmers as described in the next section 3.6.3.2.

3.6.3.2 The profit inefficiency model

The third objective of this study was to analyse the socio-economic and institutional factors influencing efficiency of wine grape farmers in the study area. According to Battese and Coelli (1995), the inefficiency effect can be expressed as a linear function of some socio-economic and institutional variables, as presented in equation 37.

$$\mu_i = \delta_0 + \delta_1\omega_1 + \delta_2\omega_2 + \delta_3\omega_3 + \delta_4\omega_4 + \delta_5\omega_5 + \delta_6\omega_6 + \delta_7\omega_7 \text{..} (37)$$

Where;

ω_1 =Farming experience

ω_2 =Education of the household head

ω_3 =Sex

ω_4 =Access to credit

ω_5 =Access to extension service

ω_5 =Group membership

ω_7 =Location of farms

δ_0 - δ_7 were the parameters of socio-economic and institutional factors estimated

3.6.3.3 Description and expected signs of the variables

The choice of explanatory variables presented in model 37 and the profit frontier (equation 33) were based on theory and empirical literature. With respect to the inefficiency model (equation 37), a variable with a negative coefficient, means that variable is positively related to profit efficiency, while a variable with a positive sign, implies that a variable increases profit inefficiency, thereby reducing the profit level (Galawat and Yabe, 2012; Ansah *et al.,* 2014; Chikobola, 2016; Saysay *et al.,* 2016). Likewise, a variable with a negative coefficient in equation 33, means that the profit function is non- increasing in input prices. The key variables which were assumed to influence efficiency are presented in Table 2.

Table 2: Descriptions of variables and expected signs for inefficiency model

Variables	**Description**	**Expected signs**
ω_1 =Farming experience	Years of experience in grape production	-

ω_2 =Educational level	Years of schooling	-
ω_3 = Sex	Dummy (Male = 1; Female = 0)	-
ω_4 =Access to credit	Dummy (Access to credit = 1; No access to credit=0)	-
ω_5 =Access to extension services	Dummy (Access to extension services =1 No access to extension services = 0)	-
ω_6 =Group membership	Dummy(Membership to group =1 Non-member = 0)	-
ω_7 =Location	Dummy(Dodoma city =1; Chamwino district =0)	-
General model		
Cost of Manure	Normalized cost of manure (TZS/ha)	-
Cost of Agrochemical	Normalized cost of agrochemicals (TZS/ha)	-
Labour cost	Normalized cost of labour (TZS/ha)	-
Number of grapevines	Total number of vines plants per ha	+

Source: Literature Review

The fourth objective of the present study dealt with factor demand response of grape farmers. The empirical models for factor demand response are presented in subsection 3.7.

3.7 Empirical Factor Demand Price Elasticities

As pointed out in section 2.4 of this thesis, the study applied Hotelling's lemma to derive factor demand functions. The first order condition for the Cobb-Douglas profit function (equation 32) in subsection 3.6.3, give factor demand equations which are specified in equation 38-40;

i. Labour demand equation

$$-\frac{\partial \pi_i^*}{\partial P_{1i}} = -\beta_1 A P_{1i}^{\beta_1 - 1} P_{2i}^{\beta_2} P_{3i}^{\beta_3} P_{4i}^{\beta_4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

ii. Manure demand equation

$$-\frac{\partial \pi_i^*}{\partial P_{2i}} = -\beta_2 A P_{1i}^{\beta_1} P_{2i}^{\beta_2 - 1} P_{3i}^{\beta_3} P_{4i}^{\beta_4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

iii. Agrochemical demand equation

$$-\frac{\partial \pi_i^*}{\partial P_{3i}} = -\beta_3 A P_{1i}^{\beta_1} P_{2i}^{\beta_2} P_{3i}^{\beta_3 - 1} P_{4i}^{\beta_4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

The linearized system of demand functions (equations 38 – 40) can be specified as follow;-

Labour demand equation

$$\ln L = -[\ln(A\beta_1) + (\beta_1 - 1)\ln P_{1i} + \beta_2 \ln P_{2i} + \beta_3 \ln P_{3i} + \beta_{4i} \ln P_{4i}] \ldots\ldots\ldots\ldots\ldots\ldots$$

Manure demand equation

$$\ln M = -[\ln(A\beta_2) + \beta_1 \ln P_{1i} + (\beta_2 - 1)\ln P_{2i} + \beta_3 \ln P_{3i} + \beta_{4i} \ln P_{4i}] \ldots\ldots\ldots\ldots\ldots\ldots$$

Agrochemical demand equation

$$\ln Agr = -[\ln(A\beta_3) + \beta_1 \ln P_{1i} + \beta_2 \ln P_{2i} + (\beta_3 - 1)\ln P_{3i} + \beta_{4i} \ln P_{4i}] \ldots\ldots\ldots\ldots\ldots\ldots$$

Where

$\ln =$ Natural logarithm;

$L =$ Quantity of Labour (man-day/ha);

$M =$ Quantity of manure (kg/ha);

$Agr =$ Quantity of Agrochemical (kg/ha);

All these systems of demand functions (equations 41-43) were estimated using MS-Excel to compute own factor and cross-factor price elasticities of wine grape farmers.

3.8 Limitations of the Study

The main limitation of the study is the use of cross-sectional data for two cropping seasons in 2015, while grape production is a perennial crop with more than 20 years of economic life. Panel data or time series data would be most suitable to assess farms` performance. Although, there is no panel data, detailed information about initial investment cost was enquired from farmers in order to compute annual capital recovery cost, which was included into annual maintenance cost to obtained total annual production cost. The study findings for all four research objectives are presented in chapter four.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Descriptive Statistics

4.1.1 Socio-economic characteristics of the respondents

According to results presented in Table 3, majority (82%) of the respondents came from male headed household, while their female counterparts represented about 18%. This proportion of male headed households from the sample is slightly higher than the national composition (71.2%). While the proportion of female headed households from the sample is lower than 28.8%, which is the national composition (URT, 2017). This is mainly because often men tend to dominate cash crops than is otherwise the case with food crops (FAO, 2011). Evidence from other African countries also support the fact that the participation of female headed households in cash crop production is often lower than that of male headed households (Kyei *et al.,* 2011; Mohammed *et al.,* 2013; Wangnaa and Awunyo, 2013), because most of the cash crops are capital intensive. The average age of the households in the sample was 43.1 years.

Table 3: Socio-economic characteristics of the respondents

District Council	Whole Sample				Dodoma City (DCC)				Chamwino district (CDC)			
Variable	**Total (n=359)** %	**Female (n=64)** %	**Male (n=295)** %	**Chi-square**	**Total (n=193)** %	**Female (n=34)** %	**Male (n=159)** %	**Chi-square**	**Total (n=166)** **%**	**Female (n=30)** **%**	**Male (n=136** **%**	**Chi-square**
Sex												
Female	17.8				17.6				18.1			
Male	82.2				82.4				81.9			
Total	**100**				**100**				**100**			
Age of Respondent												
< 30	16.4	10.9	17.6		9.8	5.9	10.7		24	16.7	25.7	
Between 30 and 50	54.3	54.7	54.2		51.3	58.8	49.7		58	50.0	59.6	
Between 51 and 65	29.2	34.4	28.1	2.1	38.9	35.3	39.6	1.2	18	33.3	14.7	5.9**
Total	**100**	**100**	**100**		**100**	**100**	**100**		**100**	**100**	**100**	
Age of household head	43.1	45.4	42.0	1.97	44.6	47	44.1	1.3	40.3	43.5	39.6	1.48
Educational Level												
None	7.0	15.6	5.1		8.8	14.7	7.5		4.8	16.7	2.2	
Primary	71.3	59.4	73.9		66.8	58.8	68.6		76.2	60.0	80.1	
Secondary and above	21.7	25.0	21.0	7.27**	24.4	26.5	23.9	1.65	19.0	23.3	17.6	8.68**
Total	**100**	**100**	**100**		**100**	**100**	**100**		**100**	**100**	**100**	
Marital Status												
Married	77.4	50	83.4		78.2	55.9	83.0		77	43.3	84	
Single (widow, divorced)	22.6	50	16.6	33.6***	21.8	44.1	17.0	12.1***	23	56.7	16	9.9***
Total	**100**	**100**	**100**		**100**	**100**	**100**		**100**	**100**	**100**	
Household size	4.9	4.6	5.0	1.51	4.9	4.5	5.0	1.5	4.9	4.8	5.0	0.56

Source: Field survey (2016)

** significant at 5%, degree of freedom (DOF) =2, Critical value at 5%= 5.991; DOF=1, critical value at 5% =3.84;

Regarding education, results presented in Table 3 show that majority (71.3%) of the respondents had primary education. About 7% had not attended any formal education while only 21.7% had attained secondary and above education. The proportion of male household heads with primary education is higher (73.9%) than the proportion of female household heads (59.4%) and the difference is significant at 5%, being higher in CDC (76.2%) compared to DCC (66.8%). In Tanzania primary education covering the first seven years of schooling is mandatory. However, there is a high drop-out rate (10.7%) among girls especially at the 4^{th} and 5^{th} grade (UNESCO, 2011), which explains the variation in primary school attainment between male and female farmers. About one fifth (21.7%) of the respondents had secondary education and above, being higher in DCC (24.4%) compared to CDC (19%). However, the highest proportion of secondary and post-secondary respondents was recorded among female respondents from DCC (26.5%) followed by female in CDC (23.3%). This can be explained by fact that few female who managed to reach secondary and post-secondary understand the importance of cash crop and some of them are employees from various institutions, hence they have capital to invest in cash crop production as their male counterparts.

Furthermore, results presented in Table 3 show about three quarter of the respondents (77.4%) were married while about one fifth (23%) were either single, widow or divorces families during the time of survey. The proportion of married couples in the sample reflects the composition of the population in the national data. However, the proportion of married couples in the sample is relative higher than the national composition (50.1%) (URT, 2017). The highest proportion of married farmers was recorded among farmers in DCC (78.2%). However, the proportion of male farmers who are married in both districts is significantly higher (above 83%) than the proportion of married female farmers in both districts (less than 56%).

In addition, the table shows that the average household size in the sample is 4.9 persons, which is slightly higher than that recorded in the national average, which is 4.7 persons per households in the Dodoma region. The higher household size was recorded among male headed households farmers (about 5 persons) compared to female household farmer. However, the difference is insignificant. Apart from discussion on socio-economic characteristic, other factors that are expected to influence wine grape production include institutional factors as described in the forthcoming section.

4.1.2 Institutional characteristics of respondents

According to results presented in table 4, majority of the respondents (63.2%) did not have access to credit. The proportion of male respondents who did not have access to credit is higher (63.7%) relative to 60.7% of female respondents, but there is no significant difference between them. However, specific comparison shows that there is a significantly high rate of access to credit for respondent from CDC (63.9%) compared to only 13.5% from DCC. In CDC a higher proportion (73.3%) of female respondents had credit compared to male respondents (61.8%). In contrast, a higher proportion (14.5%) of male respondents had access to credit relative to only 8.8% for female respondent in DCC. However, the difference is not significant between those who had credit and who did not receive credit. This is mainly because cash credit is a financial transfer of fund from a lender to a borrower hence only farmers who are willing to borrow and have the capacity to repay can access financial credit.

Table 4: Institutional characteristic of the respondents

	Whole sample				Dodoma city (DCC)				Chamwino district (CDC)			
Variable	**Total n=359** %	**Female n=64** %	**Male n=295** %	**Chi-square**	**Total n=193** %	**Female n=34** %	**Male n=159** %	**Chi-square**	**Total n= 166** %	**Female n=30** **%**	**Male n=136** **%**	**Chi-square**
Access to Credit												
Had credit access	36.8	39.1	36.3		**13.5**	8.8	14.5		63.9	73.3	61.8	
Had no credit access	63.2	60.9	63.7	0.18	86.5	91.2	85.5	0.76	36.1	26.7	38.2	1.43
Total	**100**	**100**	100		**100**	**100**	**100**		**100**	**100**	**100**	
Access to Extension service												
Received extension service	60.7	59.4	61		53.9	61.8	52.2		68.7	56.7	71.3	
Didn`t receive extension service	39.3	40.6	39	0.06	46.1	38.2	47.8	1.03	31.3	43.3	28.7	2.45
Total	**100**	**100**	**100**		**100**	**100**	**100**		**100**	**100**	**100**	
Group Membership												
Member of group	59.9	56.3	60.7		43	38.2	44		79.5	76.7	80.1	
Not member of group	40.1	43.8	39.3	0.43	57	61.8	56	0.38	20.5	23.3	19.9	0.18
Total	**100**	**100**	**100**		**100**	**100**	**100**		**100**	**100**	**100**	

Source: Field survey (2016)

** significant at 5%, DOF =2, Critical value at 5%= 5.991; DOF=1, critical value at 5% =3.84;

Also, most of the financial services providers in Tanzania are not gender insensitive; hence anyone who needs credit and has the ability to repay can access credit from private lenders regardless of their sex. In addition, most of the agricultural credit is provided upon having individual collateral such as land occupancy titled deed. Most of the farmers do not have such security. Consequently, majority of people (62%) in Tanzania can only access credit from informal financing instruments such as family, friends or informal money lenders and saving from group which is normally associated with high costs (Ellis *et al.* (2010).

Furthermore, results presented in Table 4 show that majority (60.9%) of the respondents had access to extension services being higher in CDC (68.7%) and significantly lower in DCC (53.9%). In CDC a higher proportion (71.3%) of male respondents had extension service compared to female respondents (56.7%). In contrast, a higher proportion (61.8%) of female respondents had access to extension service in DCC relative to male respondent (52.2%). The proportion of farmers who did not receive extension services is higher (46.1%) among farmers from DCC compared to farmers from CDC (31.3%), being higher (47.8%) among male farmers form DCC and significantly lower (28.7%) among male farmers in CDC. However, there is no significant difference between them in both districts because in Tanzania extension service is provided on demand driven basis and sometime farmers can get agricultural information or agricultural technical advice from alternative sources such as experienced neighbours as they meet in the field or listen at the radio or Television program (Daniel, 2013).

Slightly more than half of the respondents (59.9%) had group membership, being slightly higher for male farmers (60.7%) compared to 56.3% for female respondents, but the difference between them is not significant. Group membership was higher among respondents from CD (79.5%) compared to only 43% for respondents from DCC. In both districts a higher proportion of male respondents belong to groups relative to female respondent. The reverse holds true for farmers who did not join group organisation or cooperative, a higher proportion (57%) was found among farmers from DC relative to only 20.5% among farmers from CDC. The highest proportion (61.8%) was found among female farmers from DCC, however the difference between them was not significant because most of Agricultural Marketing and Cooperatives (AMCOs) are gender sensitive, hence each farmer who wishes to join a group or cooperative society can joined.

Understanding institutional factors is important in order to determine factors influencing farm performance. These factors act as conduits for diffusion of new knowledge and skill for grape production as well as a source of income for purchasing improved technology, which can assist farmers to improve their farm productivity. The results and discussion on farm yield and input usage are presented in the next section.

4.2 Output and Input Usage

Table 5 shows descriptive statistics of input usage and output produced. On average the mean yield of wine grapes under irrigated farms was relatively higher (6322.1 kg/ha) compared to 5078.6 kg/ha mean yield under rain-fed farms. The difference between mean yields among farmers is significant $(Z = 3.1; \alpha = 0.01)$ because vineyards under irrigated production have guaranteed water supply throughout the year to facilitate grape production, hence increases farm level productivity. Moreover, each irrigation scheme has a local area extension officer and a Cooperative Society or some form of group organisation. All these factors ensure good agronomic practices, leading to higher yields and profit among farmers.

Table 5: Output and input usage in wine grape production

Input/output	Description	Whole sample N=359	Irrigation n=176	Rain-fed n=183	Z-test	Female n=64	Male n=295	Z-test	DCC n=193	CDC n=166	Z-test
Yield (Kg/ha)	Mean	5688.2	6322.1	5078.6	3.1***	5118	5811.5	1.69*	6069.9	5236.9	2.1**
	Standard deviation	3831.7	4230.6	3302.7		2695.8	4017.9		4385.9	2969.7	
	Minimum	205.8	576.3	205.8		823.3	205.8		576.3	205.8	
	Maximum	27 993.3	27 993.3	19 759.5		13 510.9	27 993.3		27 993.3	19 760	
Labour (man-day/ha)	Mean	171.2	181.8	160.2	2.5***	156.0	174.5	1.69*	163.3	181	2.0**
	Standard deviation	83.0	84.6	76.0		78.3	83.7		83	82.2	
	Minimum	20.3	20.3	41.2		20.3	25.8		20.3	28.7	
	Maximum	349.1	349.1	256.6		343.3	349.1		341.1	349.1	
Manure (kg/ha)	Mean	5920.7	7440.6	4340.3	4.1***	6368	5823.6	0.47	5063.5	6926.4	8.9***
	Standard deviation	7477.9	9491.5	3971.7		8685.2	7202.4		4676.2	9688.7	
	Minimum	1646.7	2 470	1646.7		2470.0	1646.7		1646.7	2 470	
	Maximum	49 400	49 400	29 640		44 460.0	49 400.0		29 640	49 400	
Agrochemicals (kg/ha)	Mean	13.14	14.05	12.2	2.1**	12.8	13.2	0.31	14	12.1	2.2**
	Standard deviation	8.66	9.62	7.4		8.7	8.7		9.8	7.0	
	Minimum	3.80	3.80	2.3		2.3	3.8		3.80	3.4	
	Maximum	53.5	53.5	47.7		53.5	57.7		53.5	49.00	

Source: Field survey (2016)

Note : *** implies significance at 0.01 probability level,
** implies significance at 0.05 probability level, and
* implies significance at 0.1 probability level

Results (Table 5) also show that farmers from DCC had significantly higher mean yield (6069.9 kg/ha) compared to 5236.9 kg/ha for farmers from CDC $(Z = 2.1; \alpha = 0.05)$. A higher performance of farmers in DCC is attributed to the fact that they have better access to viticulturists from Makutupora Research and Training Centre (MRTC) and input markets compared to smallholder farmers from CDC. All these ensure good agronomic practices because exposure to viticulture service strengthens farmers` technical knowledge and skills on grape production. Meanwhile, male headed households had a higher mean yield (5811.5 kg/ha) compared to female headed households (5118 kg/ha), and difference is significant $(Z = 1.69; \alpha = 0.1)$. But, the standard deviation is also high, for example, 4230 kg/ha for farmers under irrigation, 4 385.9 kg/ha for farmers from DCC and 4017.9 kg/ha for male headed households, meaning that there is wide dispersion and could be due to few farmers having higher yields and remaining ones with low yields.

The findings also show that on average grape farmers under irrigated production technology used significantly more labour (181.8 working day/ha) compared to wine grape farmers under rain-fed production technology (160.2 working day/ha) (Table 5). This difference arises because in addition to normal vineyard operations, farmers under irrigated technology perform extra activities such as watering, they face an increased number of weeding, spraying, repair and maintenance of irrigation infrastructures. Moreover, the number of working days/ha in each farming system had a high standard deviation indicating that there is high variability in the number of working days among farmers in the study area (Table 5).

On average farmers from DCC used significantly more labour (181 man-day/ha) compared to farmers from CDC (163.3 man-day/ha) $(Z = 2.0; \alpha = 0.05)$. This difference could be attributed to the kind of production system practices in the two Districts. Wine grape farmers from DCC use furrow water irrigation system, hence more water is poured in a farm at a time while farmers from CDC uses drip water irrigation system. Consequently, farmers under furrow water irrigation face more frequent weeding and spraying. Meanwhile, male headed farmers used significantly more labour (174.5 man-day/ha) compared to 156 man-day/ha for female headed farmers $(Z = 1.69; \alpha = 0.1)$.

The results also show that irrigating farmers applied generally higher agrochemical (14 kg/ha) compared to rain-fed farmers (12.2 kg/ha) and the difference is statistically significant $(Z = 2.1; \alpha = 0.05)$, implying differences between the two farming systems. Good water supply for wine grape production apart from increasing the number of weeds also creates a conducive environment for insect reproduction, which increases the incidence of insects attack on grapes. Consequently, farmers under irrigated farming used significantly higher quantity of agrochemicals. Meanwhile, farmers from DCC applied significantly higher agrochemical (14 kg/ha) compared to rain-fed farmers (12.1 kg/ha) $(Z = 2.2; \alpha = 0.05)$ for the same reasons.

The findings also indicate that grape farmers in the study area applied a low quantity of manure (5920.7 kg/ha) compared to recommended rate of 10 to 20 t/ha of farm yard manure (Warnars and Oppenoorth, 2014). However, a significantly low quantity of manure (4340.3 kg/ha) was applied by farmers under rain-fed production compared to 7440.6 kg/ha under irrigated farms $(Z = 4.1; \alpha = 0.01)$. Moreover, farmers from DCC applied significantly low quantity of manure (5063.5 kg/ha) compared to 6926.4 kg/ha for farmers from CDC $(Z = 8.9; \alpha = 0.01)$. This difference can be explained by the fact that in rural area grape farmers cultivate many crops both requiring manure application. Sometimes cow manure is being used as a source of cooking energy. This multiple demand for manure or cow dung reduces the quantity available for use in wine grape farms. It is worth noting however that farm productivity and input usage is not only an indicator of assessing farm performance, since there are several other parameters such as farm profitability and profit efficiency, which are also used to assess farm performance. Before assessing farm profitability and profit efficiency, it worthwhile analysing farm inputs cost, as presented in the next subsection.

4.2.1 Input cost analysis

Table 6 presents input cost analysis. The results show that farmers under irrigated production technology used significantly higher labour cost (1 145 002.4 TZS/ha) compared to 999 145.31 TZS/ha for farmers under rain-fed production system $(Z = 2.6; \alpha = 0.05)$. Also, farmers from DCC incurred significantly higher labour cost (1 284 344 TZS/ha) compared to 892 154.1 TZS/ha for farmers from CDC $(Z = 5.7; \alpha = 0.01)$. This differences can be explained by the additional activities, which are performed by farmers under irrigation, as pointed out in the previous subsection (4.2). Labour cost per hectare had a higher standard deviation indicating that there was great variation in labour cost for most of the smallholder farmers. Meanwhile, female headed households used higher labour cost (1 141 395.4 TZS/ha) compared to their male counterparts (1 058 771.9 TZS/ha), however their difference between them is insignificant (Table 6).

Table 6: Input cost analysis

Cost Items	Description	Whole sample n=359	Irrigation n=176	Rain-fed n=183	Z-test	Female n=64	Male n=295	Z-test	DCC n=193	CDC n=166	Z-test
Labour cost (TZS/ha)	Mean	1 073 501.8	1 145 002.4	999 157.3	2.6***	1 141 395.4	1 058 771.9	0.90	1 284 344	892 154.1	5.7***
	Std. deviation	519 926.7	520 553.2	510 182.2		257 260.7	261 703.8		291 921.7	205 464.7	
	Minimum	134 800.8	134 800.8	242 239.6		145 338.9	134 800.8		134 800.8	221 391.5	
	Maximum	1 694 270.8	1 694 270.8	1 342 787.5		992 371.5	1 694 270.8		920 248.1	1 694 270.8	
Agrochemicals cost (TZS/ha)	Mean	367 500.2	377 113.1	323 003.7	2.2**	359 745.5	369 182.5	0.29	411 652.2	316 166.8	3.6***
	Std. deviation	267 449.6	267 440.4	185 408.4		242 164.5	272 979.6		329 088.3	155 707.4	
	Minimum	58 592.5	65 577.4	58 592.5		65 577.4	58 592.5		58 592.5	69 148.9	
	Maximum	1 464 529.0	1 342 787.5	1 464 529.0		1 045 685.9	1 464 529.0		1 464 529.0	1 319 118.4	
Annual capital recovery cost(TZS/ha)	Mean	469 193.5	619 104.3	509 825.5	3.1***	471 095.3	468 781.0	0.03	306 277.0	658 608.75	11.8***
	Std. deviation	310 662.7	329 494.5	335 479.8		121 744.3	126 833.0		81 072.2	126 222.1	
	Minimum	85 812.0	101 269.2	85 812.0		96 700.3	85 812.0		85 812.0	89 376.4	
	Maximum	914 822.3	914 822.3	673 924.2		573 875.5	914 822.3		673 924.2	914 822.3	
Manure cost (TZS/ha)	Mean	65 541.0	78 583.3	50 761.0	3.6***	63 218.4	66 044.9	0.24	65 847.3	65 184.8	0.055
	Std. deviation	83 539. 6	90 668.6	52 879.2		81 951.1	84 008.9		77 805.3	89 986.1	
	Minimum	14 114.3	14 114.3	21 051.3		15 878.6	14 114.3		16 466.7	14 114.3	
	Maximum	428 133.3	428 133.0	378 924.1		400 140.0	428 133.3		428 133.3	419 145.0	

Source: Field survey (2016)

Note: *** implies significance at 0.01 probability level,
** implies significance at 0.05 probability level, and
* implies significance at 0.1 probability level

The results also show that farmers under irrigation production technology had a higher mean cost of agrochemicals (377 113.1 TZS/ha) compared to farmers under rain-fed production technology (323 003.7 TZS/ha), being significantly different $(Z = 2.2; \alpha = 0.05)$, this is mainly because farmers under irrigation farming used significantly high quantity of agrochemicals as discussed earlier (subsection 4.2). Also, farmers from DCC had a higher mean cost of agrochemical (411 652.2 TZS/ha) compared to farmers from CDC (316 166.8 TZS/ha) and the difference is significant $(Z = 3.6; \alpha = 0.01)$. This difference arises from high amount of agrochemical applied by farmers from DCC compared to farmers from CDC.

Further analysis indicates that farmers under irrigation production technology had significantly higher annual capital expenditure (619 102.5 TZS/ha) compared to 509 825.5 TZS/ha for farmers under rain-fed production technology. This difference arises from the initial establishment cost of the vineyard, which was used to compute annual capital recovery costs. The study by LWR (2016) established that initial establishment cost of an irrigated grape farms is higher (about 16.3 million TZS/ha) compared to 7.5 million TZS/ha under rain-fed grape farms. The findings also show that significantly higher capital expenditure (658 608.75 TZS/ha) was found among farmers from CDC compared to 306 277 TZS/ha for farmers from DCC $(Z = 11.8; \alpha = 0.01)$, as pointed out in section 4.2 that some of farmers from CDC are using drip water irrigation, which is relatively expensive compared to furrow water irrigation, hence their capital expenditure is high. However, there is no significant difference in capital expenditure between male and female headed households (Table 6).

Furthermore, manure cost is significantly higher (78 583.3 TZS/ha) under irrigation farming than 50 761 TZS/ha under rain-fed production $(Z = 3.6; \alpha = 0.001)$. The main difference lies on the quantity of manure applied to the vineyard, as explained in section 4.2 of this study. These differences in input costs are expected to influence respective farm level profit as reported in table 8. This study also discussed cost structure of grape farming as presented in the next section.

4.2.2 Cost structure of grape farming

The cost structure of grape production is shown in Table 7. Irrigating farmers generally incurred higher cost of production compared to rain-fed farmers as can be seen by cost of labour, agrochemical, manure and fixed cost. The total annual cost of production under irrigation farming was about 2 219 803.10 TZS/ha while under rain-fed was about 1 882 736.26 TZS/ha. The total variable cost is 1 600 698.80 TZS/ha under irrigation and 1 372 910 TZS/ha under rain-fed farming. Total variable cost represented 72.1% of total production cost under irrigation and 73.1% under rain-fed, while fixed cost stood at 619 104.30 TZS/ha under irrigation and 509 826.25 TZS/ha under rain-fed. Total fixed cost represented 27.9% of total cost under irrigation and 26.9% under rain-fed.

Table 7: Estimated cost structure of grape farming

		Irrigation n=176		Rain-fed n=183		Female n=64		Male n=295		CDC n=166		DCC n=193	
	Description	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**	**Amount**	**Percent**
	Labour cost												
1	Pruning	159 972.83	10	142 202.2	10.4	93 475.0	6.0	108 930.2	7.3	92 851.2	5.3	196 088.6	16.1
2	Tying	123 443.60	**7.7**	136 589.0	9.9	91 110.8	5.8	143 935.0	9.6	69 306.0	3.9	132 384.3	10.9
3	Weeding	313 647.52	19.6	265 070.0	19.3	266 464.1	17.0	231 898.2	15.5	192 553.6	10.9	265 375.0	21.8
4	Trellis repair	61 721.8	3.9	77 961.8	5.7	76 198.8	4.9	79 697.4	5.3	112 738.2	6.4	95 774.2	7.9
5	Spraying	96 991.4	6.1	94 458.5	6.9	170 545.2	10.9	89 673.5	6.0	108 484.9	6.2	172 839.6	14.2
6	Irrigation	110 847.3	6.9	0	0	208 133.5	13.3	186 724.3	12.5	98 150.7	5.6	16 603.3	13.8
7	Manure application	94 472.1	5.9	82 502.2	6	48 848.0	3.1	63 738.7	4.3	34 220.9	1.9	49 188.4	4.0
8	Replacement/repair	42 197.6	2.6	60 810.2	4.4	55 582.2	3.6	54 961.8	3.7	21 779.1	1.2	46 787.5	3.8
9	Harvesting	141 708.2	8.9	139 551.5	10.2	131 037.8	8.4	99 212.8	6.6	108 069.4	6.1	157 303.2	12.9
10	**A. Total labour Cost**	**1 145 002.4**	**71.5**	**999 145.3**	**72.8**	**1 141 395.4**	**73.0**	**1 058 771.9**	**70.9**	**838 154.1**	**68.7**	**1 284 344.0**	**72.9**
11	B. Agrochemical (kg)	377113.1	23.6	323 003.7	23.5	359 745.5	23.0	369 182.5	24.7	316 166.8	25.9	411 652.2	23.4
12	C. Manure (kg)	78583.3	4.9	50 761.0	3.7	63 218.4	4.0	66 044.9	4.4	651 84.8	5.3	65 847.3	3.7
13	TVC (A+B+C)	**1 600 698.8**	**100**	**1 372 910.0**	**100**	**1 564 359.3**	**100**	**1 493 999.3**	**100**	**1 219 505.7**	**100**	**1 761 843.5**	**100**
	Fixed cost												
14	Depreciation	52 898.1	8.5	42 098.3	8.3	35 332.1	7.5	39 879.3	8.5	57 299.0	8.7	22 051.9	7.2
15	Annual recovery Cost	566 206.2	91.5	467 727.9	91.7	435 763.2	92.5	428 901.7	91.5	601 309.8	91.3	284 225.1	92.8
16	Total Fixed cost (14+15)	619 104.3	100	509 826.3	100	471 095.3	100	468 781.0	100	658 608.7	100	306 277.0	100
17	Total Cost (13+16)	**2 219 803.1**		**1 882 736.3**		**2 035 454.6**		**1 962 780.3**		**1 878 114.5**		**2 068 120.5**	

Source: Field survey (2016)

The findings also show that farmers from DCC incurred higher cost of production compared to farmers from CDC. The total production cost in DCC was about 2 068 120.50 TZS/ha while in CDC was about 1 878 114.50 TZS/ha. The total variable cost is 1 284 344 TZS/ha in DCC and 838 154.10 TZS/ha in CDC. Total variable cost represented 72.9% of total production cost in DCC and 68.7% in CDC, while fixed cost stood at 658 608.7 TZS/ha in CDC and 306 277 TZS/ha in DCC. Total fixed cost represented 27.1% of total cost in DCC and 31.3% in CDC. Results also indicate that female headed households had a higher total production cost (2 035 454.60 TZS/ha) compared to male headed households (1 962 780.30 TZS/ha). Total variable cost accounted for about 73% for female headed households and 70.9% for male headed households. Total fixed cost represents 27% of total production cost for male headed household and 29.1% for female headed households.

The findings reveal that labour cost represented the highest percentage of the cost structure for all farmers varying from 68.7% to 73% (Table 7), followed by cost of agrochemical which varied between 23% and 25.9%. The least cost component for total variable cost was manure, varying between 3.7% and 5.3% for all farmers. This high labour cost was attributable to low level of mechanization since every activity is done manually. Weeding was the most costly farm labour operations, which varied from 10.9% to 21.8% for all farmers. The least expensive labour cost component was repair and maintenance, ranging from 1.2% to 4.4%. Other cost items include annual capital recovery cost and depreciation. The annual capital recovery cost constitutes the highest share of fixed cost, which varies between 91% and 93%. As pointed out in section 4.2, the analysis of input cost is important in order to assess farm profitability, as presented in subsection 4.3.

4.3 Profitability analysis

The results presented in Table 8 show that gross returns from grape production were 6 092 308.52 TZS/ha under irrigation and 4 893 987.81 TZS/ha under rain-fed production technology. Gross margin was 4 491 609.70 TZS/ha under irrigation and 3 511 260.60 TZS/ha under rain-fed, while the net farm income was estimated at 3 872 505.42 TZS/ha under irrigation and 3 011 251.55 TZS/ha under rain-fed. The findings also reveal that male headed households had a higher gross returns (5 459 904.30 TZS/ha) compared to female headed households (4 902 020.40 TZS/ha). The net farm income was 3 497 124 TZS/ha for male headed households and 2 866 565.80 TZS/ha for female headed households.

Moreover, the results indicate that smallholder farmers from DCC had a higher gross return (5 756 086.2 TZS/ha) compared to farmers from CDC (4 549 295 TZS/ha). Likewise, net farm income was higher (3 687 965.60 TZS/ha) for farmers from DCC compared to 2 671 180.60 TZS/ha for farmers from CDC. The positive gross margin and net farm income values obtained by the farmers indicate that wine grape production is profitable venture in the study area.

Table 8: Profitability analysis

	Description	Irrigation n=176	Rain-fed n=183	Z-test	Female n=64	Male n=295	Z-test	DCC n=193	CDC n=166	Z-test
1	Quantity of grape (kg/ha)	6322.1	5078.6	3.1***	5118	5811.5	1.69*	6069.9	5236.9	2.1**
2	Mean price (TZS/kg)	963.6	963.6		957.8	939.5		948.30	868.7	
3	Mean labour (Man-day/ha)	181.8	160.2	2.5***	156	174.5	1.69*	163.3	181	2.0**
4	Gross returns(sale of grapes) (1X2)	6 092 308.5	4 893 987.8		4 902 020.4	5 459 904.3		5 756 086.2	4 549 295.0	
5	Total Variable Costs(TZS/ha)	1 600 698.8	1 372 910		1 564 359.3	1 493 999.3		1 761 843.5	1 219 505.7	
6	Total fixed cost (TZS/ha)	619 104.3	509 826.25		471 095.3	468 781.0		306 277.0	658 608.7	
7	Total Production Cost (5+6) (TZS/ha)	2 219 803.1	1 882 553.5		2 035 454.6	1 962 780.3		2 068 120.5	1 878 114.5	
8	Gross Margin (4-5) (TZS/ha)	4 491 609.7	3 511 260.6		3 337 661.1	3 965 905.0		3 994 242.6	3 329 789.3	
9	Profit (4-7) (TZS/ha)	3 872 505.4	3 011 251.6		2 866 565.8	3 497 124.0		3 687 965.6	2 671 180.6	
10	Return on Investment (9/7)	1.74	1.29	2.08**	1.30	1.70	1.9**	1.80	1.40	1.8**

Source: Field survey (2016)

Note: *** implies significance at 0.01 probability level,
** implies significance at 0.05 probability level, and
* implies significance at 0.1 probability level

The return on investment from wine grape farming was TZS 1.74 under irrigation and TZS 1.29 under rain-fed, implying for every one shilling invested in production there was an additional return of TZS 0.74 under irrigation and TZS 0.29 under rain-fed. The difference in return on investment between irrigated and rain-fed is significant $(Z = 2.08 : \alpha = 0.05)$, therefore the first null hypothesis of this study was rejected, implying that there is a significant difference in profit levels attained by farmers comparing between irrigated and rain-fed. The return on investment under irrigated farms is higher than findings by Khair *et al.* (2009) who reported a return of 38% of grape orchard in Pishin – Pakistan and the findings by Appasmandri *et al.* (2017) who found a 39% return on grapevine production in Coimbatore in India. The higher return on investment for grape farming in Dodoma could be attributed to prevailing good weather condition for grape farming in Dodoma region as compared to hot climate in Pakistan and India, eventually leads higher farm productivity and profit levels. Also, good output market which led to a higher prices during 2015 growing seasons. All these factors ensure higher farm income and profit levels leading to higher return on investment among farmers.

The findings also indicate that return on investment was significantly higher (TZS 1.80) for farmers from DCC compared to TZS 1.40 for farmers from CDC $(Z = 1.8; \alpha = 0.05)$. This means, for every one shilling invested in grape farming there was additional return of TZS 0.80 for farmers from DCC and TZS 0.40 for farmers from CDC. Meanwhile, male headed households had a higher return on investment (TZS 1.70) compared to female headed households (TZS 1.3) and the difference is significant $(Z = 1.9; \alpha = 0.05)$, implying that for every one shilling invested, there was average return of TZS 0.70 for male headed households and TZS 0.30 for female headed households. The average returns for every shilling invested in wine grape production in the study area is higher than the prevailing weighted average rates on risk free investment such as treasury bills and bonds, which currently standing at 16.8 – 18.7% (Bank of Tanzania–BOT, 2017).

4.3.1 Distribution of grape farmers by profit levels

The distribution of grape farmers by profit levels is shown in Table 9. The results indicated that approximately half of the farmers (52.5%) received profit varying between 1 001 000 and 5 million TZS/ha. About 7.5% of farmers had a loss and 7.8% received profit above 10 million TZS/ha. The proportion of farmers who received profit level between 1 001 000 and 5 million TZS/ha was higher under irrigation (56.8%) compared to farmers under rain-fed farming (48.1%). Also, the proportion of farmers who received profit level above 10 million TZS/ha was higher under irrigation (8.5%) compared to farmers under rain-fed (7.1%). Meanwhile, the proportion of farmers who incurred a loss was higher under rain-fed (9.3%) compared to those under irrigation (5.7%). The maximum return was 24 180 639.83 TZS/ha, while the highest loss was 2 147 638.73 TZS/ha. None of the wine grape farmers operated at the break-even point that is $TR - TC = 0$.

Table 9: Distribution of wine grape farmers by profit levels

	Whole sample	Rain-fed	Irrigated	Female	Male	DCC	CDC	
Profit levels (TZS/ha)	**Distribution %**	**Distribution %**	**Distribution %**	**Distribution %**	**Distribution %**	**Distribution %**	**Distribution %**	**Min/Max**
0<	7.5	9.3	5.7	6.3	7.8	7.3	7.8	-2 147 638.73
1-1 000 000	13.9	16.9	10.8	20.3	12.9	14.5	13.9	
1 001 000 –5 000 000	52.4	48.1	56.8	48.4	52.9	43.5	62.0	
5001 000 -10 000 000	18.4	18.6	18.2	23.4	17.3	22.3	13.9	
> 10 000 000	7.8	7.1	8.5	1.6	9.2	12.4	2.4	
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	24 180 639.83

Source: Field survey (2016)

Results also show that the proportion of farmers who received profit level between 1 001 000 and 5 million TZS/ha was higher (52.9%) among male headed households compared to female headed households (48.4%). Also, the proportion of farmers who received profit level above 10 million TZS/ha were higher (9.2%) among the male headed households compared to 1.6% for the female headed households. The proportion of farmers who incurred a loss was higher (7.8%) among the male headed households compared to 6.3% for their female headed counterparts (Table 9).

Furthermore, results indicate that proportion of farmers who received profit level between 1 001 000 and 5 million TZS/ha was higher (62%) among farmers from CDC compared to 43.5% for farmers from DCC (Table 9). However, the proportion of farmers who received profit level between 5001 000 and 10 million TZS/ha was higher (22.3%) among farmers from DCC compared to farmers from CDC (13.9%). Likewise, the proportion of farmers who received profit level above TZS 10 million TZS/ha were higher (12.4%) among farmer from DCC compared to farmers from CDC (2.4%). The possible explanation for this is that smallholder farmers in DCC fetch higher prices compared to farmers in CDC who are found far away from processing industries and other markets. Meanwhile, the proportion of farmers who incurred a loss was slightly higher (7.8%) among farmers from DCC compared to those from CDC (7.3%).

The profitability analysis is an important economic indicator for measuring farm performance. However, this measure cannot be used to assess the effect of socio-economic, institutional factors and other factors on farm profit. The profit efficiency indicators would be useful to assess the effect of socio-economic and institutional factors to compliment the profitability or return on investment. However, before presenting results on profit efficiency and factors accounting for efficiency differences, it is important to check the existence of profit efficiency among farmers, which is presented in subsection 4.4.

4.4 Hypotheses Tests for Inefficiency Effects

The estimated value of gamma (γ) was 0.845 for irrigated and 0.713 for rain-fed farms, all values were significantly different from zero at 99% level of significance (Table 10). This means, the inefficiency effects does exist; therefore, the second null hypothesis of this study $(H_{02}: \mu_i = 0)$ is rejected $(\alpha = 0.01)$, implying that some smallholder wine grape farmers in the study area are not operating on the profit frontier due to farm specific characteristics. The Log Likelihood statistic (λ) was 90.82 for irrigated farms and 81.10 for rain-fed farms, all being significant different from zero at 99% level of significance (Table 10). Hence, the third null hypothesis testing for absence of profit inefficiency $(H_{03}: \gamma_{ij} = \delta_{ij} = 0)$ is rejected $(\alpha = 0.01)$, implying that some socio-economic and institutional variables (such as extension services, access to credit and farmer`s experience) explain variation of profit inefficiency among farmers.

Table 10: Hypotheses tests for profit efficiency and inefficiency effects

Model	Restriction	H_0	Log Likelihood tests (λ)	Outcome
Irrigated	$H_{02}: \gamma_{ij} = \mu_{ij} = 0$	No inefficiency	90.82***	Reject H_0
Rain-fed			81.10***	Reject H_0
Irrigated	$H_{03}: \gamma_{ij} = \delta_{ij} = 0$	Specific farm characteristics does not influence efficiency	0.845***	Reject H_0
Rain-fed			0.713***	Reject H_0

Source: MLE results
***significant at 1% level of significance

4.4.1 Stochastic profit frontier estimates

The stochastic profit frontier model was tested for its goodness of fit and accuracy of the specified distribution of the composite error term. The estimated total variance (σ^2) of the composite error for each model (0.459 for irrigated and 0.391 for rain-fed farming) was significantly different from zero $(\alpha = 0.01)$ (Table 11), indicating goodness of fit and correct specification for the distribution of the composite error term.

The maximum likelihood parameter estimates are presented in Table 11. With the exception of manure which was not significant, the coefficient of labour and agrochemical cost for all models had expected negative sign and were both significantly different from zero 5% level. This implies that estimated wine grape profit function is non-increasing in input prices. Reducing the cost of these variables, especially agrochemical and labour will significantly increase profit in wine grape farming. This implied that one shilling increase in labour cost would reduce wine grape profit by; 0.078 TZS under rain-fed production and by 0.036 TZS under irrigated production.

The findings also show that agrochemical cost can potentially lower the profit of wine grape farmers in the study area, implying that a one shilling increase in agrochemical costs can decrease the profit by; 0.031 TZS for irrigated and by 0.095 TZS under rain-fed production. The estimated coefficient for number of plants per hectare under irrigation and rain-fed production were all positive and statistically significant different from zero at 95% and 99% level, implying that an increase of one grapevine plant per hectare up to optimum plant population can increased profit by; 0.089 TZS under rain-fed production and by 0.054 TZS under irrigated production.

Table 11: Maximum likelihood estimates

Stochastic profit frontier	Irrigated farms			Rain-fed farms		
	Coefficient	**Standard error**	**t-test**	**Coefficient**	**Standard error**	**t-test**
Intercept	29.292	4.846	6.04	6.052	1.417	4.27
Cost of labour	-0.036**	0.016	-2.26	-0.078**	0.038	-2.03
Cost of manure	-0.019	0.075	-0.26	-0.012	0.051	-0.25
Cost of agrochemical	-0.031**	0.014	-2.22	-0.095**	0.049	-1.93
Number of plants	0.054**	0.026	2.06	0.089**	0.034	2.10
Diagnostic statistic						
Sigma-squared $\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.459***	0.068	6.79	0.391***	0.098	3.99
gamma $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$	0.845***	0.173	4.88	0.713***	0.139	5.13
LR test of one sided error	90.816			81.099		

Source: Computer print-out of FRONTIER 4.1

Note: *** implies significance at 0.01 probability level,
** implies significance at 0.05 probability level, and
* implies significance at 0.1 probability level

Dependent variable is the logged profit

4.4.2 Distribution of profit efficiency

The profit efficiency scores presented in Table 12 show that majority (above 65%) of the farmers had scores greater than 60% relative to the estimated profit frontier. The proportion of farmers under irrigation who had profit efficiency scores greater than 60% was slightly higher (67%) compared to the proportion farmers under rain-fed (65%). Moreover, the proportion of farmers from CDC who had profit efficiency scores greater than 60% was higher (73%) compared to 70% for the farmers from DCC. Meanwhile, the proportion of male headed households under irrigation who had profit efficiency scores greater than 60% was higher (79%) compared to female headed households (76%). The results also show that a higher proportion (80%) of female headed households under rain-fed had profit efficiency scores greater than 60% compared to 67% for male headed households (Table 12)

Table 12: Profit efficiency scores of wine grape farmers

Efficiency score	Irrigated n=176	Rain-fed n=183		DCC	CDC		Under Irrigation			Under Rain-fed		
							Female n=34	Male n=142		Female n=30	Male n=153	
	%	%	Z-test	%	%	Z-test	%	%	Z-test	%	%	Z-test
Below 20	5	4		3	4		3	4		3	1	
21 - 30	6	6		4	6		6	6		3	4	
31 - 40	5	3		1	2		3	3		3	6	
41 - 50	5	6		7	5		6	4		3	7	
51 - 60	12	16		16	10		6	4		7	15	
above 60	67	65		70	73		76	79		80	67	
Total	**100**	**100**		**100**	**100**		**100**	**100**		**100**	**100**	
Mean	69	63	2.86***	69	66	1.64*	68	70	0.46	66	63	1.16
Standard deviation	21	20		19	18		22	19		16	16	
Maximum	95	93		91	91		90	95		85	93	
Minimum	12	6		8	7		19	12		6	15	

Source: Computed from MLE Results

Note: *** implies significance at 0.01 probability level, and
* implies significance at 0.1 probability level

The maximum profit efficiency score attained was 95% while the minimum was 6% (Table 12). A significantly high mean profit efficiency (69%) was achieved by farmers under irrigated farming compared to 63% for farmers under rain-fed $(Z = 2.86 : \alpha = 0.01)$, implying potential for improvement by more than 30% through more efficient use of the available resources. Similarly, a higher mean profit efficiency score (69%) was obtained by farmers from DCC compared to farmers from CDC (66%) and the difference between them was significant $(Z = 1.64; \alpha = 0.1)$, implying that on average grape farmers from DCC perform better than farmers from CDC. The findings also show that the mean profit efficiency was slightly higher (70%) for male headed households under irrigation compared to 68% for female headed households, although the difference between them was insignificant. Likewise, the mean profit efficiency score for female headed households under rain-fed was higher (66%) compared to male headed households (63%), however, their difference is also insignificant.

Most of the farmers in the study area are not fully profit efficient because more than 30% of profit is lost due to inefficiency. Hence, it is important to identify sources of profit inefficiency among farmers. This can be done by investigating the relationship between farm`s specific characteristic and profit efficiency. Identifying sources of profit inefficiency is important for policy recommendation in order to improve and sustain grape productivity and production in the study area. Results of the profit inefficiency model are presented and discussed in subsection 4.5 of this thesis.

4.5 Factor Explaining Profit Efficiency Variation

Results in Table 13 show factors that explain profit inefficiency variation among farmers. As described in subsection 3.6.3.3, a variable with a negative coefficient, means that variable is positively related to profit efficiency, while a variable with a positive sign, implies that a variable increases profit inefficiency. The coefficient for experience had the expected negative sign for both models, however only the coefficient for rain-fed production was statistically significantly $(\alpha = 0.05)$. This implies that farmers with more years of experience exhibited significantly higher profit efficiency compared to farmers with less years of experience because experience in wine grape production and marketing assist farmers to improve managerial skill acquired over time, which enabled them to reduce unnecessary production and transaction cost. This result is consistent with findings of Lwelamira *et al.* (2015b) while studying technical efficiency in grape farming among smallholder farmers in Dodoma District. Similarly, Guesmi *et al.* (2012) found that farmers` experience improve technical efficiency of organic grape farming in Catalonia-Spain.

The findings also indicate that access to credit had a negative sign that was statistically significant $(\alpha = 0.05)$ for both farming systems. This implies that access to credit increases profit efficiency among farmers because credit enables farmers to purchase productive input such as fertilizers and agrochemicals, which they cannot afford to purchase from their own cash. These inputs can increase farm level productivity and eventually increases farm profit. Similar results were also reported by Mulie (2014) among coffee farmers in Ethiopia. However, other studies have revealed that farmers who accessed credit are as efficient as those who did not (Dziwornu and Sarpong, 2014; Chikobola, 2016; Saysay *et al.* 2016).

Table 13: Source of profit inefficiency

	Irrigated farms			Rain-fed farms		
Variables	**Coefficient**	**Standard error**	**t-test**	**Coefficient**	**Standard error**	**t-test**
Intercept	1.34	0.538	2.48	1.905	0.323	5.90
experience	-0.012	0.079	-0.16	-0.248**	0.111	-2.24
Education level (years)	-0.086	0.139	-0.62	-0.210	0.152	-1.38
Sex (dummy: Male=1, Female =0)	-0.049	0.191	-0.26	-0.018	0.258	-0.07
Credit (dummy: accessed=1,no access=0)	-0.835***	0.230	-3.63	-0.617**	0.227	-2.72
Extension (dummy: accessed=1, no access =0)	-0.856***	0.315	-2.72	-3.602***	0.656	-5.49
Membership (dummy: member=1, non- member=0)	-0.472**	0.182	-2.60	-0.815***	0.261	-3.12
Location (DCC=1, CDC=0)	-0.455*	0.240	-1.90	-0.801***	0.239	-3.35

Source: Computer print-out of FRONTIER 4.1

Note: *** implies significance at 0.01 probability level,
** implies significance at 0.05 probability level, and
* implies significance at 0.1 probability level

Similarly, access to extension service had a negative sign (as expected) that was significantly related to profit inefficiency $(\alpha = 0.01)$, suggesting that farmers who had access to extension services had higher profit efficiency. This should be expected because extension service acts as a channel for diffusion of new technologies to farmers. Therefore, exposure to extension service strengthens farmers` technical knowledge and skills on grape production. All these improve their performance, which is translated into higher farm level productivity. This result collaborates with the findings of Dziwornu and Sarpong (2014), Mulie (2014), Chikobola (2016) and Saysay *et al.* (2016) who found that access to extension service can reduce profit inefficiency among farmers.

Moreover, there is a significant negative relationship between group membership and profit inefficiency for both farming systems (Table 13), implying that farmers who joined groups operate closer to the profit frontier than farmers who do not belong to groups. Membership in group organizations or cooperatives allow them to share information among them, especially on farm management practices and market information, which eventually leads to higher grape yield and farm profit. Membership in cooperative also helps farmer to reduce transaction and marketing cost. This finding is in line with that of Galawat and Yabe (2012), Tanko and Obalola (2013), Saysay *et al.* (2016) and Kuboja *et al.* (2017) who noted that membership in cooperatives or farmers` groups determined the improvement of resource use efficient for different crops.

The coefficient for location had a negative and significant relationship with profit inefficiency for both models, implying that wine grape farmers from DCC receive significantly higher profit $(\alpha = 0.05)$ compared to farmers from CDC. This difference can be explained by several factors such as access to viticulture services and closeness to input and output markets. These factors lead to better farm management practices which improve farm productivity, eventually translating to higher farm profit. The present study also used parameter estimates of the profit frontier model presented in Table 11 (subsection 4.4.1) to compute indirect factor demand price elasticities among farmers. Results of the factor demand response analysis are presented in subsection 4.6.

4.6 Factor Demand Analysis

Results presented in Table 14 show estimates of factor demand functions. The findings show that the F - *statistics* was 105.8 for labour demand, 633.1 for manure and 424.9 for agrochemical demand functions, all were statistically significant at 1% level, indicating that each model has good fit of the data. Although, the coefficient of determination for labour $(R^2 = 0.54)$ is low compared to coefficient of determination for agrochemicals $(R^2 = 0.83)$ and manure $(R^2 = 0.88)$. This means, the explanatory variables included in the model explained only 54% of variation in labour demand, 83% of variation in agrochemicals and 88% of variation in farm yard manure, other percent was explained by the factors which are not included in the models. The parameter estimates of factor demand functions indicate either own factors or cross-factor price elasticities with respect to labour, manure and agrochemicals.

Table 14: Factor demand elasticities for whole sample

Description	Local wage	Price of manure	Price of Agrochemical	F-test	Adjusted R^2
	Coefficient	Coefficient	Coefficient		
Labour	-0.80*** (-20.37)	-0.52 (-0.47)	3.58*** (6.83)	105.8***	0.54
Manure	-0.56 (-1.29)	-0.83*** (-47.93)	-0.71** (-1.95)	633.1***	0.88
Agrochemical	-0.48 (-1.31)	-2.89*** (-4.46)	-0.81*** (-37.57)	424.9***	0.83

Source: Field survey (2016)

Note: *** implies significance at 0.01 probability level,
** implies significance at 0.05 probability level, and
* implies significance at 0.1 probability level

Figures in parenthesis are t-values

The findings also indicate that the coefficient for own factor price elasticities for labour, manure and agrochemicals had an anticipated negative sign and were statistically significant (*i.e.,* -0.80 for labour, -0.83 for manure and -0.81 for agrochemicals), implying that on average a 1% increase in price of these inputs would result to a reduction of 0.80% demand for labour, 0.83% demand for manure and 0.81% demand for agrochemical. These results were consistent with the theory of demand, which states that there is negative relationship between factor demand and factor price. This findings further suggest that in the short-run, farmer`s demand for the inputs does not quickly adjust to changes in their own input prices.

The possible explanation for this is that first, wine grape is a perishable fruit which is very much affected by insects, fungi and termites. Hence, the use of agrochemical is a must; secondly, wine grape production in the study area is not mechanized hence the use of labour is inevitable; third, wine grape is a perennial crop therefore in order to realize higher productivity, manure application is of paramount important; fourth grapes is the only perennial commercial crop grown in Dodoma city and Chamwino district and wine grape farmers are price taker in input and output markets as such changes in factor prices are likely to have little influence on their decision to raise or reduce the input utilization because effect of non-price factors could have significant effects on input utilization that overrides the effect of prices.

The coefficient for cross-factor price elasticities had a mixed sign (Table 14). The results show that the elasticity of labour demand with respect to agrochemical price is 3.58, implying that on average a 1% increase in the price of labour will increase the demand for agrochemical by 3.58%. This means, labour and agrochemical are substitutes, especially for weeding. Moreover, the results show that manure and agrochemical had a negative sign and statistically significant relationship, implying that manure and agrochemical are complementary inputs such that this pair of input fails to replace one another. For example, the factor demand response for manure with respect to agrochemical price was -0.71, was significantly different from zero at 5% level significance. This means, on average a 1% increase in manure price would reduce the demand for agrochemical by 0.71%.

Meanwhile, demand for agrochemical with respect to manure price was -2.89 (Table 14), which was significant different from zero at 1% level. This means, on average a 1% increase in agrochemical price would reduce demand for manure by 2.89%. In practice, this means that agrochemical and manure are complementary inputs; hence usage of these inputs for grape production goes together in fixed proportion. The economic implication is that, any policy targeting on reducing fertilizer, agrochemical and labour cost would improve productivity and profit efficiency. Based on these findings, the fourth null hypothesis of this study, which states that changes in the price of labour, manure and agrochemical do not influence the demand for corresponding own inputs and other related inputs, was rejected. This implies that changes in the price of labour, manure and agrochemical influence the demand for corresponding own inputs and other related inputs. In addition to the analysis of factor demand response for the whole sample, the present study also analyse factor demand response among irrigating farmers and rain-fed farmers. Factor demand responses for these farming systems are presented in the next section.

4.6.1 Factor demand response of rain-fed farmers

The results presented in Table 15 shows own and cross-factor price elasticities for labour, manure and agrochemical under rain-fed production. The findings show that the coefficient for determination of labour $(R^2 = 0.57)$ is low compared to coefficient for determination of agrochemicals $(R^2 = 0.83)$ and manure $(R^2 = 0.91)$. This means, in the short run, about 83% and 91% of variation in demand for agrochemical and manure respectively was explained by factors that are included in the models, while the rest was explained by other factors that are not included in the models. Only 57% of the variation in demand for labour was explained by the factors included in the model. Notwithstanding these variations in the coefficient for determination, the $F-$ test for each model (*i.e.,* 61.3 for the labour demand, 444 for manure and 216 for agrochemical demand) was statistically significant at 1% level, implying that the models provide the best fit for the data.

Table 15: Factor demand response under rain-fed

Description	Local Wage Coefficient	Price of Manure Coefficient	Price of Agrochemical Coefficient	F-test	Adjusted R^2
Labour	-0.74*** (-14.39)	-13.52*** (-4.84)	3.84*** (7.50)	61.3***	0.57
Manure	-2.00*** (-3.96)	-0.95*** (-23.75)	-0.35 (-0.97)	444***	0.91
Agrochemical	-0.68 (-1.40)	-7.70*** (-4.03)	-0.80*** (-26.34)	216***	0.83

Source: Field survey (2016)

Note: *** implies significance at 0.01 probability level,

** implies significance at 0.05 probability level, and

* implies significance at 0.1 probability level

Figures in parenthesis are t-values

The results show that own price elasticities for labour, manure and agrochemical were negative and statistically significant at 1% level (*i.e.,* -0.74 for labour, -0.95 manure and -0.80 for agrochemical), implying that an increase in price of these inputs by 1% would reduce demand for labour, manure and agrochemical by 0.74%, 0.95% and 0.80% respectively. This also implies that in the short-run farmer`s demand for the inputs does not quickly adjust to changes in their own input price for the same reasons explained in subsection 4.6 of this study.

The results also show that there is a pair of complementary and substitute inputs. For example, a pair of manure and agrochemical had a negative relationship (*i.e.*,-7.70), which was significant different from zero at 1% level $(\alpha = 0.01)$, indicating that this pair of input has complementary relationship. Results also show that labour and manure had a negative sign (-13.52), implying that labour and manure are complementary inputs in wine grape farming. Meanwhile, the demand for labour with respect to agrochemical price was 3.84, which was statistically significant at 1% level $(\alpha = 0.01)$. This means, on average a 1% increase in agrochemical price would increase demand for labour by 3.84.

Based on these findings, the fourth null hypothesis of this study, which states that changes in the price of labour, manure and agrochemical do not influence the demand for corresponding own inputs and other related inputs, was rejected at 1% level. This implies that changes in the price of labour, manure and agrochemical influence the demand for corresponding own inputs and other related inputs. In addition to the analysis of factor demand response for the rain-fed, the present study also analysed factor demand response under irrigation, as presented in the next subsection.

4.6.2 Factor demand response under irrigation

On the basis of coefficient of determination (R^2), which was 0.74 for labour, 0.95 for farm yard manure and 0.83 for agrochemical (Table 16), implying that in the short–run the explanatory variables included in the regression model explains well the variation of the demand for labour, manure and agrochemical. The F-statistic was 126.5 for the labour, 848.5 for farm yard manure and 213.4 for agrochemical, indicates that all models were the best fit for the data.

Table 16: Factor demand responses under irrigation

Description	Local Wage Coefficient	Price of Manure Coefficient	Price of Agrochemical Coefficient	F-test	Adjusted R^2
Labour	-0.86*** (-12.29)	-6.85*** (-3.90)	-1.65 (1.14)	126.5***	0.74
Manure	1.47** (2.40)	-0.85*** (-21.25)	-0.57 (-0.79)	848.5***	0.95
Agrochemical	-0.33 (-0.39)	-2.74** (2.22)	-0.83*** (-16.6)	213.4***	0.83

Source: Field survey (2016)

Note: *** implies significance at 0.01 probability level,

** implies significance at 0.05 probability level, and

* implies significance at 0.1 probability level

Figures in parenthesis are t-values

The findings also indicate that the coefficient for own factor price elasticities for labour, manure and agrochemicals had a negative sign and were statistically significant at 1% level (Table 16), which is consistent with demand theory (Thakare *et al.,* 2012). The results show that own factor elasticity was 0.86 for labour, 0.85 for manure and 0.83 for agrochemical, implying that on average a 1% increase in the price of these inputs would result to a reduction of 0.86% in the demand for labour, 0.85% in the demand for manure and 0.83% in the demand for agrochemical. The absolute values of own price elasticities for the whole sample, under irrigation and rain-fed were less than one, which means factor demand due to changes in the corresponding own factor price is inelastic. This means, a small change in own factor price would result into less than proportionate change in quantity demanded for respective factor (Junaid *et al.*, 2014).

The possible explanation for this inelastic demand response are; (i) it takes sometimes for the farmer to adjust to market prices because grape is a perennial cash crop, (ii) grape farming is less mechanized, hence the use of labour is inevitable, (iii) grape is a perishable fruit, which is very much affected by insects and fungi, therefore application of agrochemical is necessary, and (iv) since wine grape is a perennial crop, therefore in order to realize high productivity, manure application is of paramount important.

The results also show that demand for labour with respect to manure price had a negative sign, implying that manure and labour are complementary inputs such that this pair of input is used jointly in grape farming. For example, the factor demand response of labour with respect to manure price was -6.85, was significantly different from zero at 1% level significance $(\alpha = 0.01)$. This means, on average a 1% increase in manure price would reduce the demand for labour by 6.85%. Meanwhile, demand for agrochemical with respect to manure price was -2.74, was significantly different from zero at 5% level $(\alpha = 0.05)$. This means, on average a 1% increase in manure price would reduce demand for agrochemical by 2.74%. The economic implication is that, any policy targeting on reducing fertilizer, labour and agrochemical price would improve productivity and production.

Based on these findings, the fourth null hypothesis of this study, which states that changes in the price of labour, manure and agrochemical do not influence the demand for corresponding own inputs and other related inputs, was rejected. This implies that changes in the price of labour, manure and agrochemical influence the demand for corresponding own inputs and other related inputs.

4.7 Summary of Results

This study was guided by four research hypotheses which correspond to four specific objectives, as described in subsection 1.3.2 of this study. The first hypothesis states that there is no significant difference in profitability of farmers comparing between irrigated and rain-fed wine grape farmers. This hypothesis was rejected. It was found that farmers under irrigation production had significantly higher profit levels compared to farmers under rain-fed production. The second hypothesis stated that smallholder wine grape farmers operate on the profit frontier $(\mu_i = 0)$. This hypothesis was also rejected, implying that some of the smallholder farmers in Dodoma City and Chamwino District operate below the profit frontier $(i.e., \mu_{ij} > 0)$. A significantly higher mean profit efficiency (69%) was achieved by farmers under irrigated farming compared to 63% for the farmers under rain-fed.

The third hypothesis stated that socio-economic and institutional factors (such as sex, farmers experience, education level, location, group membership, access to credit and extension service) do not account for variation of efficiency levels among farmers, this hypothesis was also rejected. The results revealed that some of the hypothesized factors had a significant influence on farm level efficiency. These included farmers` experience, membership in groups, location, access to credit and extension services. Finally, the fourth null hypothesis stated that changes in the price of labour, manure and agrochemical do not influence the demand for corresponding own inputs and other related inputs, this null hypothesis was also rejected. Results showed that that factor demand response due to changes in own factor price is inelastic, mostly because grapevine production is a perennial crop, which requires a longer time for farmers to respond to price changes. Moreover, grapes are a perishable crop which is affected much with insects and fungi, this situation force farmers to use agrochemical in grape production. Meanwhile, cross-factor price elasticity for a pair of agrochemical and manure, as well as a pair of labour and manure had a complementary relationship, while labour and agrochemical had a substitute relationship.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study was conducted to establish farm level profit efficiency and identify specific factors that account for profit efficiency variation among wine grape farming. Specifically, the study focused on comparing profitability between irrigated and rain-fed farmers, analysing their profit efficiency and identifying farm level factors influencing efficiency as well as analysed factor demand response due to changes in own price and price other inputs. Multistage and random sampling techniques were used to select study area. A sample of 359 farmers was selected from two strata using a systematic sampling procedure. Descriptive statistic, farm budgeting technique and stochastic profit frontier models were used for analysis. In addition, a regression model was used to determine own factor price and cross-factor price elasticity.

The findings show that grape cultivation is a profitable venture in the study area. Farms under irrigation had significantly higher profit levels compared to those under rain-fed wine grape farming. Likewise, smallholder farmers from DCC had significantly higher profit levels compared to farmers from CDC. Profit of smallholder farmers is significantly influenced by changes in the cost of labour and agrochemicals. Reducing the cost of these inputs can significantly increase farm profit among farmers and hence raise farm level profitability. It was established that wine grape farmers in the study area are not fully profit efficiency, since mean profit efficiency score was 69% for irrigated farms and 63% for rain-fed farms. Hence, an opportunity exists to increase profit efficiency by more than 30% without changing resources mix. Farmer`s experience, group membership, access to extension service and credit service are the main factors that significantly influence profit efficiency among grape farmers. The results further suggest that own price elasticities for labour, manure and agrochemicals are inelastic, implying that in the short-run the farmer`s demand for these inputs does not adjust quickly to changes in their own input prices. The cross-factor price elasticity of agrochemical against manure and labour versus manure had negative values, implying that demand for these pairs of inputs is noted to have complementary relationship, while cross-factor price elasticity of labour and agrochemical had a positive sign. This means that to some extent demand for labour and agrochemical can be substituted especially for weeding.

5.2 Recommendations

Based on the study findings that farmers under irrigation scheme operate near the profit frontier compared to rain-fed farmers, the study recommends;

i. In order to ensure sustainable grape subsector development, government and private sector interventions such as establishing irrigation schemes is required in order to improve farm productivity and hence increasing farm`s income and profit.
ii. Establishment of new irrigation schemes require capital investment, therefore availability of credit at the farmer`s disposal should be emphasised and facilitated at the study area and for the rest country wide.
iii. The study also established that farmers who joined groups or belonged to cooperative operate closer to the profit frontier than farmers who do not belong to groups, it is therefore recommended that wine grape farmers should be encouraged to join groups or form associations because membership allow farmers to share information with other farmers about input and output prices as well as technical knowledge and skills. However, joining groups alone may not be enough, but parallel efforts such as provision of extension services and training, are required to make farmer`s associations effective and functioning. Effective and

well-functioning farmer`s group can benefit farmer through economies of scale thereby reducing each members' production cost.

iv. The study further recommends that any policy targeting on reducing labour and agrochemical costs for wine grape farming would improve grape productivity and hence increase farmer`s profit and profitability. Such improvement could be attained using small-scale tractors and other machinery such as power tiller, to substitute for labour.

v. It was established that demand for agrochemical and manure had a complementary relationship, it therefore important to strengthen farmer`s knowledge and skills on agrochemical and manure application for wine grape farming because these inputs have a joint effect on improving wine grape productivity and profit among farmers.

5.3 Recommendations for Further Research

Based on shortcomings identified in this study, further research on grape farming is necessary using panel data or longitudinal data. In addition, this study focused on comparing profitability between irrigated and rain-fed a using single type of grapes. More accurate results could be obtained if the analysis also distinguished between type and variety of grapes, type of soils, temperature and amount of sunshine during the growing period in order to be sure that observed differences in profitability arises from difference in production technology. Information obtained in the current data set did not allow for such analysis. Thus, further analysis of farm level performance should include these factors. For a more effective viticulture sector in Dodoma region that is more industrial oriented; the economic analysis should distinguish between wine grape and other types of grapes such as table grapes is necessary.

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APPENDICES

Appendix 1: Research Permit from DPRTC to Dodoma Regional Secretariat

CLEARANCE PERMIT FOR CONDUCTING RESEARCH IN TANZANIA

SOKOINE UNIVERSITY OF AGRICULTURE
OFFICE OF THE VICE-CHANCELLOR
P.O. Box 3000, MOROGORO, TANZANIA
Phone: 023-2604523/2603511-4; Fax: 023-2604651

Our Ref. SUA/ADM/R.1/8/ **Date: 29th October 2015**

Regional Administrative Secretary,
DODOMA.

Re: UNIVERSITY STAFF, STUDENTS AND RESEARCHERS CLEARANCE

The Sokoine University of Agriculture was established by Universities Act No.7 of 2005 and SUA Charter of 2007 which became operational on 1st January 2007 repealing Act No.6 of 1984. One of the mission objectives of the University is to generate and apply knowledge through research. For this reason the staff, students and researchers undertake research activities from time to time.

To facilitate the research function, the Vice-Chancellor of the Sokoine University of Agriculture (SUA) is empowered under the provisions of SUA Charter to issue research clearance to both, staff, students and researchers of SUA.

The purpose of this letter is to introduce to you **Ms. Natalia Kalimang'asi**, a PhD student from Sokoine University of Agriculture registration number **PAC/D/2014/0001** of SUA. By this letter **Ms. Natalia** has been granted clearance to conduct research in the country. The title of his research is **'Technical efficiency of Wine grape production'.**

The period for which the permission has been granted is from **November 2015 to March 2016**. The rssearch will be conducted in protected areas under six ecosystems of Tanzania namely: Dodoma Region.

Should some of these areas/institutions/offices be restricted, you are requested to kindly advice the researcher(s) on alternative areas/institutions/offices which could be visited. In case you may require further information on the researcher please contact me.

We thank you in advance for your cooperation and facilitation of this research activity.

Yours sincerely,

Prof. Gerald C. Monela
VICE-CHANCELLOR

Copy to: **Ms. Natalia Kalimang'asi**

VICE CHANCELLOR
SOKOINE UNIVERSITY OF AGRICULTURE
P. O. Box 3000
MOROGORO, TANZANIA

Appendix 2: Research Permit from DPRTC to Dodoma City Council

CLEARANCE PERMIT FOR CONDUCTING RESEARCH IN TANZANIA

SOKOINE UNIVERSITY OF AGRICULTURE
OFFICE OF THE VICE-CHANCELLOR
P.O. Box 3000, MOROGORO, TANZANIA
Phone: 023-2604523/2603511-4; Fax: 023-2604651

Our Ref. SUA/ADM/R.1/8 **Date: 14th March 2016**

The Municipal Director
Dodoma Municipal Council
DODOMA

Re: UNIVERSITY STAFF, STUDENTS AND RESEARCHERS CLEARANCE

The Sokoine University of Agriculture was established by Universities Act No.7 of 2005 and SUA Charter of 2007 which became operational on 1st January 2007 repealing Act No.6 of 1984. One of the mission objectives of the University is to generate and apply knowledge through research. For this reason the staff, students and researchers undertake research activities from time to time.

To facilitate the research function, the Vice-Chancellor of the Sokoine University of Agriculture (SUA) is empowered under the provisions of SUA Charter to issue research clearance to both, staff, students and researchers of SUA.

The purpose of this letter is to introduce to you **Ms. Natalia Kalimang'asi** a bonafide **PhD** student with registration number **PAC/D/2014/0001** of SUA. By this letter **Ms. Natalia** has been granted clearance to conduct research in the country. The title of the research in question is **"Efficiency of Smallholders wing grape production in Dodoma"**

The period for which this permission has been granted is from **15 March 2016 to 15 September 2016.** The research will be conducted in **Dodoma Municipal Counci.**

Should some of these areas/institutions/offices be restricted, you are requested to kindly advice the researcher(s) on alternative areas/institutions/offices which could be visited. In case you may require further information on the researcher please contact me.

We thank you in advance for your cooperation and facilitation of this research activity.

Yours sincerely,

Prof. Gerald C. Monela
VICE-CHANCELLOR

Copy to: Student – **Ms. Natalia Kalimang'asi**

VICE CHANCELLOR
SOKOINE UNIVERSITY OF AGRICULTURE
P. O. Box 3000
MOROGORO, TANZANIA

Appendix 3: Research Permit from DPRTC to Chamwino District Council

CLEARANCE PERMIT FOR CONDUCTING RESEARCH IN TANZANIA

SOKOINE UNIVERSITY OF AGRICULTURE
OFFICE OF THE VICE-CHANCELLOR
P.O. Box 3000, MOROGORO, TANZANIA

Phone: 023-2604523/2603511-4; Fax: 023-2604651

Our Ref. SUA/ADM/R.1/8 **Date: 14th March 2016**

The District Executive Director
Chamwino District Council
CHAMWINO

Re: UNIVERSITY STAFF, STUDENTS AND RESEARCHERS CLEARANCE

The Sokoine University of Agriculture was established by Universities Act No.7 of 2005 and SUA Charter of 2007 which became operational on 1st January 2007 repealing Act No.6 of 1984. One of the mission objectives of the University is to generate and apply knowledge through research. For this reason the staff, students and researchers undertake research activities from time to time.

To facilitate the research function, the Vice-Chancellor of the Sokoine University of Agriculture (SUA) is empowered under the provisions of SUA Charter to issue research clearance to both, staff, students and researchers of SUA.

The purpose of this letter is to introduce to you **Ms. Natalia Kalimang'asi** a bonafide **PhD** student with registration number **PAC/D/2014/0001** of SUA. By this letter **Ms. Natalia** has been granted clearance to conduct research in the country. The title of the research in question is **"Efficiency of Smallholders wing grape production in Dodoma"**

The period for which this permission has been granted is from **15 March 2016 to 15 September 2016.** The research will be conducted in **Chamwino District Counci.**

Should some of these areas/institutions/offices be restricted, you are requested to kindly advice the researcher(s) on alternative areas/institutions/offices which could be visited. In case you may require further information on the researcher please contact me.

We thank you in advance for your cooperation and facilitation of this research activity.

Yours sincerely,

Prof. Gerald C. Monela
VICE-CHANCELLOR

Copy to: Student – **Ms. Natalia Kalimang'asi**

VICE CHANCELLOR
SOKOINE UNIVERSITY OF AGRICULTURE
P. O. Box 3000
MOROGORO, TANZANIA

Appendix 4: Research Permit from Dodoma City Council

JAMHURI YA MUUNGANO WA TANZANIA
HALMASHAURI YA MANISPAA DODOMA
(Barua zote zipelekwe kwa Mkurugenzi wa Manispaa)

MKOA WA DODOMA

Tel.: 2354817/2321550
Fax: 2321550

Ofisi ya Mkurugenzi wa Manispaa
S.L.P.1249
Dodoma
E-mail: dodomamunicipality@yahoo.co.uk

Unapojibu tafadhali taja:

Kumb. Na. HMD/E.10/4/107 Tarehe 04 Aprili, 2016

WATENDAJI WA KATA,
Mpunguzi, Mbabala, Hombolo Bwawani,
Miyuji na Makutopora,

YAH: KIBALI CHA KUFANYA UTAFITI

Husikeni na somo tajwa hapo juu.

Mkurugenzi wa Halmashauri ya Manispaa ya Dodoma ametoa kibali cha kufanya utafiti kwa **Bi. Natalia Kalimang'asi** ambaye ni mwanafunzi wa Shahada ya Uzamivu katika Chuo Kikuu cha Kilimo Sokoine. Utafiti huu unahusu Kilimo cha Zabibu katika Mkoa wa Dodoma. Utafiti huu utafanyika kuanzia tarehe ya barua hii hadi tarehe 15 Septemba, 2016.

Watendaji wa Kata zilizotajwa hapo juu, tafadhali mpokeeni mtafiti huyu na apewe ushirikiano wote atakaohitaji ili kufanikisha utafiti wake.

Nawashukuru kwa ushirikiano wenu

Innocent D. Kessy
Kny: MKURUGENZI WA MANISPAA
DODOMA

Nakala:

Mkuu wa Idara ya Kilimo, Umwagiliaji na Ushirika - Kwa Taarifa
Manispaa ya Dodoma

Appendix 5: Research Permit from Mpunguzi Ward

JAMHURI YA MUUNGANO WA TANZANIA
HALMASHAURI YA MANISPAA DODOMA
(Barua zote zipelekwe kwa Mkurugenzi wa Manispaa)

MKOA WA DODOMA

Tel.: 2354817/2321550
Fax: 2321550

Ofisi ya Mkurugenzi wa Manispaa
S.L.P.1249
Dodoma
E-mail: dodomamunicipality@yahoo.co.uk

Unapojibu tafadhali taja:

Kumb. Na. HMD/E.10/4/107

Tarehe 04 Aprili, 2016

WATENDAJI WA KATA,
Mpunguzi, Mbabala, Hombolo Bwawani,
Miyuji na Makutopora,

YAH: KIBALI CHA KUFANYA UTAFITI

Husikeni na somo tajwa hapo juu.

Mkurugenzi wa Halmashauri ya Manispaa ya Dodoma ametoa kibali cha kufanya utafiti kwa **Bi. Natalia Kalimang'asi** ambaye ni mwanafunzi wa Shahada ya Uzamivu katika Chuo Kikuu cha Kilimo Sokoine. Utafiti huu unahusu Kilimo cha Zabibu katika Mkoa wa Dodoma. Utafiti huu utafanyika kuanzia tarehe ya barua hii hadi tarehe 15 Septemba, 2016.

Watendaji wa Kata zilizotajwa hapo juu, tafadhali mpokeeni mtafiti huyu na apewe ushirikiano wote atakaohitaji ili kufanikisha utafiti wake.

Nawashukuru kwa ushirikiano wenu

Innocent D. Kessy
Kny: MKURUGENZI WA MANISPAA
DODOMA

Nakala:

Mkuu wa Idara ya Kilimo, Umwagiliaji na Ushirika - Kwa Taarifa
Manispaa ya Dodoma

Amenipoti apewe Ushirikiano

AFISA MTENDAJI WA KATA
KATA MPUNGUZI

14/04/2016

Appendix 6: Research Permit from Chamwino District Council

HALMASHAURI YA WILAYA YA CHAMWINO

(Barua zote ziandikwe kwa Mkurugenzi Mtendaji)

Nambari ya Simu Binafsi Ofisini kwa
Mkurugenzi: 026-2321449

S.L.P. 1126
DODOMA
TANZANIA

Kumb. No.HW/T.10/37/95

27 Aprili, 2016

MAOFISA WATENDAJI WA KATA:
Makang'wa,
Mvumi Makulu,
Mvumi Mission,
Handali,
Buigiri.

YAH: KUMTAMBULISHA MTAFITI KUTOKA CHUO KIKUU CHA KILIMO CHA SOKOINE -MOROGORO

Tafadhali husika na somo hilo hapo juu.

Ndg **NATALIA KALIMANG'ASI** ni Mtafiti kutoka Chuo Kikuu cha Kilimo Sokoine ambaye anafanya utafiti kwenye zao la zabibu. Utafiti wake utahusisha wakulima wadogo wa zao hilo katika vijiji vinavyozalisha zao hili wilayani Chamwino.

Naomba apatiwe ushirikiano ili aweze kufanikisha utafiti huu muhimu kwa maendeleo ya sekta ya kilimo.

Godfrey G. Mnyamale
AFISA KILIMO, UMWAGILIAJI NA USHIRIKA (W)
WILAYA YA CHAMWINO

DISTRICT AGRICULTURE AND LIVESTOCK
DEVELOPMENT OFFICER
P. O. Box 832

Nakala: Mkurugenzi Mtendaji-HW Chamwino-Aione kwenye jalada

Appendix 7: Questionnaires for wine grape producers

Interviewer’s Name…………………………………………………………….................

Interviewee Name……………………………………………………………………….

Date for interview…………………………………………………………….…………

Questionnaire Number (QIDN)…………………………………………………………

Variable code	Question or variable	Response	Coding key	Skip Rule
A001	District		1. Dodoma Municipal council 2. Chamwino District council	
A002	Wards		1. Buigiri 2. Mvumi Makulu 3. Mpunguzi 4. Handali 5. Mbabala 6. Hombolo Bwawani	
A003	Village/Street		1. Hombolo Bwawani “B” 2. Mpunguzi “A’ 3. Nkulabi 4. Other (specify) ……………..	
A004	Type of farming system practiced		1. Irrigation 2. Rain-fed	
A. **SOCIO- DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS**				
A005	Name of the household head		…………	
A006	Age of the household head		…………. (Years)	
A007	Sex of the household head		1. Male 2. Female	
A008	Education level (Please state the number of years of schooling)		……………..(Years)	
A009	Marital Status		1. Married 2. Single never married 3. Widow 4. Divorced	
A010	How many members were in the household? (head count)		…………………………	

A011. Please fill in the table information regarding the household members who are actively involved in grape farming

No.	Name of household member	Relation to HHD 1. Spouse 2. Brother 3. Sister 4 . Children 5.Others (specify)……….	Sex 1.male 2.female	Year of Birth	Educational level (Years)
1					
2					
3					
4					
5					
6					

Note: HHD-Household head

Variable code	Question or variable	Response	Coding key	Skip rule
A012	Do you have other occupation apart from grape production?		1. Yes 2. No	
A013	If Yes in A012, What is main occupation		1. Salaried employment 2. Other crops faming 3. Livestock keeping 4. Businessman/woman 5. Others (specify)……..…………	
A014	What is the main source of income		1. Grape farming 2. Salaries employment 3. Other crop farming 4. Livestock keeping 5. Others (specify) …………….	
A015	How many crops did you cultivate last year? *Please list the name of each crop*		1………………………………. 2………………………………. 3………………………………. 4……………………………….	
B. WINE GRAPE PRODUCTION PRACTICES				
B001	How many acres of land are under wine grape production		1. 0.25 acre 2. 0.5 acre 3. 0.75 acre 4. 1 acre 5. Other (specify) …….………….…	
B002	When did you start wine grape production? Please mention year you began growing grape		…………………………………….	

Variable code	Question or variable	Response	Coding key	Skip rule
B003	What kind of wine grapes do you grow?		1. Makutupora red 2. Chinin Blanc 3. Both Makutupora red and Chinin Blanc 4. Brown grape 5. Others (specify) ……...……	
B004	Do you have any reasons for the choice made		1. Drought resistance variety 2. It is widely and locally available in the vicinity 3. Diseases resistance 4. Others (specify)……...…	
B005	What methods of planting did you use?		1. Trenches 2. Pits 3. Others (specify)……..…...	
B006	How many trenches or pits did you make?		……………………Trenches ……………………Pits	
B007	Before planting wine grapes, did you put manure in each trench or pit?		1= Yes 2= No	If NO, skip B008
B008	How many trip of truck or Ox-curt did you use in your vineyard?		…………………….. Ox-curt ……………………... Trips	
B009	On average one truck/ox-curt is equal to how many tons?		1.Truck ……………....tons 2. Ox curt ……………..tons	
B010	What was the price of one truck or ox curt?		1.Truck …………….(TZS) 2. Ox-curt ..……….. (TZS)	
B011	Did you use manure in wine grape production last year 2015?		1. Yes 2. 2. No	If no, skip B012
B012	If yes B011, how many trips/ox-curt did you use?		…………………………….	
B013	What was the price of one truck or ox curt?		1. Truck ……….………(TZS) 2. Ox-curt ……...…….. (TZS)	
B014	Did you use any kind of insecticides control before planting the grape seedlings?		1. Yes 2. No	

B015. If Yes B014, which ones did you use and how many quantities were used?

Insects control and treatment		
Type	Quantity (litre/kg)	Price (TZS) of each quantity
Gammalin 20		
Attakan		
Agrecid-3		
Duduba		
Others (specify) ………………………….		
……………………………………………		

Variable	Question or variable	Response	Coding key	Skip Rule

code				
B016	Before planting grapes, did you apply improved fertilizer such as NPK 6:20:18?		1.Yes 2.No	If no, skip B017
B017	If YES in B016, how many bags (50kg) did you use?		1. 2 bags 2. 4 bags 3. Others (specify)………	
B018	What was the price of each bag?		……………..(TZS/bag)	
B019	During plantation, did you use small cuttings or seedling?		1.Small cuttings 2. Plantlets	
B020	Approximately, how many plantlets /cuttings did you plant in your farm?		1. 550 plantlets/cuttings 3. 825 plantlets/cuttings 4. 1100 5. Others (Specify) ...……….	
B021	Where did you get the plantlets/cuttings?		1. Own nursery 2. Makutupora research and Training Centre 3. Neighbouring farmers 4. Others (Specify) ……….	
B022	Did you buy those plantlets/cuttings?		1. Yes 2. No	If no, skip B023
B023	If **YES** in B022, how much did you pay for each seedling?		1. 50 TZS 2. 100 TZS 3. 200TZS 4. Other (Specify)……...........	

B024. Please fill in the table information regarding family labour input used in preparing a vineyard

B024Farm activity	**Male family labour**			**Female family labour**			**Children labour**		
	No. of men	**hrs/day**	**days**	**No. of Female**	**hrs/day**	**days**	**No.of children**	**hrs/day**	**days**
B0241Land preparation									
• Bush clearing									
• Field layout									
• Trenching									
B0242 Manure application									
B0243 Filling trenches									
B0244 Trellis cutting									
B0245 Transport Trellis									
B0246 Erection of Trellis									
B0247Insect control									
B0248Trenches lining/ pegging									
B0249 Planting seedling									
B02410Irrigating									

B025. Did you use hired labour in preparing a vineyard? Please put tick for an appropriate answer 1. Yes () 2.No (). If Yes B025, please fill the table below regarding the hired labour.

B025Farm activity	**Male hire labour**			**Female hire labour**			**Children labour**		
	No. of men	**hrs/day**	**days**	**No. of Female**	**hrs/day**	**days**	**No. of children**	**hrs/day**	**days**
B0251Land preparation									
• Bush clearing									
• Field layout									
• Trenching									
B0252 Manure application									
B0253 Filling trenches									
B0254 Trellis cutting									
B0255 Trellis transport									
B0256 Erection of Trellis									
B0257 Insect control									
B0258Trenches lining/pegging									
B0259 Planting seedling									
B02510Irrigating									

B026. Please provide information on cost of each vineyard preparations

B0261Farm operations	**B0262 Male hired labour cost**	**B0263 Female hired labour cost**	**B0264 Children hired labour**	**B026Total cost**
B0261Land preparation				
• Bush clearing				
• Field layout				
• Trenching				
B0262 Manure application				
B0263 Filling trenches				
B0264 Trellis cutting				
B0265 Trellis transport				
B0266 Erection of Trellis				
B0267 Insect control				
B0268Trenches lining/pegging				
B0269 Planting seedling				
B02610 Putting irrigation systems				

B027. Please fill in the table information regarding family labour input used in maintaining last year 2015

	Season I									Season II								
B027Farm activity	**Male family labour**			**Female family labour**			**Children labour**			**Male family labour**			**Female family labour**			**Children labour**		
	No. of men	**hrs/day**	**days**	**No. of female**	**hrs/day**	**days**	**No. of children**	**hrs/day**	**days**	**No. of men**	**hrs/day**	**days**	**No. of female**	**hrs/day**	**days**	**No. of children**	**hrs/day**	**days**
B0271 Pruning																		
B0272 Tying																		
B0273 Weeding																		
B0274 Trellis repair																		
B0275 Spraying (fungi/diseases control)																		
B0276 Irrigation																		
B0277Applying manure /fertilizer																		
B0278 Replacement of seedling																		

B028. Did you use hired labour in maintaining a vineyard last year 2015? Please put tick in an appropriate answer 1. Yes () 2.No (). If **YES**, please fill the table below regarding the hired labour

	Season I									Season II								
B0282Farm activity	**Male hired labour**			**Female hired labour**			**Children hired labour**			**Male hired labour**			**Female hired labour**			**Children hired labour**		
	No. of men	**hrs/day**	**days**	**No. of Female**	**hrs/day**	**days**	**No. of children**	**hrs/day**	**days**	**No. of men**	**hrs/day**	**days**	**No. of Female**	**hrs/day**	**days**	**No. of children**	**hrs/day**	**days**
B0281 Pruning																		
B0282 Tying																		
B0283 Weeding																		
B0284 Trellis repair																		
B0285Spraying (fungi/diseases control)																		
B0286 Irrigation																		
B0287Applying manure /fertilizer																		
B0288 Replacement of seedling																		

B029. Please indicate cost of maintaining your vineyard per season in 2015

Season I					Season II			
B0291 Farm operations	**B0292 Male hired labour cost**	**B0293 Female Hired labour cost**	**B0294 Children labour cost**	**B029Total cost (TZS)**	**B0292 Male hired labour cost**	**B0293 Female Hired labour cost**	**B0294 Children labour cost**	**B029Total cost (TZS)**
B02911 Pruning								
B02912 Tying								
B02913 Weeding								
B02914 Trellis repair								
B02915 Spraying (fungi/ diseases control)								
B02916 Irrigation								
B02917Applying manure /fertilizer								
B02918 Replacement of seedling								

B030. Did you use insecticides/ herbicides/ pesticides and fungicides last year 2015? 1. Yes… 2. No…
If **YES** which ones did you use and how much did you applied?

Insects and termites control				
	Season I		**Season II**	
Type	quantity(litre/kg)	Price (TZS)	quantity(litre/kg)	Price (TZS)
Malathion				
Basudin				
Gammalin 20				
Agrocide- 3				
Actellic				
Others (specify)…………………				
Downy mildew control and treatment				
	Season I		**Season II**	
Type	quantity(litre/kg)	Price (TZS)	quantity(litre/kg)	Price (TZS)
Mancozeb 80%				
Blue copper				
Ridomil MZ 63.5				
Sandofan M				
Karathane				
Others (specify) ....……………				
Powdery Mildew control				
Type	**Season I**		**Season II**	
	quantity(litre/kg)	price (TZS)	quantity(litre/kg)	Price (TZS)
Thiovit				
Spersul				
Anvil-5				
Linkion				
Exthantol				
Others (specify)…….……………				
Termites control and treatment				
	Season I		**Season II**	
Type	quantity (litre/kg)	Price (TZS)	Quantity (litre/kg)	Price (TZS/ litre/kg)
Malathion				
Kareti				
selecron				
Others (specify)…………………				

B031. What farm implements did you use to perform activity in your vineyards?

Type of equipment	Please tick farm tools you used in 2015
B0311 Scissors	
B0312 Hand hoe	
B0313 Spades	
B0314 Machete	
B0315 Sprayers	
B0316 Water can	
B0317 Wire	
B0318 Irrigation pump	
B0319 Wheel barrow	
B03110 Others (please specify)……………..	

B032: Please fill in the information about farm input used in wine grape production

Type of equipment	Number owned	Year bought	Useful life	Purchase price (TZS)
B0321 Scissors				
B0322 Hand hoe				
B0323 Spades				
B0324 Machete				
B0325 Sprayers				
B0326 Water can				
B0327 Wire				
B0328 Irrigation pump				
B0329 Wheel barrow				
B03210 Others (specify)……				

Variable code	Question or variable	Response	Coding key	Skip Rule

B033	Did you receive an extension services last year 2015?		1. Yes 2. No	If no, skip B033
B034	If **Yes** in B033, please specify where did you		1. Government extension officers 2. NGOs 3. Others (specify)……..……	
B035	Apart from extension agents, where else did you get information about grape production?		1. Radio 2. Neighbour 4. Other (specify)…….…….	
B036	Are you a member to any wine grape famer`s association?		1. Yes 2. No	If no, skip B037
B037	If **yes** in B036, what is the name of that group or association?		1. UWAZAMA (MandH) 2. CHABUMA AMCO 3. FUNE SACCOS 4. Mjelo AMCOS 5. Others (specify)…………..	
B038	Did you access credit for wine grape production in 2015?		1.Yes 2. No	If no, Skip B039
B039	If YES in B038, where did you get that credit?		1.Banks 2.SACCOS 3. Informal money lender 4. Others (specify)…..……..	
B040	Did you attend any kind of training on wine grape production in 2015?		1.Yes 2.No	If no, skip B041
B041	If YES in B041, who was the host institution of such training?		1. Municipal/District council 2. Research institute 3. Processing firm or buyers 4. Others (specify)…………	

SECTION C. HARVESTING AND MARKETING OF WINE GRAPES

C01. How many harvesting seasons do you normally have for each year? Please put tick for an appropriate answer 1. One season 2. Two seasons

C02. How many kilogram of grape did you harvest last year 2015?

1. Season I …………………………..kg 2. Season II…….…………………………..kg

C03. What was selling price of one kilogram of wine grapes?

1. Season I ……………………TZS/kg 2. Season II……………………TZS/kg

C04. Please fill in information regarding family labour input used in harvesting last year 2015

Season I									
Farm activity	**Male hired labour**			**Female hired labour**			**Children hired labour**		
	No. of men	hrs/day	days	No. of Female	hrs/day	days	No. of children	hrs/day	days
C041Harvesting									
C042 Packaging									
C043 Sorting									
C044 Transporting									
Season II									
Farm activity	**Male hired labour**			**Female hired labour**			**Children hired labour**		
	No. of men	hrs/day	days	No. of Female	hrs/day	days	No. of children	hrs/day	days
C041Harvesting									
C042 Packaging									
C043 Sorting									
C044 Transporting									

C05. Did you use hired labour in harvesting? Please put tick for an appropriate answer 1. Yes () 2.No ()

If Yes C05, please fill the table below regarding the hired labour

Season I									
Farm activity	**Male hired labour**			**Female hired labour**			**Children hired labour**		
	No. of men	hrs/day	days	No. of Female	hrs/day	days	No. of children	hrs/day	days
C051Harvesting									
C052 Packaging									
C053 Sorting									
C054 Transporting									
Season II									
Farm activity	**Male hired labour**			**Female hired labour**			**Children hired labour**		
	No. of men	hrs/day	days	No. of Female	hrs/day	days	No. of children	hrs/day	days
C051Harvesting									
C052 Packaging									
C053 Sorting									
C054 Transporting									

C06. Please indicate cost of each activity involved in harvesting period in 2015

Season I				
C06 Farm operations	**Male hired labour cost**	**Female Hired labour cost**	**Children labour cost**	**Total cost (TZS)**
C061Harvesting				
C062 Packaging				
C063 Sorting				
C064 Transporting				
Season II				
C06 Farm operations	**Male hired labour cost**	**Female Hired labour cost**	**Children labour cost**	**Total cost (TZS)**
C061Harvesting				
C062 Packaging				
C063 Sorting				
C064 Transporting				

Code	**Question or variable**	**Response**		**Skip Rule**
C07	Where do you normally sell your grapes?		1. Processing firms 2. Traders 3. Street Vendors 4. Other (specify) …..…….	
C08	From the category of market listed in C006, what is the most important market to you?		….…………………..........	
C09	Where else the market transactions took place?		1. At the farm 2. At the processing firm 3. At the market 4. Export market	
C010	Who else set the market price for wine grapes?		1. Buyer 2. Seller 3. Other (specify)............	
C011	What do you consider as big challenges in wine grape production (rank in terms of importance/ threat)?		1) ……………………… 2) ……………………… 3) ………………………	
C012	What is your opinion regarding the challenges you faced on wine grape production?		1) ……………………… 2) ……………………… 3) ………………………	
C013	What do you consider as big challenges in wine grape marketing (rank in terms of importance/ threat)?		1) ……………………… 2) ……………………… 3) ………………………	
C014	What is your opinion regarding the challenges you faced on marketing of wine grape?		1) ……………………… 2) ……………………… 3) ………………………	

THANK YOU FOR YOUR COOPERATION