COMPARATIVE ANALYSIS OF GREENHOUSE VERSUS OPEN-FIELD SMALL-SCALE TOMATO PRODUCTION IN NAKURU-NORTH DISTRICT, KENYA

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A Thesis submitted to the Graduate School in partial fulfilment of the requirements of the Master of Science Degree in Agricultural and Applied Economics of Egerton University

EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

I declare that this thesis is my original work and has not been presented in this or any other university for the award of a degree.

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DEDICATION

My mom, Veronica Wachira, is undoubtedly a great gift from God. Thank you for your encouragement all the time, and especially, as I was pursuing my studies.

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This study may not exactly match your expectations, and I wish to carry the cross: the flaws and deficiencies solely remain mine.

ABSTRACT

Tomato (*Lycopersicon esculentum*) is one of the major vegetables grown in Kenya as a commercial crop. It is mainly grown in the open-field under both rain-fed and irrigation production systems. The crop has gained popularity as a cash crop due to declining land sizes as it can be grown on small-scale unlike traditional cash crops like coffee and tea. Since the crop is susceptible to diseases and weather conditions, the country does not have an all year round supply of the produce. Consequently, tomato production in Kenya has taken a new dimension of greenhouse production. The uptake of the technology has however been low with the cost of greenhouse installation and maintenance being cited as a major obstacle. However, studies elsewhere have shown that this is a short term problem but the long term use of the technology is economically viable. To validate these arguments, this study sought to carry out a comparative analysis of greenhouse versus open-field small-scale tomato production, in Nakuru-North district. The main objective was to provide insights into the feasibility and profitability of small-scale tomato farming. Stratified sampling procedure was used for greenhouse and open-field systems. Primary and secondary data were gathered for both systems. Primary data were collected through a field survey with the help of structured interview schedules, while secondary data were gathered through literature review. STATA and SPSS software packages were used to process collected data for 216 farmers of these farmers comprising of 96 and 120 greenhouse and open-field farmers, respectively. The Binary Logit model was used to determine the factors influencing a tomato farmer's decision to adopt a given tomato production system while gross margin and net profit was used in economic analysis. From the results, greenhouse tomato farmers had a mean of 13 years of education while open-field tomato farmers had 11 years. Open-field tomato growers had more farming experience of 11.5 years compared to 6.5 years for greenhouse farmers. The mean income for greenhouse tomato growers was almost twice, higher than that of open-field tomato growers. The Binary Logit results indicate that the decision to adopt greenhouse tomato farming was significantly influenced by road type, land tenure, age of household head, education level of household head, access to credit, farm income, experience, labour and group membership. Net profit/m^2 and gross margin/m^2 for greenhouse tomato farmers were found to be significantly higher (10 times) than that of their open-field counterparts, implying that greenhouse tomato production system is more profitable than the open-field system. These results imply that education, credit and infrastructural improvement issues need to be addressed for efficient and effective adoption of the viable tomato technology.

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LIST OF ACRONYMS AND ABREVIATIONS

AR-Average Revenue

ATC-Average Total Cost

BCR-Benefit Cost Ratio

CRS- Creative Research Systems

EurepGAP- European Good Agricultural Practices

GDP-Gross Domestic Product

GoK-Government of Kenya

GPV- Gross Product Value

HCDA-Horticultural Crops Development Authority

IPM- Integrated Pest Management

IRR- Internal Rate of Return

KHDP-Kenya Horticultural Development Programme

KNBS-Kenya National Bureau of Statistics

MC- Marginal Cost

MR – Marginal Revenue

MNL- Multinomial Logit

NALEP-National Agriculture and Livestock Programme

NPV- Net Present Value

PAM- Policy Analysis Matrix

SPSS- Statistical Package for Social Sciences

TC-Total Cost

TR- Total Revenue

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Agriculture is a leading sector in the Kenyan economy, contributing 24% directly and 27% indirectly to the Gross Domestic Product (GDP) (Government of Kenya (GoK), 2010). Of the agricultural sub-sectors, horticulture is among the leading contributors to the national economy accounting for 33% of agriculture's contribution to the Kenyan economy (GoK, 2010). The horticulture industry is also the leading foreign exchange earner after tea. In 2009, Kenya exported 350,474,113 kg of horticulture produce valued at KES 71.6 billion. In the same year, the country earned KES 153 billion from the domestic market worth of horticultural produce. The sub-sector has continued to grow at an annual rate of 15–20% over the last decade (GoK, 2010). The main country's horticultural crops include fruits, flowers and vegetables.

Among the sub-sectors of the horticulture industry, the vegetable industry holds the future of the Kenyan horticulture industry due to the high local demand for vegetables with 80% of produce consumed locally (HCDA, 2009). One of the most widely grown vegetables in the country is tomato, which is grown mainly in the open-field for home use and local markets (Musyoki *et al*., 2005). It is also an important cash crop for small-scale growers with potential for increasing incomes in rural areas, improving standards of living and creating employment opportunities (Ssejjemba, 2008). The value of tomato produced in Kenya in 2007 was KES 14 billion (Odame *et al*., 2008). Between 2005 and 2007, the area under tomato reduced from 20,743 ha to 18,926 ha, a 9 % reduction, but in the same period, the total volume produced increased by about 5 % from 542,940 Metric tonnes to 567,573 Metric tonnes (Odame *et al*., 2008). The increase in production is attributed to the extensive adoption of high yielding varieties and other modern technologies by farmers. Since majority of farmers own less than 4 acres of land in Kenya (GoK, 2000), tomato farming will remain an important sub-sector to many farmers, because it is practical on small scale.

In Nakuru-North district, tomato is one of the major vegetable crops, in terms of acreage (GoK, 2007). The crop is largely grown in the open-field and is mainly rain-fed. Various tomato varieties are grown in the open-field production system including: Roma VF, Cal-J (Kamongo), Fortune maker, Rio-Grande, Onyx among others (GoK, 2007). The vulnerability of tomatoes to weather conditions has several consequences. Water shortage and diseases leads to produce scarcity and hence very high produce prices. In the same vein, unfavourable weather may lead to reduced farm returns. With changing weather conditions, greenhouse tomato production is likely to become more popular as it provides protection against unfavourable weather conditions.

Kenya has witnessed a start of greenhouse production of tomatoes since the year 2007 (Makunike, 2007). Behind its promotion in the country are various stakeholders including Horticultural Crops Development Authority (HCDA) through the Kenya Horticulture Development Programme (KHDP), in collaboration with the Ministry of Agriculture, and agricultural inputs suppliers like Seminis Seeds, Osho Chemical Industries and Amiran Kenya Ltd, among others. In this system a farmer needs only 240 square meters of land and a greenhouse kit to get started (Makunike, 2007). Popular varieties in the greenhouse system include hybrids like Anna F_1 among others (GoK, 2008).

Average tomato yields in Nakuru-North stand at 15 tons per hectare (GoK, 2007). This performance is however still far below the national production level of 30.7 tons per hectare (GoK, 2009), although it is a major crop in the district. The crop has some potential in terms of production especially if farmers adopted greenhouse tomato production. Studies in other parts of the world have indicated relatively higher tomato yields under greenhouse production. In Turkey, results of a research study by Bayramoglu *et al*. (2010) showed yields of between 89 tons and 114 tons per hectare using greenhouse technology. This is far above the given potential of 62.5 tons per hectare for Nakuru-North district (GoK 2007). To increase tomato productivity in the district, there is therefore need for adoption of improved and sustainable production technologies like the greenhouse system that are not only profitable, but also responsive to the changing climatic conditions.

In choosing a production system for adoption, farmers are guided by various considerations including, costs, returns, and availability of information among other factors. Greenhouse and open-field tomato production systems have varying production costs and return levels which have an implication on adoption of either of the systems. Information on the economic performance of the two systems in Nakuru-North district is however quite limited and variable.

1.2 Statement of the Problem

Tomato is one of the important cash crops in Nakuru-North district that is replacing traditional cash crops like tea and coffee. Its production in the district has been conventionally under the open-field system that is prone to adverse weather conditions. As a result, there has been a remarkable decline in yields in recent years. This decline is attributed partly to the changing climatic conditions marked by unpredictable rainfall patterns and increased tomato disease and pest incidences.

The greenhouse technology has been proved profitable and preferable to the open-field system, elsewhere in the world. However, in Nakuru-North, most farmers still use the open-field rain-fed system of tomato production reason being the high initial investment cost of the greenhouse tomato production system. This system may be more profitable if costs and returns for the entire economic life of the system are taken into account. Due to inadequate information regarding the profitability of the greenhouse and the open-field tomato production systems, farmers are unable to make informed choices which may explain in part, why there is low uptake of greenhouse tomato technology, in Nakuru-North district.

1.3 Study Objectives

The main objective of this study was to provide insights into the feasibility and profitability of small-scale tomato farming through a comparative analysis. The specific objectives of the study were:

1) To compare the socio-economic characteristics of open-field versus greenhouse small-scale tomato farmers in Nakuru-North district.

2) To determine the factors influencing the choice of tomato production system among small-scale farmers in Nakuru-North district.

3) To compare the profitability of greenhouse and open-field tomato production systems in Nakuru-North district.

1.4 Research Questions

This study was guided by the following research questions:

1) What are the socio-economic characteristics of small-scale open-field and greenhouse tomato growers in Nakuru-North district?

2) What factors influence the choice of tomato production system among small-scale farmers in Nakuru-North district?

3) Is there any significant difference between the profitability of greenhouse and open-field tomato production systems in Nakuru-North district?

1.5 Justification of the Study

Tomato is an important commercial vegetable crop in Kenya, with a potential for increasing incomes in rural areas, improving living standards and creating employment. It can also be a source of foreign exchange. The sub-sector's role can only be aptly realized through the adoption of not only the sub-sector's high production technologies but also its profitable systems. With changing climatic conditions and increased land fragmentation due to increasing human population, farmers will be required to utilize their resources like land and water, more efficiently for maximum productivity. For the tomato growers, it may require turning to technologies like the greenhouse. Although the technical aspects of tomato production have been studied extensively, studies related to the economic performance aspects are few, hence inadequate information on the subject. This study aimed to provide that information as it is likely to influence the future development of the tomato enterprise.

Nakuru-North district was selected because it is one of the major tomato producing areas in Kenya (Ssejjemba, 2008) and due to reducing farm sizes as a result of increasing population, tomato growing will remain a favourable option for increasing farm incomes in the district.

The information from study findings will hopefully, enable farmers to make an informed choice of the tomato production system to adopt. This may lead to increased adoption of the most attractive tomato production systems, leading to increased on-farm employment and increased yields, increased farm incomes, improved food nutrients and living standards. Findings of this study will also benefit other tomato sub-sector stakeholders like extension service providers, consultants, researchers, input suppliers, traders and policy makers, who will be able to make more informed decisions.

1.6 Scope and Limitations of the study

The study covered only Nakuru-North district. This is mainly due to limitation of resources in terms of time and funds required in undertaking the study on a larger scale. The study targeted small-scale tomato farmers. The selected key issues in this study were, socio-economic characteristics of the tomato farmers, factors influencing the choice of tomato production system and a comparison of the profitability of greenhouse and open-field tomato production systems. It mainly focused on a 12-months production season falling during the 2010/2011 period. Data was mainly from past information, either as recorded or as remembered by respondents. Hence, findings may be facing the limitation of memory lapses.

1.7 Definition of key terms

Comparative analysis: - The item-by-item comparison of two or more comparable alternatives, processes, products, qualifications, sets of data, systems, or the like (Business Online Dictionary, 2011). In this study, comparative analysis has been adopted as the comparison of the two alternatives of growing tomatoes using past costs and returns.

Greenhouse tomato farmer: - Somebody who grows tomatoes under a structure covered with transparent material that transmits natural light for plant growth (Liu et al., 2005). In this study a greenhouse tomato farmer has been adopted as a farmer growing commercial tomatoes under a structure covered with transparent material that transmits natural light and measuring an area of at least 6 by 10 m^2. A greenhouse of 60 m^2 is assumed to be the standard, representing the most common economic size most often used by potential entrant farmers as a planning unit for entry or for expanding an existing operation (Odame, 2009).

Open-field tomato farmer: - This study considered an open-field tomato farmer as somebody who is growing commercial tomatoes in the outdoor space that is not covered or protected from the sun or the outside environment.

Small-Scale farmer: - In this study, this is a farmer who is operating on land size not exceeding 2 hectares. Most labour is provided by the household.

Gross margin: - Is the difference between gross revenue and variable costs (FAO, 1985).

Profitability: - Is the ability of an enterprise or a project to make profit, where profit is total revenue minus total cost (Lipsey, 1975).

Market: - In this study, the market is the nearest marketing centre where tomato farmers take their produce for sale.

A Group: - Any form of assemblage a farmer may belong to, that can benefit the farmer in implementation of agricultural technologies or improved production on his/her farm.

CHAPTER TWO

LITERATURE REVIEW

2.1 Tomato Growing and Importance

Tomato, (*Lycopersicon esculentum*) is a juicy berry fruit of the nightshade family (Solanaceae). Its origin is South America and was introduced in East Africa early in 1900. It grows well in warm conditions of 20-27 ^{0}C day temperatures and 15-17 ^{0}C night temperatures (Musyoki *et al*., 2005). Regular water supplies and adequate calcium are necessary to avoid physiological disorders like cracking and blossom end rot (Musyoki *et al*., 2005). Tomato prefers deep, well-drained, sandy loam soils (Naika *et al*., 2005). In Kenya, the major producing areas include Mwea, Nakuru, Meru, Nyeri and Taita Taveta (Ssejjemba, 2008).

Tomato is grown in Kenya as a commercial and important vegetable crop, which is either used fresh in salads or cooked. It is also processed into sauce and paste (Mungai et al., 2000). The fruit is rich in minerals like calcium, phosphorus and iron as well as supplies of vitamins A and C and is an important cash crop for small-scale and medium-scale commercial farmers (Naika *et al*., 2005). It has also been reported to have medicinal values as a kidney stimulant and washing off toxins in body systems (Musyoki *et al*., 2005). In 2007 the value of tomato produced in Kenya was KES 14 billion (Odame *et al*., 2008). It is therefore an important cash crop in Kenya with a potential for increasing incomes in rural areas, improving living standards and creating employment for women and youth (Ssejjemba, 2008).

Tomatoes can also be a source of foreign exchange (Atiya, 2006), and for countries whose agriculture substantially contributes to the GDP, there is need for diversifying sources of foreign earnings through increase of exports, which can be achieved by adoption of high production technology and processing systems in the tomato sub-sector. Furthermore, the quantity of tomatoes consumed including both fresh and processed is large making tomatoes to be a source of income, food security and improved health standards to farmers (Yoshihiko, 1993).

The tomato sub-sector worldwide is among the fast evolving sub-sectors (Odame *et al*., 2008). Some of the factors leading to this evolvement are increasing population, decreasing land sizes and changing climatic conditions. As a result, various production technologies have been developed to ensure adequate tomato supply, good quality and the achievement of various farmers' objectives. One such technology is the growing of tomato in greenhouses instead of the open-field production system.

To raise a sufficient amount of plants for one hectare, 150-200 g seeds are required for the open-field production system (Naika *et al*., 2005). For the greenhouse, about 250g of seeds per 12 months production cycle are required for a unit area of 180 m^2 (Odame, 2009). Some of the popular varieties for the open-field system are Eden, Onyx, Tanzanite and Monyalla as they are high yielders while Cal J, although susceptible to diseases, is popular because of high market demand and long shelf life (14 days) (Musyoki *et al*., 2005). Greenhouse grown tomatoes have on the other hand been shown to have a longer shelf-life of up to 21 days (Makunike, 2007). The greenhouse system requires planting of either hybrid seeds or indeterminate tomato varieties like Kentom, Marglobe, Monset, Nemonneta and Anna F1 (Odame, 2009).

There are various types of greenhouses depending on: frame structure, material of the frame and the covering material. According to the frame, we have the A-frame which is sharp roofed, the uneven-span with unequal size of roofs, the one-side roof, the saw-teeth greenhouses because they have roof sides of unequal heights and the tunnels, which have round roofs and at least a height of 1.7 meters (Liu *et al*., 2005). For the case of covering materials, they can be plastic, fibreglass or glasshouses while frame materials include metal pipes, timber, bamboo and concrete. Simple plastic greenhouses made of timber and polythene sheets have gained prominence among small-scale tomato farmers in Kenya (Odame, 2009). Their sizes range from 6 m by 10 m to 8 m by 30 m. Some of the various greenhouse sizes and their corresponding yields and estimated costs are shown in Table 1 below.

It takes a shorter period of two months for greenhouse produced tomatoes to mature, while it takes a minimum of three months with open-field produced tomatoes (Makunike, 2007). The National average yields are 30.7 tons per hectare (GoK 2009). One greenhouse plant has a potential of giving up to 15 kg at first harvest, going up to 60 kg by the time it has completed its full cycle, at one year (Makunike, 2007). Farmers can get 10 times more yield with greenhouse production system than with open-field open pollinated varieties (Seminis-Kenya, 2007).

Table 1: Different sizes of plastic houses for small-scale farmers

Measurement	Size	No. of Plants	Yield per plant per season (Kg)	Total Yield per unit per season (Tons)	Estimated cost of Greenhouse structure (KES)
ALLUMINIUM TUNNELS					
8×30 m	240 m^2	1,000	15-20 (20-40)	15-20 (20-40)	190,000
WOODEN GREEN HOUSES					
6 ×10 m	60 m^2	300	15-20 (20-40)	4.5-6 (6-12)	60,000
6× 15 m	90 m^2	500	15-20 (20-40)	7.5-10 (10-20)	70,000
6× 20 m	120 m^2	700	15-20 (20-40)	10-14 (14-28)	130,000
6× 25 m	150 m^2	800	15-20 (20-40)	12-16 (16-32)	140,000
6 ×30 m	180 m^2	1,000	15-20 (20-40)	15-20 (20-40)	165,000

Key: Values in parentheses indicate achievable yields with better management practices.

Source: Odame, (2009)

2.2. Factors Influencing Technology Adoption

According to Just and Zilberman (1983), there are various factors that influence the adoption of any technology. Just and Zilberman (ibid) explain that technology may require some costs that are associated with new equipments and investments, learning time, locating and developing markets and training labour. This view is supported by Bonabana-Wabbi (2002) adding that for farmers to adopt a technology, they must see an advantage or expect to obtain greater utility in adopting it. From the study, it is argued that without a significant difference in outcomes between two options, and in the returns from alternative and conventional practices, it is less likely that farmers, especially small-scale farmers will adopt the new practice. Since adoption of a practice is guided by the utility expected from it, the effort put into adopting it is reflective of this anticipated utility. Moreover, she contends that there is no standard way of classifying factors influencing adoption and classification cannot be uniform (Bonabana-Wabbi, 2002). This is because the factors influencing adoption may be a complex set of interactions and these factors like the institution (administration), the potential/targeted adopter (the farmer) or the general setting in which the technology is introduced act either as barriers or enhancers of adoption.

Logit, Probit and Tobit models have been used in many studies to determine significance of the factors influencing adoption. These are regression models used when the dependent variable is categorical in the sense that their responses consists of a set of categories. Both the Probit and Logit models are probabilistic dichotomous choice qualitative models that assume a normal cumulative distribution function and a logistic distribution of the dependent variable, respectively. They are evaluated as a linear function of explanatory variables with similar results, and the use of either model is thus discretionary. However, according to Montgomery *et al*. (2001), Probit models lack flexibility in that they do not easily incorporate more than one prediction variable unlike Logit models. For this reason, probit models are less widely used in limited dependent variable models. There is, however, a recommendation of Probit model for functional forms with limited dependent variables that are continuous between 0 and 1 and Logit models for discrete dependent variables (Adeogun *et al*., 2008).

The Tobit is a censored model where the dependent variable assumes the value zero to one, with positive probability. The model is therefore useful for adoption and intensity of technology analysis, although some researchers combine Tobit with Probit or Logit in determining adoption behaviour and intensity based on a two stage decision argument (Nchinda *et al*., 2010).

Several factors have been found to influence adoption. A study by Bonabana-Wabbi (2002) used multivariate Logit analysis to identify factors and their relative importance in explaining adoption of eight Integrated Pest Management (IPM) agricultural technologies in Kumi District, Eastern Uganda. The study results indicated that size of household labour force had negative influence on *Celosia* adoption but positive influence on growing improved cowpea and groundnut varieties. For the gender variable, the study indicated that males were more likely to adopt *Celosia* than females while experience positively influenced timely planting of cowpeas. From the results of the study, it is argued that, farmers with accumulated farming experience may have acquired encouraging returns from the practice and thus continue with it anticipating continued benefits. Farm size and level of education did not show significance with IPM adoption. Although the researcher analysed quite a number of factors, access to market, infrastructure, gender and land tenure were left out in the study.

Nchinda *et al*. (2010) used Tobit regression method as the main analytical tool in a study of factors influencing adoption and intensity of yam seedling technology in Cameroon. Farm size was not a significant determinant in their study. However, hired labour and membership to farmers' organizations positively and significantly influenced the adoption and intensity of yam minisett technology in areas covered. They also showed that age had significant influence with farmers less than forty one years of age being found to positively influence yam adoption and its intensity.

Another study aimed at estimating and explaining the parameters of the adoption process of Hybrid Clarias "Heteroclarias" by fish farmers in Lagos State Nigeria, Adeogun *et al*. (2008) showed age, farming experience and farm size to be statistically significant in explaining hybrid catfish adoption. However their Logit model results showed that education, contact with extension agents, access to seed and market distance were significant variables that influence fish farmers' hybrid catfish adoption and use decisions.

In a study by Engindeniz (2007) on comparative economic analysis between contract-based and non-contracted farmers, a binary Logit model was estimated to determine which factors make farmers prefer to grow tomato as contract-based. Some of the independent variables of the regression included age of farmers, education level, tomato growing experience, market conditions and cooperative membership of farmers. The results pointed out that important factors affecting the profitability of tomato growing were market conditions and cooperative membership of farmers. The study concluded that contract-based agriculture can put farmers in a position to achieve greater access to credit, inputs (in particular, new technologies) and the market, relative to their peers who are not operating under contractual arrangements.

Jans and Fernandez-Cornejo (2001) in a study on the economics of tomato organic growing in the United States used the Probit model to determine factors influencing adoption. Their findings were that education level, contract farming and crop price were significant and positively influenced adoption. The price was very significant and the researchers attributed this to the fact that adoption was significantly related to price premiums. In the same study, farm size was found to be negatively significant while age and off-farm employment were not significant.

Oyekale and Idjesa (2009) showed that education, access to credit, access to farm inputs and farming experience significantly and positively influenced adoption of improved maize seeds in the River State Nigeria. They argued that, access to credit permits farmers to invest in a new technology or acquire related inputs (e.g. labour, fertilizer). In the same study, absence of visits from extension services highly influenced the adoption negatively. On the contrary, contacts and access to extension services had positive and significant influence on adoption and intensity of technology according to a similar study of adoption of improved maize seeds in Tanzania (Nkonya *et al*. 1997). In a nut shell, adoption of a technology may be dependent on a number of factors which are dynamic both in terms of geographic setting and in time (Bonabana-Wabbi, 2002).

In this study, the binary Logit regression was preferred for interpretational reasons since the model is mathematically simpler in estimation than the Probit model and the effects of the independent variables are analyzed for each outcome as opposed to ordered Probit model where only one coefficient is estimated for all the outcomes (Aldrich and Nelson, 1984).

2.3 Profitability and Economic Analysis of Technologies

Profitability is the perception that a cash crop would reward the producer with excess income and it is often viewed as the basis for a viable business (Lukanu *et al*., 2009). In their study on aspects of profitability that influence smallholder cash-crop preferences in northern Mozambique, both financial and pragmatic aspects of profitability were found to be related to cash-crop preferences. Thus, smallholders attached value not only to financial aspects of profitability but also to the pragmatic aspects (means of obtaining a higher profit), such as higher yield, the result of access to inputs, access to extension and experience, and market and price reliability (Lukanu *et al*., 2009). However, profitability is a relative term derived from profit, where profit is total revenue minus total cost (Lipsey, 1975).

Production costs can be classified into variable costs and fixed costs. The variable costs are those associated with tomato growing and include all inputs related to the production of tomatoes like labour, fertilizer, pesticide, seed-seedling, transport, among others (Engindeniz, 2007). Variable costs are calculated by using market input prices and labour costs. Fixed costs are costs that don't vary with tomato production and they include administrative costs, interest on total initial investment costs, annual initial investment costs, interest on total variable costs and land rent (Engindeniz and Gül 2009). Administrative costs can be estimated to be 2–7 % of total gross production value or 3–7 % of total costs (Mülayim, 2001; Kiral *et al*., 1999). In their respective studies, Engindeniz (2002; 2006; 2007), and Engindeniz and Gül (2009) estimated administrative costs to be 3 % of variable costs. Interest is defined as a sum paid or calculated for the use of capital. The sum is usually expressed in terms of a rate or percentage of the capital involved, called the interest rate (Chaudhary, 2006). In their respective economic analysis studies, Engindeniz (2007) used 6 %, Engindeniz (2002) used 14 %, Engindeniz and Gül (2009) used 12 %, and Engindeniz and Tuzel (2006) used 11 % as the interest rate charged on total variable costs and total initial investment costs. These interest rates were justified by the annual saving deposits interest rates on US$. Interest on total variable costs was calculated for 6 months since in most of these studies, farmers were growing two crops per year.

Depreciation is defined as the loss in value of an asset over time, mainly as a result of obsolescence (Chaudhary, 2006). In the case of buildings and equipments, it is that portion of the decrease in value resulting from the passage of time. The entire depreciation is considered a fixed cost. In computing depreciation, a 10 percent allowance or salvage value was taken from the purchase price of the greenhouse buildings and equipments (Chaudhary, 2006) and then following formula was used in arriving at depreciation:

Depreciation = (Purchase Price – Salvage Value)/Number of Years of Life………………….....1

From the above discussion, the listed indicators and methods of assessing profitability include: Cost-benefit analysis, Payback period, Net Present Value, Internal Rate of Return, Cost/return ratio, Income statement (profits or loss of the farm) and even the most common of descriptive method like Yield, without actual analysis (Danso *et al.*, 2003). There is therefore, variation observed in how researchers classify farming systems and the various indicators and measuring methods applied to assess economic and other impacts of agriculture (Danso *et al.*, 2003).

Yield and quality as the study parameters were used in an economic analysis study by Ganesan (2002) who looked at the performance of naturally ventilated greenhouse tomatoes compared with open-field tomatoes. By using number of fruits per plant, individual fruit weight and total yield per plant, the study findings were that greenhouse tomatoes had significantly higher yields than the open-field system. Further, among the different greenhouse types studied, greenhouse with ventilation gaps in four sidewalls and greenhouse with ventilation gaps in the triangular roof were found to be the best for tomato cultivation. By using economic comparative analysis, the study concluded that greenhouse tomatoes gave better results and were more suitable for the study area than open-field tomatoes.

Yields have also been used in economic analysis to evaluate of elite tomato varieties in the semi-arid regions of Eastern Kenya by Musyoki *et al.* (2005), under open-field production. The study showed that the variety Monset yielded 3 tonnes per hectare while Roma and Fortune-maker had yields below 1 ton per hectare. Higher yields are, however, possible especially with greenhouse technology (Cook and Calvin, 2005). In their study, yields of vine ripe tomatoes for the top export-oriented field tomato growers were 60-69 metric tons per hectare, compared with yields of 110-150 for lower technology plastic greenhouses growing in soil were realised. However, yields alone are a measure of productivity and do not indicate the profitability of an enterprise as they do not take into account all the production costs. Also in economics, we take into account opportunity costs to get economic profits, which is not the same as accounting profit that considers only monetary cost that involves actual cash exchange.

In a study on comparative advantages of Syria's tomato production by Atiya (2006), tomato private and social profitability were assessed using the Policy Analysis Matrix (PAM). The study results indicated more than 2 times higher total costs of greenhouse system than that of open-field. The results also showed that fixed costs of greenhouse tomato system were 1.5 times higher than that of open-field system, due to the additional cost of greenhouse construction with the cost of labour and inputs about 3 times higher.

To compare profitability of one production technology with another, Enterprise Budgets have been used by various researchers like Jones and Simms (1997), Greaser and Harper (1994) and Al-Abdulkader (2004). As Jones and Simms, (1997) observes, the biggest limitation to enterprise budgeting is lack of information, because budgets deal with future actions and it is difficult to make accurate estimates regarding future markets, input prices, yields. Otherwise, past data only provides a primary estimate to establish initial levels of budget input data.

The break-even analysis has been used to show the economic and financial performance of farm enterprises. Performance below or above the break-even point has a pointer towards profitability since the break-even point occurs when total receipts equal total costs (Greaser and Harper, 1994). However it may be a weak tool when it comes to comparison of profitability between enterprises or production systems.

Agricultural economic analysis for profitability determination has also been done using Net Present Value (NPV) and Internal Rate of Return (IRR) methods. For example Taiwo *et al*. (1997), evaluated the profitability of retort pouch as an alternative to the canning system for packaging and processing of cowpeas and tomato sauce using the Net Present Value (NPV) and Internal Rate of Return (IRR). These methods were chosen for they directly account for the time value of money and are hence considered superior methods (Taiwo *et al*., 1997). Since this proposed study focused largely on past data and not expected future cash flows, the NPV method was found inappropriate.

The gross margin has been used as a proxy for profitability in many studies. This is because gross margin as a farm management analytical tool used in capital budgeting, provides an estimate of the returns of a particular enterprise. However, it has the weakness of using only the variable costs, thus not including fixed costs and capital costs like equipments and buildings, capital interests and depreciation (Sullivan and Greer, 2000).

Bayramoglu *et al*. (2010) calculated profitability and productivity of greenhouse tomato production using Gross margins per hectare combined with Net Incomes in a comparative analysis between certified and uncertified greenhouse tomato producers. By using yields to determine Gross Product Value (GPV), the gross margin was calculated as Gross Product Value (GPV) minus Variable Costs in their study done in Turkey. The Farm Net Income from tomato production was calculated as gross product value (GPV) minus production costs. Statistical tests for significant differences in mean values of variables across the producer groups were also done. The *t*-test was used to determine the significance of the sample results. Their findings showed higher GPV, Gross margin and Net income for EurepGAP certified tomato producers than those for the uncertified tomato producers.

This study used the Gross Margins combined with Net Profits to compare the profitability of the tomato producers.

2.4 Theoretical Framework

This study follows the consumer theory. In the theory of the consumer, it is assumed that consumers tend to maximize their utility.The equivalent assumption in the theory of the firm is that firms tend to maximize their profits. Profit is defined as total revenue minus total cost.as explained by Lipsey (1975). The study has the following assumptions: a) The small-scale tomato farmers are rational producers; b) The open-field and greenhouse systems of production are mutually exclusive; c) The small-scale tomato producers operate in a perfectly competitive market.

Profit is defined as total revenue minus total cost (Lipsey, 1975) and expressed as:

Total revenue (TR) = R (q) = p (q) ·q ………………………………………………..2

Where p is price of output and q is the quantity of output and;

Total cost (TC) = [C (q)] …………………………………………………….……...3

Where C is the input price and q is the quantity of inputs used. Therefore, profit (π) is the difference between total revenue and total costs:

$$\pi(q) = R(q) - C(q) = p(q) \cdot q - C(q) \quad \text{..........4}$$

Where π is profit, R (q) is total revenue and C (q) is total cost. This can be represented graphically as shown in Figure 1 below. From the diagram, the profit-maximizing output of tomatoes is represented by output Q. The profit curve is at its maximum at point A. Secondly, at point B the tangent on the total cost curve (TC) is parallel to the total revenue curve (TR), meaning that the surplus of revenue net of costs (BC) is at its greatest. Since total revenue minus total costs is equal to profit, the line segment CB is equal in length to the line segment AQ.

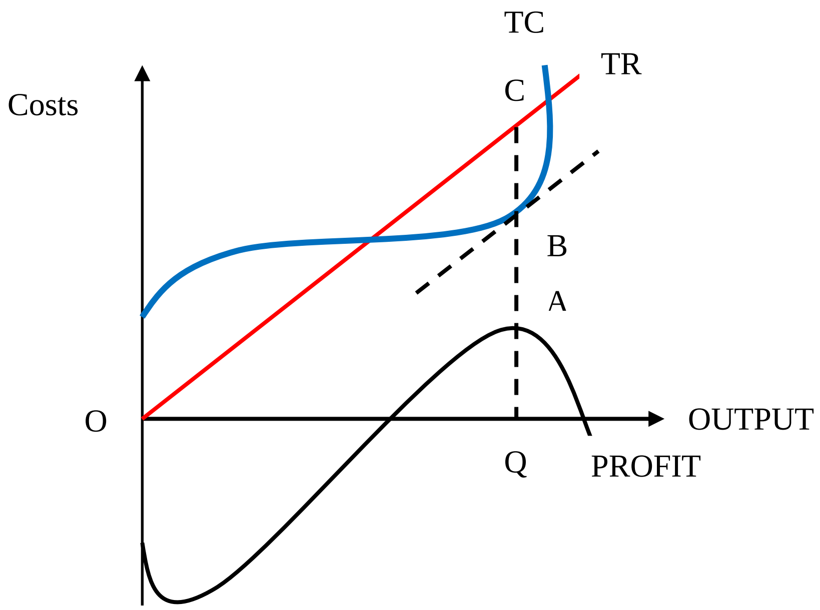

Figure 1: Profit Maximization - the Totals Approach

Source: Lipsey, (1975).

The necessary condition for choosing the level of *q* that maximizes profits can be found by setting the derivative of the π function with respect to *q* equal to zero:

$$\frac{d\pi}{dq} = \pi'(q) = \frac{dR}{dq} - \frac{dC}{dq} = 0 \quad \text{..........5}$$

Hence $$\frac{dR}{dq} = \frac{dC}{dq} \quad \text{..........6}$$

Therefore to maximize profits, a tomato farmer should choose the output for which marginal revenue is equal to marginal cost. This is called the first order condition for profit maximization.

Thus $$MR = \frac{dR}{dq} = \frac{dC}{dq} = MC \quad \ldots\ldots 7$$

This can be presented graphically as shown in Figure 2 below: From the diagram, intersection of MR and MC is shown as point A. If the market is perfectly competitive as is assumed in the diagram, the farmer faces a demand curve (D) that is identical to its Marginal Revenue curve (MR), and this is a horizontal line at a price determined by the market supply and demand. Average total costs are represented by curve ATC. Total economic profit is represented by area P, A, B, C. The optimum quantity (Q) is the same as the optimum quantity (Q) in Figure 1.

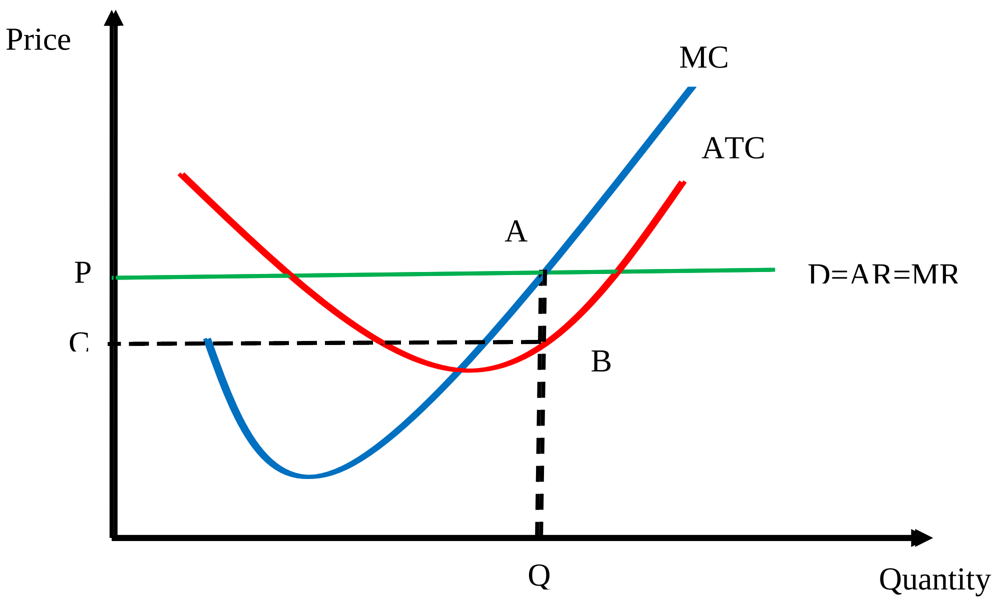

Figure 2: Profit Maximization - the Marginals approach

Source: Lipsey, (1975).

For each unit sold, marginal profit (MP) equals marginal revenue (MR) minus marginal cost (MC). It follows that, if marginal revenue is greater than marginal cost, marginal profit is positive, and if marginal revenue is less than marginal cost, marginal profit is negative. When marginal revenue equals marginal cost, then marginal profit is zero (Lipsey, 1975). Since total profit increases when marginal profit is positive and total profit decreases when marginal profit is negative, it must reach a maximum where marginal profit is zero - or where marginal cost equals marginal revenue. If there are two points where this occurs, maximum profit is achieved where the producer has collected positive profit up until the intersection of MR and MC (where zero profit is collected), but would not continue to after, as opposed to vice versa, which represents a profit minimum (Lipsey, 1975).

However, $MR = MC$ is only a necessary condition for profit maximization. For sufficiency, it is also required that:

$$\left.\frac{d^2\pi}{dq^2}\right|_{q=q^*} = \left.\frac{d\pi'(q)}{dq}\right|_{q=q^*} < 0 \quad \text{……………………………………………………8}$$

That is, “Marginal” profit must be decreasing at the optimal level of *q*. This is called the second order condition for profit maximization. Therefore tomato farmers will choose a system given an individual’s level of perceived profitability and other socio-economic factors. This study will compare the open-field system and the greenhouse production on the basis of their profitability as conceptualized below.

2.5 Conceptual Framework

A farmer will decide on whether to use the open-field or the greenhouse tomato production system given the farmer’s socio-economic characteristics such as, gender, age, education, income, farm size, land tenure, and experience in tomato growing among other factors. However, institutional factors will also influence the choice of tomato production system by the farmer. Some of the institutional factors include: credit, extension, access to markets, infrastructure, and group participation among others.

After choosing either the greenhouse or open-field production system (assumed to have different profitability levels), given a farmer’s socio-economic characteristics and institutional factors, the farmer will have different costs and returns from each choice, hence different profitability levels. A rational farmer seeking to maximize profit will choose a production system with higher profit. The system that gives the highest profitability, results to higher farm incomes.

In Figure 3, the arrows indicate that small-scale farmers’ choice of production system is influenced by socio-economic and institutional characteristics of the farmers. The available alternative in this case is either open-field or greenhouse system and it is assumed that alternative chosen is the one with highest profit in order to maximize profits. Once the information is available, the farmers will be able to make informed decisions that will lead to maximized profits, and in turn lead to increased farm incomes.

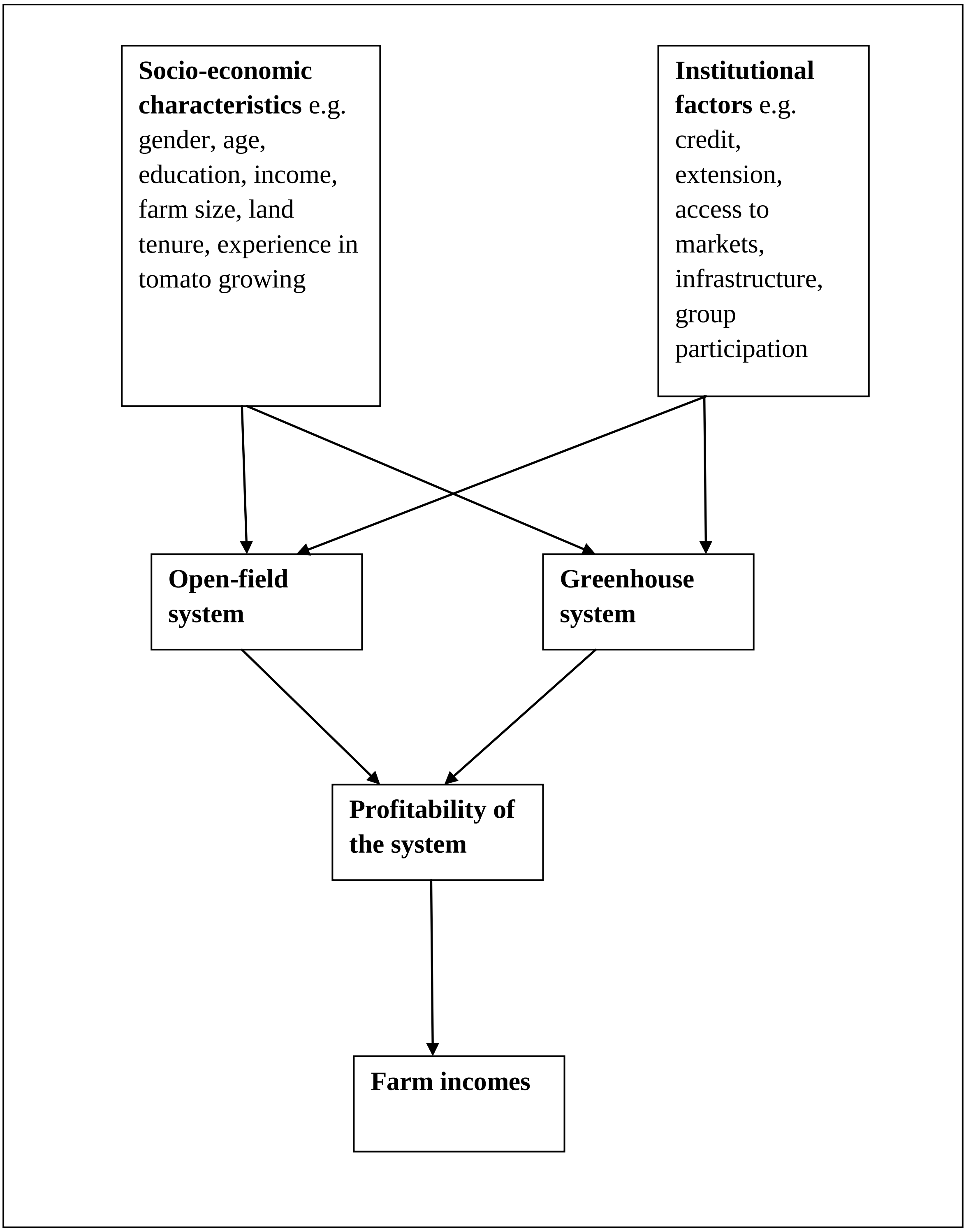

Figure 3: Factors Influencing Tomato Production Technology Adoption

CHAPTER THREE

METHODOLOGY

3.1 Area of Study

The study was conducted in Nakuru-North district. The district was created out of the larger Nakuru district in 2007 with its headquarters in Bahati town. It is one of the major tomato producing areas in Kenya. The district has two divisions: Bahati, and Dundori and covers an area of 647 km^2 with an arable area of 468.5 km^2 (GoK, 2007). The district has an estimated human population of 215,000 people and 20,200 farm families. It falls under the Upper highlands-1 (UH1), Lower Highlands-2 (LH2), Lower Highlands-3 (LH3), Upper Midlands-3 (UM3) and Upper Midlands-4 (UM4) Agro-ecological zones with an average rainfall of between 800 and 1,600 mm per year. It lies at an altitude of between 1,700 and 2,500 meters above sea level. The conventional tomato production system in the district is the open-field system. The greenhouse system is a recent system of growing tomatoes in Nakuru-North district. Figure 4 shows the location of the study sites.

3.2 Sampling Design

Multistage sampling technique was used for the study. The first stage was purposive sampling to select the area of study which is a major tomato growing area in the country, has high potential for tomato growing and it is strategically located relative to major tomato market out-lets (Ssejjemba, 2008). The target population of the study included all the small-scale tomato farmers. The unit of research was the farm household. Since the district has been under the National Agriculture and Livestock Project (NALEP) since year 2000, from lists of the Common Interest Groups, and with the help of enumerators and the Ministry of Agriculture's officers, a sampling frame was prepared. The district's producers were categorized into two: small-scale greenhouse tomato producers and open-field tomato producers. Thus the sampling frame consisted of two strata: - the first being those farmers growing tomatoes in the open-field and mainly practicing rain-fed production system; and the second being famers growing greenhouse tomatoes. The open-field farmers to be interviewed were then randomly selected. For greenhouse tomato stratum, since the expected number of farmers was small, a census survey was done so as to obtain the vital statistics as accurately as possible with reduced errors.

The stratification of the households along the tomato production systems implied that descriptive results would not be representative of the population in the survey area. To correct for this, the descriptive analysis used sampling weights. Since this was a disproportionate stratified sample design, the data required weighting to remove sampling bias so as to make it representative of its population, before it was analyzed. The weighting factor was obtained as the population proportion of the stratum divided by the sample proportion of the number of farmers in that stratum (Johnson 2008; van Turnhout *et al*., 2008 and Deaton, 1997), and determined as: **Weight factor** = (% in population / % in sample).

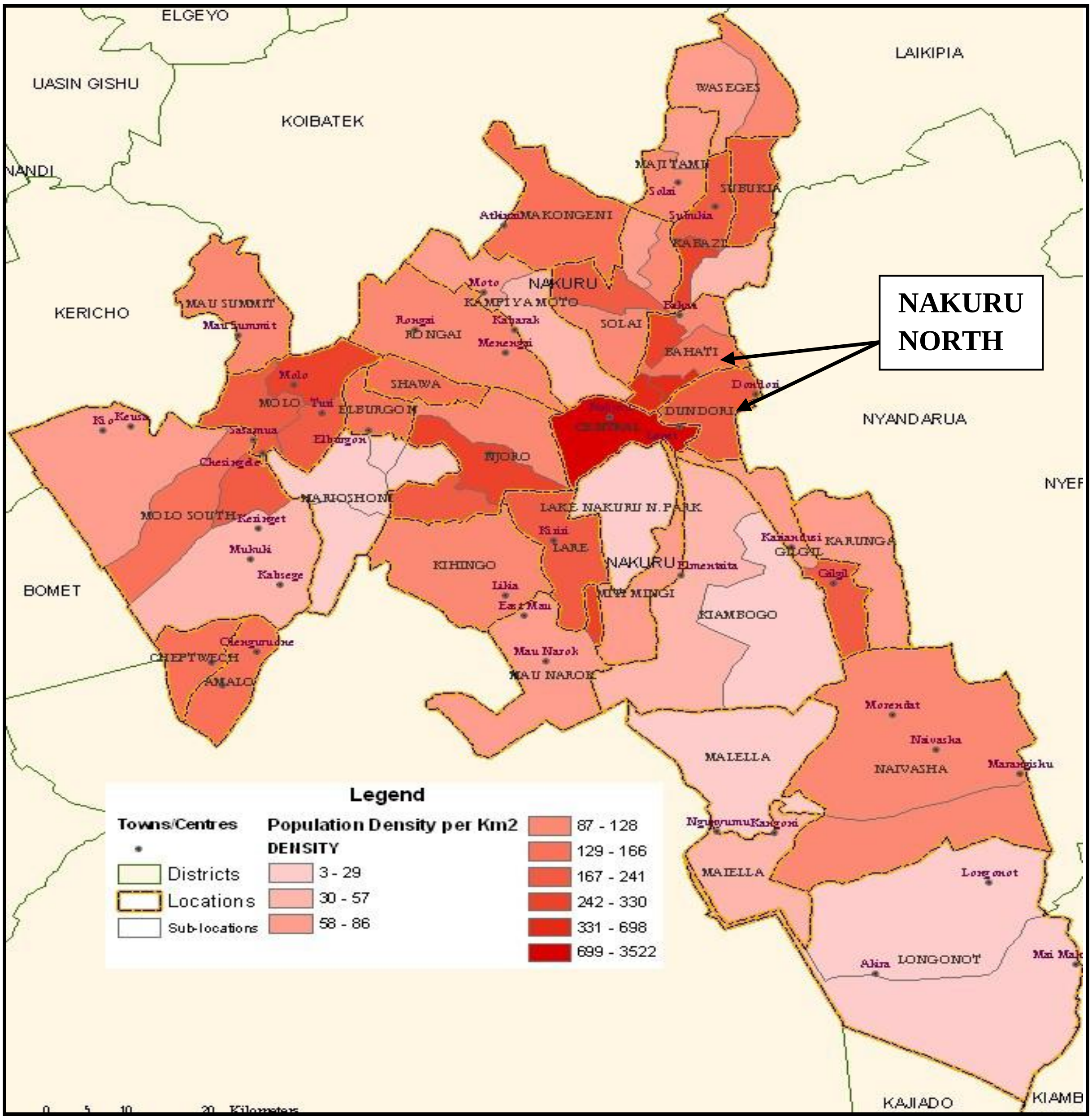

Figure 4: Nakuru County map

(Showing Administrative Divisions of Nakuru-North District: Bahati and Dundori)

Source: Nakuru District Strategic Plan (2005 – 2010)

3.3 Sample size

For the open-field stratum, a sample size of 120 farmers was used. This was a sample size that had been used in many previous similar studies like by Desta (2003); Jamala *et al*. (2011) and Shinde *et al*. (2009). In addition, it was based on Balian's recommendation, that a final sample size of 100 respondents can be used and increased by 20% to 120 (Balian, 1988). Another crucial consideration was with regard to available budget and other resources especially, time. In total, the sample size from both strata was expected to be 200. Since the greenhouse sub-population census realized a total of 108 farmers, there was a resultant of 228 farmers for the entire survey.

3.4 Data Collection

Secondary data were collected through literature review. A review of various government departmental reports like the Ministry of Agriculture reports was done. Other sources included various publications by the government, non-governmental organizations, research organizations, universities and international bodies. Secondary data on socio-economic characteristics of small-scale farmers and factors influencing technology adoption were used as source of variables for analysis.

Primary data were gathered from respondents by use of structured interview schedules (Appendix 2). The interview schedules were administered by enumerators after a pretesting exercise with 10 interview schedules. Discussions through informal surveys were also held with relevant informants. Some of the informants included farmers, extension agents, relevant agricultural inputs suppliers and administration. Information from informal surveys was especially necessary for developing and improving the structured interview schedules.

3.5 Analytical Framework

3.5.1. Socio-economic Characteristics of the Tomato Farmers

To establish the characteristics of the various farmers participating in the two tomato production systems, this study used the following descriptive statistics: Mean, Frequency, Percentage, and Standard deviation. These descriptive statistics explain, describe, compare, and contrast the producers in the tomato production systems in terms of the socio-economic and institutional characteristics that include gender, age, education level, farm size, tomato greenhouse units, tomato greenhouse sizes, type of tomato greenhouse, group participation, income level, land tenure, experience in tomato growing, acreage of tomatoes, access to credit, access to extension, access to markets and infrastructure. The farm size and tomato land area were standardized into metres squared by multiplying the acreage by a factor of $4046.85642M^2$ which is equivalent to 1 acre (Unit Online Converter, 2011).

3.5.2. Factors Influencing Adoption of a Tomato Production System

Numerous studies have been conducted on factors affecting adoption of agricultural technologies, either on intensity of adoption or identifying the factors in terms of characteristics associated with the farmers who adopt the technologies. For example, Nchinda *et al*. (2010) used Tobit to study factors influencing adoption and intensity of yam seedling technology in Cameroon, while Jans and Fernandez-Cornejo (2001) in a study on the economics in the United States used the Probit model to determine factors influencing adoption of tomato organic growing. Another study was by Engindeniz (2007) on comparative economic analysis between contract-based and non-contracted farmers where a binary Logit model was estimated to determine which factors make farmers prefer to grow tomato as contract-based. The second objective of this study focused on determination of factors that influence farmers' adoption of greenhouse tomato production system, against retaining the open-field system in Nakuru-North district.

Fourteen factors were hypothesized to influence the adoption of tomato production system. The dependent variable of the model represents a situation of whether a farmer is an adopter or a non-adopter of greenhouse tomato production system. The variable was coded either as 1 for adoption of greenhouse technology or 0 for retaining the open-field system. Since the dependent variable was of dichotomous nature, this suggests that either a binary Probit or a binary Logit model is appropriate because they would give similar results.

The binary Logit model was preferred in this study, and it was applied to test the hypotheses so as to achieve this second objective. According to Aldrich and Nelson (1984) the Logit distribution function for the adoption of a production system can be specified as:

$$P_i = \frac{1}{1+e^{-Z_i}} \quad \text{..........9}$$

Where p_i: is the probability of event (success), Z_i: is a function of n- explanatory variables (X) and expressed as:

$$Z_i = -(\beta_0+\beta_1 X_{i1}+\beta_2 X_{i2}+....+\beta_n X_{in}) \quad \text{..........10}$$

Where:

β_0 is is the intercept; β_1, β_2 and β_n are coefficients of the equation in the model.

P_i can be written as:

$$P_i = \frac{e^Z}{1+e^{-(\beta_0+\beta_1 X_{i1} + \beta_2 X_{i2} + ... + \beta_n X_{in})}} \quad \text{.......11}$$

This means that we cannot use the Ordinary Linear Square procedure to estimate the parameters. But this equation is intrinsically linear, which can be shown as follows.

If Pi is the probability of event (success), then (1- Pi) the probability of event not occurying (failure) and can be written as:

$$1-P_i = \frac{1}{1+e^{Z_i}} \quad \text{.......12}$$

The ratio of the probability of event (success) to the probability of event not occurying (failure) can be written as:

$$\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} = e^{Z_i} \quad \text{.......13}$$

Where $\frac{P_i}{1-P_i}$ is simply the odds ratio event (success).

In this study this odds ratio is the ratio of the probability that the farmer will adopt greenhouse tomato production system to the probability that he will not adopt. Finally taking natural log of equation 13 we get:

$$L_i = \ln\frac{P_i}{1-P_i} = Z_{i(0,1)} = \beta_0+\beta_1 X_{i1}+ \beta_2 X_{i2}+....+ \beta_n X_{in} \text{.......14}$$

Where L_i is log of the odds ratio (logit), which is linear not only in X, but also in the parameters. Thus, if the stochastic disturbance term ε is introduced, the logit model becomes:

$$Z_i = \beta_0+\beta_1 X_{i1}+ \beta_2 X_{i2}+....+ \beta_n X_{in}+ \varepsilon \text{.......15}$$

In this study, the above econometric model has been used to analyze the data. The model has been estimated using the iterative maximum likelihood estimation procedure. This estimation procedure yields unbiased, efficient and consistent parameter estimates (Aldrich and Nelson, 1984).

Based on the literature reviewed in Chapter 2 plus some past experience, the factors that were expected to influence adoption of the profitable tomato production system and thus have been applied in the model as the independent variables were hypothesized as follows:

Gender of household head (Gndr)**:** - This was a dummy of either male or female. There are certain agricultural technologies or enterprises that are predominantly taken by a certain gender on the basis of their profitability. It was hypothesized that gender would positively influence adoption when male.

Age of household head (Age)**:** - This is the number of years of the household head. The study hypothesized that age may influence adoption either negatively or positively. The first scenario was by assuming that, the young are less risk averse and thus more willing to take up a tomato production system that is more profitable (hence more risky) than the aged (Abdulai and Huffman, 2005). Therefore, age in that case was hypothesized would negatively influence adoption. However, age of farmer can influence technology adoption in any direction depending on his/her position in the life cycle, education level and experience. Younger farmers are more likely to be interested in adopting new technologies if they are not constrained by limited cash resources, while older farmers are less likely to be able to use new technologies if they require extra physical labour and/or older farmers may be less interested because they have less need for extra income Tiamiyu *et al*. (2009).

Education level (Educ)**:** - This is number of years of schooling and as Abdulai and Huffman (2005) observes, it was expected that more educated farmers would use their acquired skills and adopt the more profitable production system. It was therefore hypothesized that, education would have a positive coefficient.

Household size (Hhsz)**:** - This was expressed as a number. It was hypothesized that it may have either a positive or a negative coefficient.

Farm size (Farmsz)**:** - Farm size can influence and in turn be influenced by other factors influencing adoption. The effect of farm size has been variously found to be positive since it affects adoption costs, risk perceptions, human capital, credit constraints, labour requirements, tenure arrangements and more (Bonabana-Wabbi, 2002). A substantial farm may also be good collateral for credit, which is much needed to adopt a profitable technology. On the other hand, farm size may have negative influence on adoption of a technology. Especially, where adoption of land-saving technologies, seems to be the only alternative to increased agricultural production (Bonabana-Wabbi, 2002).

Level of income (Income)**:** - The level of income has been expressed in Kenyan shillings. It encompasses both on-farm and off-farm incomes. By assuming that the more profitable tomato production system is likely to require higher capital investment, then it was expected that, households whose levels of income are higher would be the most likely to adopt the system. A positive coefficient was therefore hypothesized.

Contact with extension (ContExt)**:** - This has been reflected by number of extension contacts either through farm visits made or training sessions received during the preceding one year production season. Most studies analyzing this variable in the context of agricultural technology show its strong positive influence on adoption (Bonabana-Wabbi, 2002). Contact with extension is expected to provide information not only on a technology but also its profitability. A positive coefficient was hypothesized.

Access to credit (Credt)**:** - Just as argued in the case of income, households with access to credit may have the capital required for adopting the higher profit production system. The variable which was expressed as amount of credit was hypothesized to have a positive coefficient. A dummy variable was used.

Access to market (Accmark)**:** - Access and availability of market is bound to reduce marketing costs like transport and other transaction costs and offer favourable price for tomatoes. This means higher profitability. This was captured by distance in terms of number of kilometres acting as a proxy of marketing costs. Access to market was hypothesized to have a negative coefficient.

Experience (Expe): - This was been measured by the number of years of farming. Experienced farmers are assumed to have tried out a number of profitable technologies. It was hypothesized to have a positive coefficient.

Infrastructure (Infrast)**:** - The condition of infrastructure which has been represented by roads in this study can influence on choice of profitable production. Poor infrastructure may deter taking up what may be profitable enterprises due to frustrations and increased transport costs. Nearness to good infrastructure was expected to have a positive influence on adoption of profitable tomato production system.

Group membership (Grupmemb)**:-** When farmers participate in group activities, they may tend to share ideas on profitable enterprises and adopt them as well as engage in market activities of inputs acquisition or selling of produce and thereby improve their profits. It was therefore hypothesized that, group participation would have a positive coefficient. The variable has been expressed as a dummy of either participating in a group or otherwise.

Land tenure (Landten)**:** Where the land tenure system is of the leasing type, profit may be lower and thus negatively influence adoption. This has been used as a dummy of either individually owned with a title deed or otherwise.

Availability of family labour (Avaifamlab)**:** With availability of family labour, it may be more encouraging to adopt a profitable production system than in a situation where family labour is inadequate. This has been reflected as a dummy and it was hypothesized to have a positive influence.

In this study, the econometric model used to analyze the data was expressed as:

$$\mathbf{Z_{i(0,1)}}=\beta_0+\beta_1\mathbf{X_{i1}}+\beta_2\mathbf{X_{i2}}+....+\beta_n\mathbf{X_{in}}+\varepsilon \quad ......16$$

Where:

$\mathbf{Z_i}$ was the dependent variable constrained to take the values 0 and 1;

β_S are coefficients of the equation in the model;

$\mathbf{X_s}$ are a set of explanatory variables and ε is the error term

The model was thus estimated as follows:

In deciding whether to adopt greenhouse production system or retain open-field system, the model identifies factors influencing adoption and those which do not and is specified as:

$$Z_{(0,1)} = \beta_0X_0 + \beta_1X_1 + \beta_2X_2 + ...\beta_nX_n + e \quad ......17$$

Where adoption is denoted by 1 and non-adoption is denoted by 0, β_0 is a constant, $\beta_{1.....n}$ are parameters to be estimated, X_is are vector of explanatory variables which include:

X_1= Gender of household head (Gndr), X_2= Age of household head (Age), X_3= Education level (Educ), X_4= Household size (Hhsz), X_5= Farm size (Farmsz), X_6= Level of income (Income), X_7= Contact with extension (ContExt), X_8= Access to credit (Credt), X_9= Access to market (Accmark), X_{10}= Experience (Expe), X_{11}= Infrastructure (Infrast), X_{12}= Group membership (Grupmemb), X_{13} Land tenure (Landten) and X_{14} =Availability of family labour (Avaifamlab).

The empirical model for analyzing the factors affecting the adoption becomes:

$$Y_{(0,1)} = \beta_0 + \beta_1 \text{Gndr} + \beta_2 \text{Age} + \beta_3 \text{Educ} + \beta_4 \text{Hhsz} + \beta_5 \text{Farmsz} + \beta_6 \text{Income} + \beta_7 \text{ContExt} + \beta_8 \text{Credt} + \beta_9 \text{Accmark} + \beta_{10} \text{Expe} + \beta_{11} \text{Infrast} + \beta_{12} \text{Grupmemb} + \beta_{13} \text{Landten} + \beta_{14} \text{Avaifamlab} + \varepsilon_i \quad ......18$$

Table 2 summarizes the explanatory variables used in the model.

Table 2: Description of explanatory variables

Variable	Abbreviation	Measurement	Priori expected sign
Gender	Gndr	Dummy: Male = 1, Female = 0	+
Age	Age	Number of years	+/-
Education	Educ	Number of years	+
Household size	Hhsz	Number of persons	+/-
Farm size	Farmsz	Number of acres	+/-
Level of income	Income	Number of KES.	+
Contact with extension	ContExt	Number visits	+
Access to credit	AccCred	Number of KES.	+
Access to market	Accmark	Number of Kms	-
Experience	Expe	Number of years	+
Road Infrastructure	Infrast	Dummy: 0=Dirt,1=Gravel, 2=Tarmac	+
Group Membership	Grupmemb	Dummy:1= Member of a group, 0 = Not a member	+
Land tenure	Landten	Dummy:1=Owned with title, 0=Otherwise	+
Availability of family labour	Avaifamlab	Dummy: 1=With labour shortage 0=With no labour shortage	+

3.5.3. Profitability of the Different Tomato Production Systems

To achieve the third objective, the study used Gross margin and Net Profit to determine and compare the profitability levels for both greenhouse and open-field tomato production systems. Gross margins have been calculated by subtracting total variable costs from gross revenue (FAO 1985) and specified as:

$$\mathbf{GM_i = TR_i - TVC_i} \qquad \text{.........19}$$

Where, GM is gross margin; TR is Total (Gross) Revenue; TVC is Total Variable Costs;

(For i = 1, 2) either the open-field or the greenhouse system.

The net profit has been calculated by subtracting total production costs from gross (total) revenue as:

$$\boldsymbol{\pi_i = TR_i - TC_i} \qquad \ldots 20$$

Where, π is Net Profit; TR is Total Revenue; TC is Total Cost.

The gross (total) revenue was calculated using the stated price of tomatoes multiplied by the quantity of production as was reported by the survey respondents. Quantity of production includes total amount produced and was either, marketed, consumed at household level, or gifted out. The only direct and measurable return was obtained from the sale of tomatoes. In this case, current season's (2010/2011) prices and labour costs were used.

Variable costs included in the study were inputs and costs for labour. The costs were calculated as the product of the unit input cost and the quantity of each input used in production. They included inputs and labour costs at production, harvesting and marketing stages. Inputs included: seeds/seedlings, fertilizers, chemicals and water. Labour costs included: greenhouse construction, nursery work, land preparation, planting, watering, weeding, training, pruning, de-suckering, harvesting, sorting, packing, marketing and transportation. For family labour, the opportunity cost was used by adopting the average wage levels in the locality.

Fixed costs included interest on total initial investment costs, interest on total variable costs, depreciation, and administrative costs. The study assumed that land is owned by the farmer and not rented, although cost of land renting has also been established and used to calculate the fixed cost where land hiring was the case. Interest on total initial investment costs and total variable costs were calculated by charging an average simple savings deposits interest rate. Thus, interest reflects the investment's opportunity cost. Some examples of the initial investment costs are cost of constructing the greenhouse unit and the irrigation system unit costs. Administrative costs have been estimated as 3 percent of Total Variable costs. This method has been applied in most previous studies (Engindeniz & Tuzel, 2006). Depreciation has been estimated using the straight-line method. Assets initial cost after being subtracted their salvage value are divided by their expected economic life to determine the annual costs or depreciation (Chaudhary, 2006).

Thus, Depreciation = (Asset Price – Salvage Value)/ Number of Years of Life

The total costs were a summation of variable costs and fixed costs:

$$TC_i = TVC_i + TFC_i \quad \ldots\ldots 21$$

Where TC is Total costs, TVC is total variable costs and TFC is Total Fixed costs. Gross margin per meter squared and net profit per meter squared were then calculated by dividing gross margin and net profit by the area in meters squared, respectively. Once the gross margins and net profits had been computed, a t- test has been carried out to determine the gross margins and net profits are statistically different between the open-field and greenhouse production systems.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

This chapter presents results and discussions for the survey. Section 4.1 summarizes descriptive analysis on the socio-economic characteristics of small-scale open-field and greenhouse tomato growers. Section 4.2 gives results of the Binary Logit model for factors influencing the choice of tomato production system among small-scale farmers, while section 4.3 gives results of a comparison of the profitability of greenhouse and open-field tomato production systems in Nakuru-North district.

4.1 Socio-economic Characteristics of Tomato Growers

The survey was pretested with 10 tomato farmers. Survey responses were obtained from 228 farmers, 120 for open-field and 108 for greenhouse tomato production systems. For the greenhouse system, this was a census. However, 12 greenhouse tomato farmers, 10 of which were found with extreme production values and 2 which belonged to institutions, were dropped in the analysis. Consequently, the analysis was done with a sample size of 216 farmers comprising of two strata of 120 and 96 of open-field and greenhouse tomato growers, respectively.

Before the analysis, the weighting factors were calculated and then the SPSS statistics package was used to weight the data. With an estimated 2500 households of tomato growers in the study area (GoK, 2008), and a sample size of 216 comprising of 96 and 120 sub-samples for greenhouse and open-field tomato growers, respectively, the weight factors which are determined as the population proportion of the stratum divided by the sample proportion of the number of farmers in that stratum, were obtained as follows:

a) Greenhouse weight factor = (106/2500) / (96/216) = 0.0424/0.4444 = <u>0.0954</u>
b) Open-field weight factor = (2,394/2500) / (120/216) = 0.9576/0.5555 =<u>1.7237</u>

During pre-testing of the interview schedules, it emerged that majority of the farmers were not willing to disclose the household's members' accurate estimate of ages. The question was thus approached using non-continuous data during the survey. The age results are as summarized in Tables 3 and 4. From the age distributions shown in Table 3, the mean ages of the tomato farmers were calculated using the following formula:

$$AM = \sum fx / \sum f \qquad (21)$$

Where, AM is Arithmetic Mean, x is value of mid-point, f is frequency of group, ∑ is summation.

Table 3: Age analysis of the tomato farmers

Age	Open-field farmers			Greenhouse farmers			Sample		
	f	**x**	**fx**	**f**	**x**	**fx**	**f**	**x**	**fx**
20-30 years	12	25	300	0	25	0	12	25	300
30-40 years	52	35	1,820	1	35	35	53	35	1,855
40-50 years	80	45	3,600	5	45	225	85	45	3,825
50-60 years	35	55	1,925	1	55	55	36	55	1,980
60-70 years	19	65	1,235	1	65	65	20	65	1,300
Above 70 years	10	75	750	0	75	0	10	75	750
Total	208		9,630	8		380	216		10,010

Source: Survey data (2011)

Applying the formula in equation 21, the calculated means for age were as follows:

For the sampled farmers: AM = ∑fx / ∑f =10,010/216 = 46.34 years;

For open-field farmers: AM= ∑fx / ∑f = 9,630/208 = 46.30 years; and

For greenhouse farmers: AM= ∑fx / ∑f = 380/8 = 47.5 years

From the above calculations, the mean age for the tomato farmers was 46.34 years. It implies that tomato farming in the study area is mainly a middle-aged farmers' activity. For the open-field tomato farmers and greenhouse tomato farmers, their mean ages were 46.30 years and 47.5 years, respectively. The results show that the greenhouse tomato farmers were older than the open-field tomato farmers.

Table 4 summarizes the age comparison results for the tomato farmers. The results show that majority (39.1%) of the tomato producers were in the age bracket of 40-50 years while the least (4.7%) were in the age bracket of over 70 years of age. For the rest of the tomato growers, 5.6% were in the 20-30 years age bracket, 24.7% in the 30-40 years age bracket, 16.3% in the 50-60 years age bracket and 9.8% were in the 60-70 years age bracket.

Table 4: Age comparison of the tomato farmers

Age of household head		Open-field	Greenhouse	Total	Chi-Square value	Sig
20-30 years	Number	12	0	12	3.959	0.555
	% within stratum	5.8%	0.0%	5.6%		
	% of sample	5.6%	0.0%	5.6%		
30-40 years	Number	52	1	53		
	% within stratum	25.2%	11.1%	24.7%		
	% of sample	24.2%	0.5%	24.7%		
40-50 years	Number	79	5	84		
	% within stratum	38.3%	55.6%	39.1%		
	% of sample	36.7%	2.3%	39.1%		
50-60 years	Number	34	1	35		
	% within stratum	16.5%	11.1%	16.3%		
	% of sample	15.8%	0.5%	16.3%		
60-70 years	Number	19	2	21		
	% within stratum	9.2%	22.2%	9.8%		
	% of sample	8.8%	0.9%	9.8%		
Above 70 years	Number	10	0	10		
	% within stratum	4.9%	0.0%	4.7%		
	% of sample	4.7%	0.0%	4.7%		
Total	Number	206	9	215		
	% within stratum	100.0%	100.0%	100.0%		
	% of sample	95.8%	4.2%	100.0%		
		95.8%	4.2%	100.0%		

Source: Survey data (2011)

Note: The small discrepancy in totals is as a result of SPSS rounding off the decimals to the nearest integer due to weights.

Moreover, similar age results were revealed within the production systems as Table 4 depicts. Majority of the farmers were falling in the same 40-50 years age bracket at 38.3%

and 55.6% for open-field and greenhouse farmers, respectively. While 4.9% open-field tomato farmers were over 70 years of age, only less than 1 % was of over 70 years of age for the case of the greenhouse tomato farmers. The percentages of farmers in the 20-30 years age bracket were 5.8% and less than 1% for open-field and greenhouse tomatoes farmers, respectively. No statistically significant difference was observed in age between the open-field and greenhouse farmers.

Table 5 summarizes gender, access to credit and land tenure characteristics of the producers. For gender, 81.5% of tomato growers were males while 18.5% were females. Very similar results were obtained within the two tomato production systems, with only 17.6% and 1% of the tomato growers being females for open-field and greenhouse tomatoes systems, respectively. This implies that tomato farming is predominantly a male activity. Gender was not found to be significantly different between the two systems as shown by the Chi-square value.

For access to credit, there were an overall 28.2% of tomato growers who had indicated interest in credit use while the rest 71.8% did not apply. Within the production systems, more open-field growers applied for credit than greenhouse tomato growers at 28.5% and 22.2%, respectively. However, access to credit was not observed to be statistically different between the producer groups.

Land tenure characteristics of tomato farmers showed that on the overall, 79.2% of the farmers owned the land and had title-deeds and the rest 20.8% did not have title-deeds. Within the systems, whereas 100% of greenhouse tomato farmers owned the land and had title deeds, for the open-field system, 78.3% farmers owned the land and had title deeds. The Chi-Square results show that the difference in land tenure between the farmers of both systems was not statistically significant.

Table 5 : Gender, Credit and Land Tenure analysis of the farmers

Socio- economic characteristic		Open-field	Greenhouse	Total	Chi^2	Sig
Gender of farmers						
Females	Number	38	2	40	0.085	0.770
	% within stratum	18.4%	22.2%	18.5%		
	% of Total	17.6%	0.9%	18.5%		
Males	Number	169	7	176		
	% within stratum	81.6%	77.8%	81.5%		
	% of Total	78.2%	3.2%	81.5%		
Total	Number	207	9	216		
	% within stratum	100.0%	100.0%	100.0%		
	% of Total	95.8%	4.2%	100.0%		
Applied for credit						
No	Number	148	7	155	0.168	0.682
	% within stratum	71.5%	77.8%	71.8%		
	% of Total	68.5%	3.2%	71.8%		
Yes	Number	59	2	61		
	% within stratum	28.5%	22.2%	28.2%		
	% of Total	27.3%	0.9%	28.2%		
Total	Number	207	9	216		
	% within stratum	100.0%	100.0%	100.0%		
	% of Total	95.8%	4.2%	100.0%		
Land tenure						
Without title	Number	45	0	45	2.471	0.116
	%	21.7%	0.0%	20.8%		
With Title	Number	162	9	171		
	%	78.3%	100.0%	79.2%		
Total	Number	207	9	216		
	%	100.0%	100.0%	100.0%		

Source: Survey data (2011)

Note: The small discrepancy in totals is as a result of SPSS rounding off the decimals to the nearest integer due to weights.

The other results of the farmers' socio-economic characteristics are summarized in Tables 6 and 7. They include farm size, land under tomatoes, household size, attained education levels, experience, market distance, extension contacts and income levels. From Table 6, the mean farm size for the tomato farmers was 7881.27 m^2 (1.95acres) although many farmers reported owning 4,000 m^2 (1 acre) of land. The mean area of land put under tomatoes was 2294.55 m^2 (0.57acres) with a minimum area of 60 m^2 (0.0001acres) and a maximum area of 18,000 m^2 (4.5 acres). The mean household size was 5.42 persons with the highest number of household size being 12 persons.

The mean number of education years was 11.28 and the most reported number of education years was 12 (equivalent of secondary level of education attained). However, the results show that there were tomato farmers with 0 numbers of years of education, implying that the farmers had not even attended primary level of education. The tomato farmers had a mean experience of 11.34 farming years with the lowest and highest experiences being 1 and 40 farming years, respectively. The average distance to the market for the tomato farmers was 13.02 km, with the farthest and the nearest distances being 32 km and 0.5 km, respectively. The mean number of extension contacts for the year 2010 was 2, while the lowest and the highest were 0 and 36 number of contacts, respectively. The mean annual household income for the tomato farmers was KES 195262.35 whereas the highest and the lowest annual household incomes were KES 1,070,000 and KES 9,000, respectively.

Table 6: Socio-economic characteristics of tomato farmers

Characteristic	**Mean**	**Mode**	**Std. Deviation**	**Minimum**	**Maximum**
Farm size (m^2)	7881.27	4,000	5373.508	450	20,000
Tomato land size (m^2)	2294.55	1000	2514.830	60	18,000
Household size	5.42	5	2.050	0	12
Education level (Years)	11.28	12	2.890	0	16
Experience (Years)	11.34	10	8.311	1	40
Market Distance (Km)	13.02	0.5	9.605	0.5	32
Extension (Number)	2.00	0	3.895	0	36
Income (KES)	195262.35	60,000.00	1.64965E5	9,000.00	1,070,000.00

Source: Survey data (2011)

Table 7 shows a comparison of these socio-economic characteristics between the open-field and greenhouse small-scale tomato farmers. The results show that the average farm size was 7917.08 m^2 (1.96 acres) and 7072.50 m^2 (1.75 acres) for open-field and greenhouse farmers, respectively. The mean tomato land was 2,384.79 m^2 (0.59 acres) and 256.41 m^2 (0.063 acres) for open-field and greenhouse farmers, respectively. While the farm sizes were not significantly different, the difference of tomato land sizes between the two groups of producers was found to be statistically different at 1% significance level.

The average household size was 5.43 and 5.21 for open-field and greenhouse farmers, respectively. These can be rounded off to 6 members for both systems. No statistical significant difference existed in terms of the household sizes of the two tomato growing systems. As regards to the attained levels of education by the household head, the open-field tomato growers had a mean of 11.20 years of education (equivalent of secondary school) compared to 13.06 years of education (equivalent of diploma/certificate college level) attained by the greenhouse tomato farmers. There were some open-field farmers without any formal education including primary level of education, and thus had 0 number of education years. On the whole, greenhouse tomato farmers were on average significantly more educated ($P = 0.009$) than open-field producers.

The mean number of farming years of experience was 11.57 years and 6.47 years for open-field and greenhouse farmers, respectively, implying that open-field farmers had more years of farming than those practicing greenhouse tomatoes production. The difference in experience among the two groups was significantly different at 5% level of significance. The distance to the tomato market was on average, 13.05 km and 12.36 km for open-field and greenhouse farmers, respectively. Although the open-field tomato growers appeared to be located slightly farther away, the difference between mean market distances was not significantly different.

The number of extension contacts for the year 2010, either from the government, research or non-governmental institutions was 1.92 and 3.79 for open-field and greenhouse farmers, respectively. These can be rounded off to 2 and 4 times of extension contacts for open-field and greenhouse farmers, respectively, meaning that greenhouse tomato farmers had twice number of extension contacts than open-field farmers. The number of extension contacts was, however, not statistically different.

As regards to income, the greenhouse farmers had higher level of income with an annual total income mean of KES 345,920.83. For the open-field farmers, the mean annual total income was KES 188,591.67. The two income levels were statistically different at 10% significance level.

Table 7: Comparison of the farmers' characteristics

Characteristic	Type of farmer						**t-ratio**	**Sig**
	Open-field			Greenhouse				
	Mean	**Min.**	**Max.**	**Mean**	**Min.**	**Max.**		
Farm size (m^2)	7917.08	450	28,000	7072.50	500	64,000	0.333	0.747
Tomato land size (m^2)	2384.79	225	18,000	256.41	60	1216	11.23	0.000
Household size	5.43	1	12	5.21	2	11	0.299	0.772
Education level (Years)	11.20	0	16	13.06	8	16	-3.210	0.009
Experience (Years)	11.57	2	40	6.47	1	31	2.303	0.046
Market Distance (Km)	13.05	0.5	32	12.36	0.5	30	0.230	0.823
Extension (Number)	1.92	0.5	18	3.79	0.5	36	-1.040	0.327
Income (KES)	188,591.67	9,000	680,000	345,920.83	17,000	1,070,000	-1.760	0.099

Source: Survey data (2011)

4.2 Factors Influencing Choice of Tomato Production System

This section presents regression results of factors influencing the choice of a tomato production system among small-scale farmers in Nakuru–North district. The Binary Logit was used to analyze the factors.

Before taking the selected variables into the logit model, it was necessary to check for the existence of multicollinearity among the continuous variables and verify the degree of association among discrete variables. The reason for this is that the existence of multicollinearity seriously affects the parameter estimates. The Variance Inflation Factor (VIF) was used to test for the existence of multicollinearity between continuous explanatory variables. VIF shows how the variance of an estimator is inflated by the presence of multicollinearity (Gujarati, 2004). As a rule of thumb, values with VIF greater than 10 are often taken as a signal for the existence of multicollinearity problem in the model (Gujarati, 2004). The survey results had a mean VIF of 1.22.

Before using the model to make any statistical inference, there was also need to check whether the model fitted sufficiently well and check for influential observations that may have had impact on the estimates of the coefficients. The goodness of fit test used for the model was the Hosmer and Lemeshow's goodness-of-fit test under which, a large p-value would indicate that the model fits the data well (UCLA, 2011). The inferential goodness-of-fit test's Hosmer–Lemeshow (H–L) yielded a Chi^2 (8) of 8.57 and was insignificant ($p > 0.05$), suggesting that the model was fit to the data.

The use of the usual testing procedures despite heteroscedasticity may make whatever conclusions or inferences drawn to be misleading (Gujarati, 2004). In this study, the problem was tested using the 'hettest' test where the rule of thumb is that if the Breusch-Pagan p-value is > 0.1, there is no heteroscedasticity. The survey results gave p-value of 0.9853. The results for these tests are presented in Tables 12, 13 and 14 (Appendix 1).

Fourteen explanatory variables were included in the model. These variables had been hypothesized to influence the farmer's adoption of a tomato production system. Out of the 14 proposed explanatory variables, gender, land size, household size, experience and group participation were found to have a negative sign, while the remaining variables: age, labour, education, land tenure, market distance, farm income, access to credit, road type and access to extension, had a positive sign of association with adoption of greenhouse tomato production. The obtained results for the coefficients and odds ratios are as presented in Table 8.

Table 8: Maximum Likelihood Estimates for factors influencing adoption

				Number o f Obs	=	216
				LR Chi2 (14)	=	120.65
Logistic regression				Prob > Chi2	=	0.0000
Log likelihood -88.057602				Pseudo R 2	=	0.4066

Explanatory variable	**Coef.**	**Std. Err.**	**Odds Ratio**	**Std. Err.**	**z**	**P>|z|**
Road type	0 .124	0. 6725352	2.506	0. 672535	3.42	0.001
Land size	-4.31e-06	0.0000293	1.000	0.000029	-0.82	0.412
Land tenure	0 .130	1.952844	2.856	1.952844	1.53	0.125
Experience	-0.015	0. 0325527	0 .885	0.032527	-3.32	0.001
Market distance	0.003	0. 0233077	1.016	0.0233077	0.69	0.489
Household size	-0.006	0. 1065284	0.951	0.1065284	-0.44	0.657
Gender	-0.078	0. 3130358	0.599	0. 313036	-0.98	0.327
Age	0.105	0. 4635148	2.120	0. 463515	3.43	0.001
Education	0 .033	0. 1309929	1.307	0. 130993	2.67	0.008
Extension Contacts	0.008	0. 0536527	1.054	0. 0536527	1.04	0.297
Credit	1.01e-06	2.70E-06	1.000	2.70E-06	2.48	0.013
Labour	0.152	0. 1400756	0 .322	0. 1400756	-2.60	0.009
Group Membership	-0.183	0. 1370753	0 .2660	0. 1370753	-2.57	0.010
Income	6.73e-07	1.19E-06	1.000	1.19E-06	4.44	0.000
Constant	-0.389	0.2061378			-3.85	0.000

Source: Survey data (2011)

Based on the model results, 8 out of the 14 explanatory variables were found to be statistically significant including: road type, experience, age of household head, education of household head, access to credit, labour, group membership and farm income. The rest like land size, household size, market distance, gender and access to extension were insignificant. The interpretations of the significant explanatory variables are given below:

Road Type: This variable was significant at 1% significance level and positively associated with the adoption of greenhouse tomato farming. The sign shows that as the type of road serving a household improves from dirt/earth road to tarmac/bitumen road, the probability to adopt greenhouse tomato farming increases. All other things being kept constant, the odds ratio in favour of showing interest in greenhouse farming increases by a factor of 2.5 as the location to tarmac/bitumen (better infrastructure) road of the household head is increased by one unit. The positive sign indicates there is a positive impact of road type on adoption of greenhouse farming. The possible explanation is that in the study area, better roads provide an incentive to adopt worthwhile enterprises due to better linkage between the farms and the markets. There are in fact more greenhouse tomato farmers in Bahati division, which is served with longer murram/gravel and tarmac road networks, hence better infrastructure, than for Dundori which is served with more dirt/earth and gravel roads and less tarmac roads. These results are consistent with previous studies that had showed that infrastructural problems arising from low quality and insufficient supplies of roads can be constraints to the development of small and micro enterprises (Destaw, 2003). Moreover, farmers located near to better infrastructure may have more contacts with extension and subsequent extension follow-ups and thus be more likely to adopt a technology (Desta, 2003).

Experience: Experience was in terms of number of farming years and was found to be significant at 1% level of significance and negatively associated with the adoption of greenhouse tomato farming. The sign is quite in contrast to what was hypothesized, and it shows that as experience of the household increases, the probability to adopt greenhouse tomato farming decreases. Holding all other explanatory variables constant, the odds ratio in favour of adopting greenhouse tomato farming decreases by a factor of 0.89 as the experience of the household head is increased by one unit (one year). The greenhouse tomato technology is being adopted by farmers who have been in farming for an average of 6.43 years as compared to11.57 years for farmers practicing open-field tomato farming as shown in section 4.1. A likely explanation is that due to acquired experience and accumulated knowledge stemming from a long period of observations and experimenting, some farmers may have perfected in the open-field tomato farming and combining this with the age factor, these farmers are likely to be more risk averse and are more reluctant to change to the greenhouse tomato growing technology. Another possible explanation is that there may be some past unpleasant experience with the performance of conventional tomato production which may be a barrier to the adoption of greenhouse tomato growing. These results confirm those of Bonabana-Wabbi (2002) where past experience with poor performance of cowpea intercrops was cited as a probable reason that discouraged increased practice of intercropping cowpeas with cereal crops as an IPM technology in Kumi District, Uganda. It is also possible that greenhouse tomato growing is a case where experience within the general population is limited, and more information induces negative attitudes towards its adoption, probably because more information exposes an even bigger information vacuum, hence increasing the risk associated with it (Bonabana-Wabbi, 2002). Past studies have also shown that, though age and farming experience significantly influences adoption positively, they may not go together in empirical analysis if a high correlation is established between the two. Thus, one may be used as a proxy for the other (Nchinda *et al*., 2010). However, in this study the multicollinearity test done indicated no any such collinearity.

Age: The age of the household head in years was significant at 1 % significance level and positively associated with the adoption of greenhouse tomato farming. The sign shows that as the age of the household increases, the probability to adopt increases. Holding all other explanatory variables constant, the odds ratio in favour of showing interest to greenhouse tomato farming increases by a factor of 2.12, as the age of the household head increases by one unit (one year). This indicates that in the study area, participation in greenhouse tomato farming is higher for older farmers than for younger farmers. The positive impact of age on adoption of greenhouse tomato growing may be explained by the fact that with time, the older household heads may have gathered more resources and experience required for technology adoption than younger household heads. Similar results were reported by Nchinda *et al*. (2010) and Tassew and Oskam. (2001) were shown.

Education: The education level of the household head was significant at 1 % significance level and positively associated with the adoption of greenhouse tomato farming. The sign shows that as the education level of the household head increases, the probability to adopt greenhouse farming increases. Holding all other explanatory variables constant, the odds ratio in favour of showing interest to greenhouse tomato farming increases by a factor of 1.31, as the education level of the household head increases by one unit (one year). Greenhouse production technology requires a lot of knowledge, especially on proper use of chemicals, management and structure construction. Education is therefore a very important factor. The acquired knowledge and skills improves the ability to comprehend and implement instructions and proper crop husbandry and management practices required in greenhouse tomato growing. These results are consistent with several past studies like the study by Ridgley and Brush (1992), which showed a positive correlation between education and adoption of IPM techniques and also the study by Tiamiyu *et al*. (2009) on adoption of rice.

Access to Credit: Access to credit in terms of Kenya shillings of credit received was significant at 5% significance level and positively associated with the adoption of greenhouse tomato farming. The sign shows that as access to credit increases for the household, the probability to adopt greenhouse tomato farming increases. Holding all other explanatory variables constant, the odds ratio in favour of adopting greenhouse tomato farming increases by a factor of 1.0 as access to credit for the household is increased by one unit (one shilling). The possible justification for this is the fact that, access to credit compensates for insufficient household income, thereby providing the required initial capital required for greenhouse tomato production. Access to credit permits farmers to invest in a new technology or acquire related inputs (e.g. labour, fertilizer) (Nchinda *et al*., 2010). The results of this study are similar to those of Destaw (2003).

Labour: Labour was a dummy variable in terms of either having labour shortage or not and was significant at 1% level of significance and positively associated with the adoption of greenhouse tomato farming. The sign is in line with what was earlier hypothesized, and it shows that as labour availability of the household increases, the probability to adopt greenhouse tomato farming increases. Holding all other explanatory variables constant, the odds ratio in favour of adopting greenhouse tomato farming increases by a factor of 0 .32 as the labour for the household is increased by one unit (person). The possible explanation is that tomato growing may be labour intensive, and greenhouse tomato growing is more attractive to households with more farm labour. The results are similar to those of Ben-Houassa (2011) which indicated that among the important factors directly related to adoption of fertilizer was hired labour. However, these results are inconsistent to the study by Bonabana-Wabbi (2002) where the size of household labour force negatively influenced *Celosia* adoption.

Group Membership: Participation of household members in group organizations was treated as a dummy variable and the model results show it was significant at 5 % significance level and negatively associated with the adoption of greenhouse tomato farming. The sign shows that as the participation in organization of a household member tends to increase, the probability to adopt decreases. With all other explanatory variables held constant, the odds ratio in favour of adopting greenhouse tomato farming decreases by a factor of 0.27 as the participation in organization of a household member tends to increase. This sign is contrary to what was expected since membership in community farmers' organizations had been used as a proxy for farmer-to-farmer sharing of information and access to extension service packages (Nchinda *et al*., 2010). This does not however appear to be so in the study area probably because information shared in these organizations may not have contained greenhouse tomato production messages. It is also possible that even the extension agents in the study area may not be disseminating tomato production technology messages through the group-approach like the Self Help Groups or Common Interest Groups. Similar results were obtained by

Bonabana-Wabbi (2002) in which Integrated Pest Management (IPM) technology transfer in Eastern Uganda, exerted a negative influence on the probability of adoption. However, the results are inconsistent with many previous studies like by Tiamiyu *et al*. (2009) on adoption of New Rice for Africa in Savanna Zone of Nigeria.

Farm Income: The level of both on-farm and off-farm income in Kenya shillings for the household head was significant at 1 % significance level and positively associated with the adoption of greenhouse tomato farming. The sign shows that as the income level of the household head increases, the probability to adopt increases. With all other explanatory variables held constant, the odds ratio in favour of adopting greenhouse tomato farming increases by a factor of 1.0 as the income level of the household head is increased by one unit (Kenya shilling). With a higher level of income, there is the tendency to adopt greenhouse technology which requires a substantial amount of money especially for initial investment. These results are consistent with various other studies. One such example is the study by Alston and Reding (1998) where annual on-farm income was positively and significantly correlated with adoption level of IPM practices among wheat growers.

4.3 Comparing the Profitability of Greenhouse and Open-field Tomato Production

To achieve the third objective of the study, Gross Margin and Net Profit were used. The gross margin and net profit were standardized per meter squared to enable the comparison between both systems of production. Revenue and costs data were collected for both categories of farmers. The yields, price and variable costs were based on farmers' responses for the 2010/2011 production season. The cost items of tomato production were classified into: variable costs, and fixed costs. The variable costs were all inputs and labour costs that were directly related to tomato production like seeds, seedlings, herbicides, fertilizers, land preparation, planting, disinfectants, pruning, training, water, watering, harvesting, sorting, packing, transport etc. In this study, fixed costs included annual initial costs, interest on total initial costs, and interest on total variable costs, administrative costs, and land rent. Interest is defined as a sum paid or calculated for the use of capital. In this study, interest on total initial investment costs and total variable costs was calculated by charging a simple interest rate of 1.63% (annual saving deposits interest rates on KES1). This method of calculating interest was used in several previous studies (Engindeniz, 2002; Engindeniz & Tüzel, 2006; Engindeniz and Gül 2009). The interest rate of 1.63% used was the average annual saving deposits interest rate for commercial banks in 2010 according to the Kenya National Bureau of Statistics (KNBS) (2011). For the open-field system, interest would have been charged on one-half of total initial investment costs and total variable costs, but since in practice, only one tomato crop is possible per year due to weather conditions, the interest was charged per annum.

In this study, administrative costs were estimated to be 3% of total variable costs. This method was applied in most of the previous studies (Engindeniz, 2002; Engindeniz & Tüzel 2006; Engindeniz and Gül 2009). Depreciation for greenhouse initial cost and also equipments and tools was estimated using the straight-line method. Initial costs were divided by their expected economic life after a 10 % allowance or salvage value had been taken from the purchase price of the buildings and equipments (Chaudhary, 2006). The total costs were a summation of variable costs and fixed costs.

The total revenue was estimated by multiplying the estimated yield by the average price of the produce. The gross margin was estimated by subtracting total variable costs from the total revenue. The net profit was the difference of total revenue and total costs. Gross margin per meter squared and net profit per meter squared were then calculated by dividing gross margin and net profit by the area in meters squared, respectively. The results were as shown in Table 9.

From the results, the mean yields are 0.95 kg/m^2 and 10.53 kg/m^2 for open-field and greenhouse tomato farmers, respectively. Thus the greenhouse yields are higher, although the two systems use different tomato varieties and have different harvesting regimes. Thirty five point eight percent of open-field tomato farmers grew Rio Grande variety, followed by 25.8% who grew Onyx. For the case of greenhouse tomato farmers, 54% grew Anna F1 followed by 7.1% who grew Tylka F1. The survey also established that about 25% of greenhouse tomato farmers grew open pollinated tomato varieties like Roma (9%), Cal J (6%), Onyx (6%) and Rio Grande (4%). Similarly, a few open-field tomato farmers amounting to 3% grew hybrid tomato variety Anna F1. The yields differences between the two production systems were statistically significant at 1% significance level.

The mean prices were KES 26.02 and KES 41.78 per kg of tomatoes for open-field and greenhouse tomato farmers, respectively. The price differences between the two systems were statistically significant at 5% significance level. Greenhouse tomatoes therefore fetch a higher average price per kilogram than open-field grown tomato. This may be attributed to better quality produce, premium prices, market timing, and selling to regular markets among other advantages. These results are consistent with many previous studies. For example, a study by Engindeniz and Gül (2009) showed that, the basic determinants of the profitable greenhouse production are the economical rather than the ecological factors. The higher prices and exploitation of regular markets by greenhouse farmers makes the greenhouse system more profitable than the open-field system in the study area.

Table 9: Profitability analysis of the Tomato Production systems

Parameter	Type of farmer	Mean	Std. Deviation	Min.	Max.	t-ratio	sig
Yield (Kg/m^2)	Open-field	0.95	0.584	0.00	3.46	-4.144	0.003
	Greenhouse	10.53	6.989	0.33	29.13		
Average price (KES/ Kg)	Open-field	26.02	12.267	0.00	62.50	-3.039	0.015
	Greenhouse	41.78	15.473	15.63	75.00		
Total Variable costs (KES/m^2)	Open-field	9.16	5.411	2.84	50.56	-5.442	0.001
	Greenhouse	134.94	69.938	15.08	314.50		
Gross Margin (KES/m^2)	Open-field	14.92	14.376	-12.92	56.77	-3.067	0.015
	Greenhouse	288.34	269.786	-23.30	1143.83		
Fixed costs (KES./m^2)	Open-field	1.93	2.871	0.20	28.92	-6.417	0.000
	Greenhouse	119.23	55.317	12.85	344.53		
Total costs (KES./m^2)	Open-field	11.09	7.8597	3.32	79.48	-6.864	0.000
	Greenhouse	254.18	107.163	27.93	540.79		
Net profit (KES/m^2)	Open-field	12.99	14.692	-36.81	49.50	-1.864	0.099
	Greenhouse	169.11	253.411	-134.97	917.54		

Source: Survey data (2011)

The mean variable costs were KES 9.16/m^2 and KES 134.94/m^2 for open-field and greenhouse systems, respectively. For the greenhouse system, seeds and watering took the bulk of the variable costs. For the case of the open-field system, fungicides and insecticides formed the most sizeable amount. The fixed costs averaged KES 1.93/m^2 and KES 119.23/m^2 for open-field and greenhouse systems, respectively. The bulk of the greenhouse fixed costs arose from the cost of the greenhouse structure, totalling an average of KES 500/m^2. This average greenhouse cost is less than the estimated greenhouse structure cost by Odame (2009). A likely explanation for this is that most of the farmers in the study area use second-hand greenhouse plastic covering materials. The mean total costs were KES 11.09/m^2 and KES 254.18/m^2 for open-field and greenhouse systems, respectively. The differences between the total costs were statistically significant at 1% significance level.

The mean gross margins were KES 14.92/m^2 and KES 288.34/m^2 for the open-field and greenhouse tomato farmers, respectively. The gross margin for greenhouse tomatoes is therefore higher than for the open-field system. The differences between the gross margins were statistically significant, at 5% significance level. The mean net profit were KES 12.99/m^2 and KES 169.11/m^2 for open-field and greenhouse tomatoes, respectively. The differences between the net profits were statistically significant at 10% significance level. This means that the greenhouse production system is more profitable than the open-field. These results are consistent with various past studies. The tomato greenhouse system has been shown to have a higher profitability than the open-field system as shown by the private and social profits, and is more efficient which compensates its extra costs (Atiya, 2006).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The study analysed the socio-economic characteristics of small-scale tomato farmers, the factors influencing the adoption of a tomato production system and the profitability of small-scale open-field and greenhouse tomato production in Nakuru-North district, Kenya. The socio-economic characteristics were analysed using descriptive statistics. For comparison purposes, these socio-economic characteristics were tested using chi-square and t-ratios. To determine factors influencing the choice of a tomato production system, the Binary Logit model was used. The study used Gross margin and Net Profit to determine and compare the profitability levels for both greenhouse and open-field tomato production systems. A t- test was carried out to determine whether the gross margins and net profits were statistically different.

. The socio-economic characteristics analysis revealed that there were significant differences in the number of years of schooling, experience and levels of income between the adopters and non-adopters of a tomato production system. On average most (36.7%) of the tomato farmers had attained secondary level of education. However, there were farmers (1.4%) with zero years of education. Majority (39.2%) of the tomato farmers were in the age bracket of 40-50 years and 81.6% of them were males. It can therefore be concluded that tomato farming in the study area is a middle-aged and males dominated activity. The tomato farmers had a mean experience of 11.34 farming years with the lowest and highest experiences being 1 and 40 farming years, respectively. The results revealed that open-field farmers had more years of farming (11.57 years) than those practicing greenhouse tomatoes production (6.47 years). The mean annual household income for the tomato farmers was KES 195,262.35 whereas the highest and the lowest annual household incomes were KES 1,070,000 and KES 9,000, respectively. Greenhouse tomato growers had a mean income of KES 345,920.83. This was higher than that for the open-field tomato growers of KES 188,591.67. Majority of the sampled farmers (71.8%) showed no interest in credit. More open-field tomato growers (28.5%) had applied for credit compared to 22.2% for greenhouse tomato farmers. This suggests that most of the tomato growers relied heavily on their income (on-farm and off-farm). 55.6% of the greenhouse farmers used second hand greenhouse covering material that are prone to wind destruction, which may in fact influence adoption of greenhouse production. The mean greenhouse structure cost was KES 500/m^2 and the mean cost of a greenhouse unit used by farmers in the study area was KES 89, 623.82.

The significant factors found to be influencing the probability of adoption of a tomato production system were the road type, age of household head, education of household head, access to credit, and farm income which had a positive sign of association and in addition, experience, labour and group membership which had a negative sign of association.

The mean gross margins were KES 14.92/m^2 and KES 288.34/m^2 for the open-field and greenhouse tomato farmers, respectively. The mean net profits were KES 12.99/m^2 and KES 169.11/m^2 for open-field and greenhouse tomatoes, respectively. Thus the greenhouse tomato production system is able to offset its higher mean total costs of KES 254.18/m^2 compared to KES 11.09/m^2 for open-field systems. The results therefore, show that greenhouse tomato production technology is more profitable than the open-field production system.

Some important inferences for the improvement of tomato production can be drawn from the findings of this study. The implication of these findings is that since greenhouse tomato production is more profitable and coupled with its many other advantages, the system should be promoted to help alleviate the problem of poverty as well as increase employment opportunities in the study area. The other implications are that labour, education and income are important to tomato technology adoption. Increased labour, education and sources of rural income will therefore improve the adoption of the profitable tomato production technology. It may also by extension, suggest that due to the capital requirement for greenhouse tomato production, and so as to provide the capital that may be insufficient with low income farmers, credit issues need to be addressed. The study also shows the need for infrastructural improvement and especially to grade or tarmac main roads serving the farmers to enable linkage with the tomato market.

From the findings of the study, it emerges that only a few farmers showed interest in credit use, majority of who were open-field tomato farmers. This may be probably because greenhouse farmers were found to be having higher incomes than open-field farmers. The major reason why farmers did not engage in credit issues is because of lack of interest in credit. Since the study has also established that income is a very significant factor influencing adoption of a tomato production system, policies addressing tomato farming can be used to reverse this trend of use of credit. Any barriers impending interest in credit need to be addressed. Most importantly, the issues to be dealt with may include, availability of credit facilities, credit conditions, borrowing rates and education on need and use of credit.

Perhaps, the exploitation of groups that already exist or new ones, purposively to disseminate technology adoption messages may also be critical. This will enable farmers to learn issues regarding costs and returns of the tomato production systems and thus adopt the preferable one.

5.2 Policy Implications

Several conclusions can be made from these findings that are relevant to policy makers or technology suppliers, for efficient and effective small-scale tomato technology adoption. Policy makers and technology suppliers should take into account the following:

1) The importance of education and thus education facilities should be considered when designing economic policies to enhance small-scale tomato technology adoption in order to achieve the adoption of the technology.
2) Policies promoting small-scale tomato technology adoption should be complemented by strategies that promote rural income creation.
3) Adult education institutions need to be started or improved and farmers who are illiterate can be encouraged to join adult education lessons so as to improve their education status as well as credit use.
4) Rural infrastructural development policies should consider the importance of improving road-networks serving small-scale farmers as these roads are the only means to the markets and however lucrative the tomato enterprise may seem, the utmost benefit is its profitability which will very likely be influenced by access to its market.

5.3 Suggestions for Further Research

In the study area, it was revealed that small-scale tomato farming is predominantly a middle-aged male's activity. Further research may help to establish the reasons for this so as to encourage other farmers and especially the youth who are desperately searching for employment, to practice the viable tomato production system.

From the study findings, it emerged that there are so many varieties of tomatoes being planted by the small-scale farmers. It also emerged that, varieties that are ideally recommended for the open-field are being grown in the greenhouses and vice versa. Other findings were that some farmers grew an assortment of tomato varieties. There is need to establish why this is so and most importantly, determine the profitability levels of each practice, so as to equip all the stakeholders with that information.

Contrary to the study's earlier expectations, group participation was found to negatively influence adoption of a tomato production system. Access to credit was also found to be more prevalent with open-field tomato growers than those doing greenhouse tomato farming, whereas the reverse was expected since greenhouse farming was presumed to be requiring more capital. There is need to establish why these scenarios so as to encourage more tomato farmers to participate and reap from the benefits of group participation and credit use.

Study findings revealed that majority of the tomato farmers in the study area sold their produce to the wholesale markets in Nakuru town. Other marketing channels included contracted markets, traders, middle-men and farm-gate. There is need for research on value chain analysis so as to determine the major constraints and opportunities to growth and expansion of the small-scale tomato sub-sector in the study area and even beyond.

It also emerged that majority of the tomato greenhouses were made of used plastic covering materials and only a few had new ones. There is need to establish why this is so but most importantly, also compare the profitability levels of the two types of greenhouses. In the same vein, it was established that there were various sizes of tomato greenhouses. The smallest was measuring 60 m^2. There is need to determine the economical size of the tomato greenhouse that will at least allow a farmer to break-even.

Generally, the study area was found to have farmers growing tomatoes with varying management levels. Some established their seedlings from a nursery, while others practiced direct sowing in the main field. There was also use of varying fertilizer types and levels as well as varying modes of weeding. Further research may address economic analysis of the different management levels.

A study should also be conducted to establish the consumers' preference as regards greenhouse grown tomatoes compared to those from the open-field and how this may affect greenhouse tomato adoption. Some greenhouse tomato growers reported that their produce was discriminated in the market. Some of the reasons given for the discrimination included inferior taste of the greenhouse grown tomatoes, while other consumers expressed fears of their safety referring to them as Genetically Modified Tomatoes.

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APPENDIX 1: Tests of the model and profitability tables

Table 10: Logistic model: Goodness-of-fit-test

(Table collapsed on quantiles of estimated probabilities)

Number of observations =216, Number of groups = 10

Hosmer-Lemeshow Chi2 (8) = 8.57 Prob > Chi2 = 0.3797

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.0310	1	0.3	21	21.7	22
2	0.0759	0	1.1	22	20.9	22
3	0.1463	4	2.3	17	18.7	21
4	0.2693	5	4.8	17	17.2	22
5	0.4159	7	7.0	14	14.0	21
6	0.5637	7	10.6	15	11.4	22
7	0.6845	16	13.7	6	8.3	22
8	0.8103	15	15.9	6	5.1	21
9	0.9456	20	19.8	2	2.2	22
10	0.9971	21	20.6	0	0.4	21

Source: Survey data (2011)

Table 11: Test for Heteroscedasticity

Number of obs 216, F (14, 201) = 10.49

Prob > F 0.000, R-squared 0.4222

Adj R-squared 0.3882, Root MSE 0.3819

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance; Variables: fitted values of Farmer Type

Chi2 (1) = 0.00; Prob> Chi2 = 0.9853

Farmer Type	**Coef.**	**Std. Err.**	**t**	**P>|t|**
Road type	0 .124	0.0350747	3.54	0.000
Land size	-4.31e-06	4.56E-06	-0.95	0.345
Land tenure	0 .130	0.0824219	1.58	0.116
Experience	-0.015	0. 0039219	-3.81	0.000
Market distance	0.003	0. 0031644	0.84	0.400
Household size	-0.006	0. 0147271	-0.42	0.673
Gender	-0.078	0. 071118	-1.09	0.276
Age	0.105	0. 0264926	3.97	0.000
Education	0 .033	0. 0126332	2.63	0.009
Extension Contacts	0.008	0. 0064873	1.22	0.225
Credit	1.01e-06	3.58E-07	2.82	0.005
Labour	0.152	0. 0582099	-2.63	0.009
Group Membership	-0.183	0. 068382	-2.68	0.008
Income	6.73e-07	1.36E-07	4.86	0.000
cons	-0.389	0. 2061378	-1.89	0.061

Source: Survey data (2011)

Table 12: Test for Multicollinearity

Variable	VIF	1/VIF
Education	1.49	0.6728201.5
Experience	1.33	0.752350
Age	1.29	0.773583
Household Size	1.31	0.761758
Income	1.26	0.793564
Group Membership	1.24	0.809587
Extension Contacts	1.21	0.829119
Land tenure	1.18	0.850037
Road type	1.17	0.852425
Market distance	1.17	0.857743
Labour	1.15	0.867699
Gender	1.14	0.880203
Land size	1.12	0.890646
Credit	1.10	0.909254
Mean VIF	**1.22**	

Source: Survey data (2011)

APPENDIX 2: Interview schedule

Interview Schedule Number:

EGERTON UNIVERSITY

TOMATO PRODUCTION SURVEY 2011

Introduction

We are carrying out a research survey in this region and would like to conduct interviews with households on tomato production. The survey's objective is carrying out **an economic analysis of small-scale greenhouse versus open-field tomato production systems** in terms of: the extent, factors influencing adoption, and their profitability. Respondents are randomly selected to participate **VOLUNTARILY** and their participation in this survey is highly appreciated. Opinions gathered in the survey will be completely **CONFIDENTIAL** and will be analyzed solely for academic purposes. The research findings will benefit the farmers, the government and other tomato stakeholders, so as to improve the production of tomatoes in this region and even beyond.

BACKGROUND INFORMATION

Date: ____

Household No.:____

Enumerator's Name: __________________________________

Respondent's Name___________________________________

District: ____

Division: ____

Location: ____

Sub-Location: ______________________________________

Village: ____

Type of farmer (√)

1. Greenhouse tomato farmer (...)   2. Open-field tomato Farmer (...)

SECTION A: GENERAL INFORMATION

A1. Which **year** did you **star**t tomato growing? **Yearstart1_______**

A2. When you **started,** what area did you have**? Acrestart_______acres**

Or _______Unit(s) totaling _____ **M^2/Ft^2** (Can explain if necessary____________________)

A3. How many **acres** do you plant **now**? **Acrenow_______ acres**

Or_______ Unit(s) totaling _____ **M^2/Ft^2**

A4. How do you compare your existing tomato **production** with that of **3** years ago? **(√)**

☐ 1. Increased ☐ 2. Decreased ☐ 3. No change ☐ 4. **N/A**

A5. If production has decreased what are the **reasons**? **(√)**

☐ 1. Pests and diseases ☐ 2. Shortage of land ☐ 3. Lack of rainfall

☐ 4. Shortage of input ☐ 5. Shortage of labour ☐ 6. Poor soil fertility

☐ 7. Reduced profitability ☐ 8. Other(Specify)____________

A6. What were the **highest** and the **lowest prices per quantity unit** for your tomatoes during the year (April 2010-April 2011)?

1. Highprice(KES)___________per_________________(Output unit)
2. Lowprice(KES)___________per_________________(Output Unit)

A7. Which **months** do you record the **highest** and the **lowest** tomato prices?

1. Months high________________________________
2. Months low_________________________________

A8. What are the reasons for high prices?

____

____

A9. What are the reasons for low prices?____

____

A10. Do you obtain fair price for your tomatoes? (√)

1= Yes (...) 0= No (...)

A11. If '**No',** what are the reasons? (√)

1= Poor quality of product (...) 2= Lack of transport facility (...) 3= Low local demand (...)

4= Inadequate market (...) 5= Over supply (...) 6= Others (Specify) _________ (...)

A12. Considering the last two years how has the price of your tomatoes behaved? **(√)**

1= Increased (...) 2= Decreased (...) 3= No change (...) 4= **N/A** (…)

A13. How do you rate the **performance** of your tomato enterprise? **(√)**

1= Very good profit (...) 2= Satisfactory profit (...) 3= little profit (...)

4= No profit (...) 5= Loss (...) 6= don't know (...)

A14. What is the type of the **main road** that you use to the market? **(√)**

1=Murram (...) 2=Tarmac (...) 3=Dirt road (...)

A15. What is the **condition** of the road? **(√)**

1=Good (...) 2= Bad (...)

A16. What is your main **source** of water? **(√)**

1= Roof catchment (...) 2=Well (...) 3= Borehole (...)

4= Vendors (...) 5= Piped (...) 6= Other (specify) (...)________________

A17 Land ownership and use details

A17.1 What is the size of your farm? ___________ Acres

A 17.2 How did you acquire the land? **(√)**

1= Inherited (…) 2= Permission to use (…) 3= Rented (…)

4= Purchased (…) 5= Other (specify) (…) ………………………………..

A17.3 What is the land tenure situation of your land? **(√)**

1= Has title deed (…) 2= Doesn't have title deed (…) 3= Communally owned (…)

A17.4 For how long have you been farming? ___________ Years)

A17.5 What is the size of land occupied by Tomatoes? ___________ Acres

A18. What is the land hiring rate per acre in this area? ____________KES./Acre

NB 1. A19 – A26 applies only for greenhouse tomato farmers, else skip to A27.

NB 2. A19 –A21 may be N/A if A1 –A3 already filled for greenhouse

A19. Which **year** did you **start greenhouse** tomato growing? **Yearstart2________**

A20. How many **units** did you start with**? Unitstart___________**units of_________M^2/Ft^2

A21. How many greenhouse **units** do you have now? **Unitnow_______** units of______M^2/Ft^2

A22. How did you **acquire** your greenhouse **technology**? **(√)**

1= Ministry of Agriculture (…) 2=Non-Governmental Organization (Specify) (…) _______ 3=Inputs supplier (specify) (…) ________ 4=Own initiative (…) 5= Other (Specify) (…) ____________

A23. What **type(s**) of tomato greenhouse(s) do you use? **(√)**

1= Rectangular (Gamble) (…)   2= Round roofed (Arched) (…)

3= Other (Specify) (...) ____________

A24. What type of **plastic material cover** your tomato greenhouse? **(√)**

1= Used (...)   2= New (...)

A 25. What are your main greenhouse **frame materials** made of? **(√)**

1= Metal pipes (...) 2= Timber (...) 3= Others (specify) (...)________________

A26. What is your **main water source** for your tomato **greenhouse**? **(√)**

1= Roof catchment (...) 2=Well (...) 3= Borehole (...) 4= Roadside runoff (...)

5= Piped (...) 6= Other (specify) (...)_______________

A27. What are your **reasons** for **not growing greenhouse** tomatoes? **(√)**

1= Inadequate capital (…) 2= Inadequate knowledge (…) 3= Inadequate labour (…)

4= Poor prices (...) Not beneficial (…) 5= Inadequate water (…) 6= Inadequate market (...)

7= High production costs (...) 8= Low yields (...) 9= High Marketing costs (...)

10. Other (specify) (...)____

A28. Approximately how many kilometres is your tomato market from your farm? _____Kms

SECTION B: HOUSEHOLD DEMOGRAPHIC INFORMATION (household details)

B1. Please provide the following details as regards the **household members**

B2. Please provide the following details as regards the **household head** for the last one year

Household members	Number	Total number of household members
Number of people below 25 years in the household		
Number of people 25-40 years in the household		
Number of people over 40-60 years in the household		
Number of people above 60 years in the household		

B2. Please provide the following details as regards the **household head** for the last one year (January – December 2010)

	B2-1	**B2-2**	**B2-3**	**B2-4**	**B2-5**	**B2-6**	**B2-7**	**B2-8**
Name (Optional)	Gender of household head 1=Male 2=Female	Age *(See Age Codes below)*	Position of household head in household 1=Husband 2= Wife 3=Child 4= Other (Specify)__ __________	Number of months living at home in the last 12 months	Attained Education level 0= None 1= Primary 2=Secondary 3= Tertiary college 4= University	Occupation of the household head *(See occupation Codes below*	If employed in **B1-6**, indicate number of months involved in the employment in the last 12 months	What was the monthly estimate of income from this occupation? (KES)

Codes B2-2: 1= Below 20years 2= 20-30years 3= 30-40years 4= 40-50years 5=50-60years 6= 60-70years 7= Above 70 years

Codes B2-6: 1=Farming 2= Self employed (outside the farm) 3=Casual labour 4= Formal Employment 5= Unemployed 6= Other (specify) ________

SECTION C. COSTS INFORMATION FOR TOMATO PRODUCTION

C1. Variable costs. Please provide the following information for a **main** specified area**........................ (√)Acres (...) or M^2 (...) or Feet^2 (...)**

	C1-1		**C1-2**	**C1-3**	**C1-4**	**C1-5**	
No.	Variable costs Type.	Unit of measure for variable cost type	Price per specified unit (KES)	Quantity used	Source of inputs *(See codes)*	Transport cost per unit of inputs (KES) **(Instruction: fill for all inputs)**	Remarks (e.g. clarification of names of chemicals, number of times for activities, type of labour used etc)
1	Land rent (If rented)	Acres					
2	Seeds	Kg					
3	Seedlings	Number					
4	Nursery management	Man-days					
5	Land preparation	Man-days					
6	Herbicides	Kg/Lt					
7	Planting	Man-days					
8	Disinfectants	Kg/Lt					
9	Insecticides	Kg/Lt					
10	Fungicides	Kg/Lt					

11	Water	Litres					
12	Sisal twine	Rolls					
13	Training	Man-days					
14	Pruning	Man-days					
15	Weeding	Man-days					
16	Fungicide application	Man-days					
17	Disinfectants preparation	Man-days					
18	Insecticide application	Man-days					
19	Watering	Man-days					
20	Foliar spraying	Man-days					
21	Topdressing	Man-days					
22	Harvesting	Man-days					
23	Grading & sorting	Man-days					
24	Packing	Large box					
25	Produce Transport	Large box					
26	Other (Specify)						
27							

C1-4 Source of Inputs codes: 1=Small trader 2=Stockist 3=Company 4= Farmer /neighbour 5= Farmer group 6= Relative or friend 7= Research/learning institution 8= Other (Specify) ________________________

C2. Amount of fertilizer and foliar used. Please provide the following details for the **main tomato crop plot** or **greenhouse unit.**

	C2-1		**C2-2**	**C2-3**	**C2-4**	**C2-5**	**C2-6**	**C2-7**	**C2-8**	**C2-9**	
	Area of plot/unit	Acres or M^2 /$Feet^2$	Fertilizer type *(See codes)*	Unit of buying *(See codes)*	Unit price (KES.)	Fertilizer quantity used	Units of fertilizer used *(See codes)*	Unit transport cost (KES)	Actual transport cost (KES)	Source (see codes)	Remarks
Basal fertilizer(s)											
1											
2											
3											
Topdressing fertilizer(s)											
1											
2											
3											
Foliar fertilizer(s)											
1											
2											
3											

NB. C2-2, Basal, Topdressing and Foliar Fertilizer type codes: 0=None 1=DAP 2=MAP 3=TSP 4=NPK (20:20:0) 5=NPK (17:17:0) 6=CAN (26:0:0) 7=ASN (26:0:0) 8=UREA (46:0:0) 9= SSP 10=Manure 11=Foliar feeds 12=NPK (20:10:10) 13=DAP + CAN 14=Compost 15=NPK (23:23:0) 16=NPK (17:17:17) 17= other (specify) _______________

NB: C2-3 & C 2-6: Unit of buying & unit of using codes: 1=50 Kg bag 2=25 Kg bag 3=10 Kg bag 4=Litre 5= ½ Litre 6= Kgs 7= Grams 8=Debe 9=W/barrow 10=Others (Specify) ___________

C2-8 Source of fertilizer codes: 1=Small trader 2=Stockist 3= Company 4= Farmer /neighbour 5= Farmers group 6= Relative or friend 7= Input supplier 8=Other (Specify) __________________________

SECTION D: TOMATO PRODUCTION

D1. TOMATO YIELD LEVELS. Please indicate details on **your tomato production details** for the past year (April 2010-April 2011)

D1-1		**D1-2**	**D1-3**	**D1-4**	**D1-5**	**D1-6**	**D1-7**	**D1-8**	**Remarks**
Plot **or** unit **size**	Unit of **area**: acres **Or** (M^2 or Feet^2)	Variety(ies) grown	Quantity of **marketable** output produced	Quantity of **unmarketable** output produced	Output quantity units *(see codes below)*	Average Price per Quantity unit (KES)	Total value i.e. D3*D6 (KES)	Where sold *(see codes below)*	
	Acre/M^2/Ft^2								

Note: Output should include what was sold, consumed at home and gifted out etc.

D1-5 Units codes: 1=Kg 2= Large box (64kg); 3=Medium box (35kg); 4= Bucket (14kg); 5= Other (specify) _______

D1-8 Where sold codes: 1= Farm-gate 2= Brokers 3= Traders 4= Contracted markets 5= Whole sale markets Nakuru 6= Other (Specify) _______

D2. Machinery, equipments, structures etc used. Please provide the following details <u>specifically for tomato production</u>.

D2-1	**D2-2**	**D2-3**	**D2-4**	**D2-5**	**D2-6**	**D2-7**
Item *(see codes below)*	Number	Year bought/ constructed	Initial cost (KES)	Economic life (years)	Annual repairs, and maintenance cost (KES)	Salvage value (KES)

D2-1 Item codes: 1=Truck 2= Knapsack-Sprayer 3= Wire 4= Box 5=Store 6=Wheel barrow 7=Pruning knife 8= Protective clothing 9= Hoe 10= Panga 11= Irrigation equipment 12= Watering can 13= Water tank 14=Well 15= Water pan 16= Bicycle 17= Others (Specify) ___________________________

D3. Main tomato Greenhouse structure construction costs. Please provide the following details:

Greenhouse structure cost	Quantity used	Units	Unit cost (KES)	Total cost (KES)	**Remarks**
Posts		Number			
Trusses		Number			
Rafters		Number			
Ordinary nails		Kgs			
Ceiling nails		Kgs			
Wall pass		Kgs			
Binding wire		Rolls			
Polythene		Metres^2/Ft^2			
Wire gauze		Metres^2/Ft^2			
Labour		Man-days			
Drip kit		Number			
Tank		Number			
Water pan					
Water pan liner		Metres^2			
Water pump					
Total (KES)					

D4. What is the estimated **economic life** of this main tomato greenhouse? ________Years

SECTION E. ACCCESS TO EXTENSION SERVICES

Please provide the following information regarding any form of **extension services for tomato production** received over the last **12 months.**

	E1	**E2**	**E3**	If **Yes in E3**, what was the amount paid for the services over the last 12 months (KES)?	
Agent/source	Did you receive any information from: 1=Yes 0=No	If **Yes in E1**, how many times were you visited?	If **Yes in E1**, did you pay for receiving the information from: 1=Yes 0=No	**E4** Direct cost in KES *(see note*)	**E5** Indirect cost in KES. *(See codes)*
Government agent					
Agricultural Research					
NGO					
Others(Specify)__________					

E4 Note: Consider any payment made in form of cash to the extension service provider.

E5 Indirect cost incurred codes: 1= Travel cost 2= Gift offered 3= Telephone calls 4= Others (Specify) _______________

SECTION F. CREDIT AVAILABILITY

F1. Did any household member **try to get any credit (cash or in kind)** in the 2010/2011 year? **(√)** 1=Yes (...) 0=No (...)

(If 'No' skip to F9)

F2. If '**Yes',** did you **receive** the **credit** that you tried to obtain? **(√)**

1= Yes (...) 0=No (...)

(If 'No' skip to F6)

F3. How **much credit** did you receive? KES. ________

F4. Which were the **main sources** of credit and the **value** received from each? **(√)**

1= Family and friends (…) Value KES. ________

2= SACCO (specify) (…) ______________________ Value KES.__________

3= Commercial banks (…) Value KES. __________

4= Informal lending institutions (Specify) (…) ______________ Value KES.___________

5= AFC (…) Value KES. __________

6= other (specify) (…) ______________________________ Value KES. __________

F5. How was the **credit** used? **(√)**

1=Agricultural purposes (...) 2=Non agricultural purposes (...) 3=Both (...)

F6. Did you experience any **difficulties** in getting the credit? 1=Yes (...) 0=No (...)

F7. If **'Yes'**, what were these difficulties?

1…………………………………………………………..

2…………………………………………………………

F8. If you tried to get credit **but did not get** what was the **reason(s)** for not getting? **(√)**

1= No collateral (...) 2= Outstanding loan (...) 3= don't know (...)

4= No account (...) 5= Lender lacked cash (...) 6= It is still on process (…)

7. Other (specify) (…) _________________

F9. If no one in the household tried to get credit, what was the reason(s)? **(√)**

1= No collateral (...) 2= Outstanding loan (...) 3= Not interested 4= others (…)_________

SECTION G. LABOUR INFORMATION

G1. What is your main source of labour? **(√)**

1=Family (...) 2=Permanent (...) 3= Hired (...) 4=other (specify) (…) _____________

G2. What is the average wage rate per man-day in this area? ______KES /Md

G3. Are there times when you encounter any labour shortage in tomato production? **(√)**

1= Yes (...) 0= No (...)

G4. If **'Yes' in G3**, for what specific activities, have you encountered tomato production labour shortage? **(√)**

1= Cultivation of Land (...) 2= Planting (...) 3= Weeding (...)

4= spraying (...) 5= Pruning (...) 6= Training (...) 7= Others (Specify) __________ (...)

G5. If **'Yes' in G3**, how do you overcome these problems posed by this labour shortage? **(√)**

1= Hiring labour (...) 2= Assistance from relatives (...) 3= Social assistance (...)

4= Was not able to overcome the problem (...) 5= Others (Specify) ___________ (...)

SECTION F. GROUP MEMBERSHIP

H1. Is anybody in the household a member of a group? **(√)**

☐ 1= Yes ☐ 0 = No

H2. If '**Yes'**, which type(s) of group? **(√)**

1. Self Help group (…) 3. Cooperative Society (…)
2. Welfare group (…) 4. Farmer group (…) **5.** Other (Specify) (…) …………….

H3. If '**Yes'**, how has the household member benefited from the group? **(√)**

1. Savings (...) 2. Loans/credit (…) 3. Crop and livestock sale (...)
4. Livestock farming (...) 5. Accessibility to safe water supply (...)
6. Merry go round (...) 7. Tree seedlings sale (...) 8. Improved crop production (...)
9. Other (specify) (...) …………………….

I3. Farm income: What is your estimated annual farm income? ____________KES. Per year.

Thank You Very Much for Your participation and Cooperation!