# AN ASSESSMENT OF FACTORS INFLUENCING PRODUCTION OF HYDROPONICS FODDER AMONG SMALLHOLDER DAIRY FARMERS IN KIAMBU SUB COUNTY, KENYA

**BY**

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## DECLARATION

This research project report is my original work and has not been presented for an academic award in any other university for the award of an academic certificate.

……. …….

**PETER MWANIKI NJIMA** **DATE**

**L50/70346/2013**

This research project report has been submitted for examination with my approval as the university supervisor.

……. …….

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## DEDICATION

This research report is dedicated to my late dad Harun Njima for his moral and financial support, self-sacrifice and determination to ensure my success. I also dedicate my work to my dear wife Florence Wanjiku and my son Jayden Njima for their invaluable support during my research period.

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **FAO** | Food and Agricultural Organization |
| **GDP** | Gross Domestic Product |
| **GOK** | Government of Kenya |
| **KES** | Kenya Shillings |
| **MoALFD** | Ministry of Agriculture Livestock and Fisheries Development |
| **NGOs** | Non-Governmental Organizations |
| **PanAAC** | Pan African Agribusiness and Agro-Industry Consortium |
| **SACCO** | Savings and Credit Cooperative Society |
| **SPSS** | Statistical Package for Social Sciences |
| **VIF** | Variance Inflation Factor |

## ABSTRACT

Rapid urbanisation in Kiambu sub-county has led to subdivision of land into plots for real estate's construction. This has resulted to reduction of land for fodder production. Most smallholder dairy farmers in Kiambu sub-county feed their dairy cattle on napier grass and crop remains e.g. maize stovers, bean stalks, and banana leaves which are all poor quality feeds. Sustainable fodder production technologies could be used as an alternative for producing fodder all the year round. Hydroponics fodder production is one of such technologies. The objectives of the study were to; examine demographic factors that influence the production of hydroponics fodder production among smallholder dairy farmers in Kiambu sub-county, establish the influence of management practices on the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county, assess how marketing factors influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu sub-county, assess the role of extension service on the production of hydroponics fodder by the smallholder dairy farmers in Kiambu sub-county and establish how access to credit influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu sub-county. Descriptive survey design was used in this study. Stratified and random sampling techniques were used to select a sample size of 204 respondents and the primary data was collected using questionnaires and interview schedules. Validity of the instrument was established by a panel of experts. Reliability was tested using the Cronbach's alpha which was calculated from questionnaires from a pilot study which was conducted in Githunguri sub-county. The questionnaire had an alpha of 0.78 which was greater than 0.7 and was considered acceptable. Quantitative and qualitative approaches were used for data analysis. Statistical Package for Social Sciences was used to analyse data. Binary probit model was used in the study. The results of the study showed that majority (63%) of the farmers were males. Most (58%) of the respondents were aged between 18-45 years. Majority (58%) of the respondents had a land size of 2 acres and below. Majority (67%) of the respondents do not grow enough feeds for their dairy cows. It was only 4% of the farmers who grew hydroponics fodder and 80% of the farmers used barley as planting material. Most (51%) of the respondents do not grow hydroponics fodder because they lack the skills on hydroponics fodder production. Majority (96%) of the farmers had access to market. The results further show that majority (65%) of the farmers get information on dairy farming through radio. Most **(**50%) of the farmers had accessed a loan. The results of the study showed that the farmers' number of dependants and access to information through seminars and internet were the factors influencing hydroponics fodder production among the smallholder dairy farmers in Kiambu Sub-county. It is recommended that in order to support the adoption of hydroponics fodder production, farmers' awareness on hydroponics fodder production should be increased and the Government should provide grants, subsidy or low interest credit facilities to dairy farmers who are interested in hydroponics fodder production. Finally, the cost of hydroponics system can be reduced by using locally available construction materials. The findings of the study will benefit staff of the Ministry of Agriculture, livestock and Fisheries Development, NGO's, farmers and other stakeholders.

# CHAPTER ONE

# INTRODUCTION

## 1.1. Background to the study

Livestock plays a significant role in supporting livelihoods globally. The total population of livestock in the world is valued at $1.4 trillion. Besides providing a source of livelihood to over 500 million smallholder farmers in developing countries, the sector creates employment to more than 1.3 billion people annually (Thornton *et al*. 2006). Over the years a rising trend in livestock production has been realized globally. Beef production has increased two-folds while milk production per cow has increased by more 30% (FAO, 2006). "Kenya's livestock sector contributes to 10% of the Gross Domestic Product (GDP) and about 42% of total agricultural output" (Ministry of Agriculture, Livestock and Fisheries Development, 2008). Besides supplying both the domestic and export market with livestock products, the sector also provides raw materials for Agro-processors (Kenya Economic Report, 2013). The export of livestock products generates foreign exchange for the country. According to the MoALFD 2008, there are approximately 3.8 million dairy cattle in Kenya.

Smallholders' milk production account for 80% of the total milk production in Kenya. The smallholder farmers who own 1-3 dairy cattle mostly feed their cattle on napier grass and crop remains e.g. maize stovers, bean stalk and banana leaves (Wambugu *et al.,* 2011). Livestock feeds availability remains to be a major challenge towards the realization of sustainable milk production by the smallholder dairy farmers (Muriuki et al, 2003). Livestock feeds accounts for more than 60% of the total cost of milk production (MoALFD, 2008). This implies that for the smallholder dairy farmers to realize economically sustainable milk production, then the cost of feeds needs to be significantly reduced.

Hydroponics is defined as the science of growing plants without soil (Sinsinwar, 2012). The plants are grown in water and mineral rich solution. This technology can be used as an alternative for dairy feeds production especially where the farmers have a limitation of land size and also during the dry seasons. In hydroponics fodder production, the fodder produced can be up to ten times higher compared to conventional fodder and less space is needed because the fodder is grown in trays which are arranged in shelves inside the hydroponics system (Sinsinwar, 2012). Water use efficiency of more than 80% is achieved in hydroponics fodder production compared to growing fodder in the soil. An experiment conducted by Al-Karaki and Al-

Hashimi, (2011) reported that 1.5 litres of water was needed to produce 1 kilogramme of hydroponics fodder.

### 1.2. Statement of the problem

Availability of quality livestock feeds has been stated as the principal challenge towards the commercialization of smallholder dairy farming in Kiambu Sub-county (Wambugu et al, 2006). Rapid urbanisation in Kiambu Sub-county has led to subdivision of land into plots for real estate's construction. This has resulted to reduction of land for fodder production. To cope with this challenge majority of the smallholder farmers have resulted to feeding their dairy cattle with crop residues and grass collected from the roadside, these are poor quality feeds (Wambugu et al, 2006). To sustain the milk production, some farmers are forced to buy commercial and this has resulted in the rising cost of production which is supported by a corresponding increase in producer price at the farm level (MOALFD, 2013). Greater adoption of planted fodder will help overcome the major constraint limiting smallholder dairy production in Kiambu Sub-county.

Sustainable fodder production technologies could be used as an alternative for producing fodder all the year round. Hydroponics fodder production is one of such technologies. Despite the importance of the hydroponics fodder on enhancing feeds security and increasing milk production, the adoption of the hydroponics technology by the smallholder dairy farmers in Kiambu County has stagnated. This study sought to establish the factors that have affected the adoption of the hydroponics feeds production technology.

### 1.3. Purpose of the study

The purpose of this study was to assess the factors that influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county.

### 1.4. Research Objectives

The study was guided by the following objectives:

1. To examine the influence of demographic characteristics of the smallholder dairy farmers on the production of hydroponics fodder production in Kiambu Sub-county.
2. To establish the influence of management practices on the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county.
3. To assess how marketing factors influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county.

4. To assess the role of extension service on the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county.
5. To establish how access to credit influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county.

### 1.5. Research Questions

The study was guided by the following research questions:

1. To what extent do the demographic characteristics of the smallholder dairy farmers influence the production of hydroponics fodder production in Kiambu Sub-county?
2. To what extent do management practices influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county?
3. In what ways do marketing factors influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county?
4. To what level does extension service influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county?
5. To what extent does access to credit by the smallholder dairy farmers influence the production of hydroponics fodder production in Kiambu Sub-county?

### 1.6. Significance of the study

The study aimed at helping the smallholder dairy farmers to benefit from emerging technologies which will unlock the potential of their dairy enterprises. The study sought to contribute to knowledge base on the feasibility of investing in hydroponics fodder production which would enhance feeds security in the country. The study also sought to offer useful recommendation to Government of Kenya, policymakers, researchers and development practitioners in their work towards improving the livestock feed security for the smallholder dairy farmers in Kenya and the rest of the continent.

### 1.7. Basic assumptions of the study

It was assumed that the information obtained from the smallholder dairy farmers and Extension Officers would be accurate and is a true reflection of factors influencing the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county and that the farmers data would be available from the Kiambu County Ministry of Livestock office and will be

accurate for the purpose of this study. It was also assumed that the farmers selected were growing hydroponics fodder.

### 1.8. Delimitations of the study

The study focused on smallholder dairy farmers in Kiambu Sub-county and the information collected can reflect attributes that are unique to the area of study. Some of these characteristics could be agro-ecological zones of Kiambu Sub-county which may vary from one region to the other.

### 1.9. Limitations of the study

Due to time and resources constraints, this study was carried out only in Kiambu Sub-county. The results therefore may be different if the same research was done in the other sub counties.

### 1.10. Definition of significant terms used in the study

**Adoption** This refers to the degree of acceptance of a new product or innovation.

**Dairy technologies** These are the innovations which enhance the efficiency in dairy production. For the purpose of this study dairy technologies refers to hydroponics fodder production.

**Demographic characteristics** These are social factors of the dairy farmers e.g. age, marital status, sex among others that in one way or the other affect the adoption of hydroponics fodder production.

**Hydroponics fodder** Fodder produced by growing plants in water or nutrient rich solution without using any soil.

**Smallholder Dairy Farmer** These are farmers with land size less than five acres. Farmers with a herd of less than three were considered to be smallholder farmers in this study.

**Technology** A new invention or innovation designed to solve real world problem. In this study technology was used to mean hydroponics fodder production technology.

**Variance Inflation Factor** A measure of multicolinearity in an ordinary least square regression analysis.

## 1.11. Organisation of the study

The first chapter contains the background to the study, statement of the problem, objectives of the study, purpose of the study, Assumptions, limitations of the study and definition of significant terms used in the study. Chapter two contains literature review on overview of hydroponics feed production, overview of dairy production in Kiambu County, factors influencing the production of hydroponics fodder, theoretical and the conceptual framework. Chapter three covers research methodology, research design, target population, sample size and sampling techniques, data collection procedure and data analysis technique. Chapter four contains data analysis, presentation and interpretation while chapter five provides a summary of findings, discussion, conclusion, recommendations and suggestions for further study.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

This chapter gives a review of hydroponics fodder production, hydroponics fodder production in India, hydroponics fodder production in Kenya, dairy production in Kiambu Sub-county, the factors influencing the production of hydroponics fodder, theoretical and conceptual framework, knowledge gap and a summary of literature review.

## 2.2 Hydroponics fodder production

The word hydroponics means growing of plants in water without soil. Thus, fodder produced by growing plants in water or nutrient rich solution but without using any soil is known as hydroponics fodder (Naik et al., 2015). According to Sneath and McIntosh (2003) hydroponics fodder is the forage produced by growing plants in water or nutrients solution without soil. Different types of fodder crops can be produced by hydroponics technology i.e. barley, Oat, Wheat, Sorghum, Alfalfa, Cowpea and maize. The choice of the type of seeds to use depends on the geographical and agro-climatic conditions and seed availability (Naik and Singh, 2013). Barley is considered the best choice for production of hydroponic fodder because it's less costly, uses less water and is easily available (Al-Karaki and Al-Hashimi, 2011).

Hydroponics systems for fodder production range from hi-tech greenhouse to low cost system and the choice depends on the farmers financial capabilities (Naik *et al*., 2015). The low cost systems can be constructed using locally available materials for instance wood, bamboo, steel and polythene and this significantly lowers the cost of hydroponics system (Naik *et al*., 2015).

### Hydroponic fodder production process

The hydroponics fodder production process starts with soaking the seeds in water for about 4 hours (Sneath and McIntosh, 2003; Naik et al., 2015). The debrises and broken seeds floating on water should be removed. The seeds are then drained and placed in trays for germination. The seed rate varies with the type of seeds. A seed rate of 7.6 kg/m2 has been suggested by Naik (2013) for optimum fodder production. High seed rate enhances mould growth and this affect the quality of the fodder. Germination starts after 1 or 2 days and it varies with the seed type. The seeds are generally allowed to sprout for about seven days inside the greenhouse which must be

kept moist. On 8th day the sprouts are harvested as fodder for feeding animals (Naik et al., 2015).

To achieve high quality and optimum fodder production, clean seeds should be used for planting and also the right temperature and moisture should be maintained in the hydroponics system (Sneath and McIntosh, 2003). Mould growth is a major challenge in hydroponics fodder production and this lowers the quality of fodder. Mould growth can be reduced by; maintaining correct moisture and temperature, disinfecting the trays using chlorine solution and using clean planting materials (Sneath and McIntosh, 2003). In Kenya, hydroponics systems can be purchased from Hydroponics Kenya, a company based in Nairobi. A simple Hydroponics system for 1 cow costs KES 4,800 at hydroponics Kenya. A simple hydroponics system is shown in Appendix 4.

**Advantages of Hydroponics fodder over conventional fodder**

There are many advantages of hydroponics fodder over conventional fodder. The following are some of the reasons behind the adoption of hydroponics fodder production around the world:

**Water Usage**

Producing green fodder under hydroponic conditions increases water use efficiency when compared to field production of green fodders. "The hydroponic system requires a fraction of water compared to conventional farming while still supplying high quality stock feed" (Mooney, 2002). In conventional fodder production, 80 units of water are used to produce 1 unit of fodder while in a hydroponics system 1.5 units of water are used to produce 1 unit of fodder (Bill and Pavel, 2002; Al-Karaki and Al- Hashimi, 2011). Additionally water from the hydroponics system can be collected and recycled for other farm uses.

**Feeding Value of Hydroponics Fodder**

Naik et al., (2015) reported that hydroponics fodder is highly palatable and the germinated seeds embedded in the root system are also consumed along with the shoots of the plants without any nutrient wasting. Hydroponics fodder is extremely high in protein and energy (Morsy et al., 2014; Dung et al. 2010). The nutritional value of sprouted grains is improved due to the conversion of complex compounds into relatively simpler compounds that are nutritionally more valuable. Sprouting of grains has results in increased protein quantity and quality. Sprouting also increases the concentration of nutrients including sugars, minerals and vitamin contents (Sharif

et al., 2013). Naik and Singh (2013) noted that hydroponics fodder is alkaline and this improve the immune system of the livestock. Table 2.1 shows the nutrients content in sprouted barley.

**Table 2.1. Nutrients weights and proportions of barley sprouted over 7-day period**

**Time (Days)**

| | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|---|
| Dry Matter (g) | 1026 | 1008 | 996 | 957 | 902 | 885 | 867 | 839 |
| Dry Matter (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Dry Matter loss (%) | - | 1.7 | 2.9 | 6.7 | 12 | 13.7 | 15.5 | 18.2 |
| Crude Fibre (g) | 55.6 | 56.8 | 59.6 | 55.8 | 66.8 | 86.7 | 94.5 | 119 |
| Crude Fibre (% of DM) | 5.4 | 5.6 | 5.9 | 5.8 | 7.4 | 9.7 | 10.8 | 14.1 |
| Crude Fibre gain (%) | - | 2.1 | 7.1 | 3.5 | 20.1 | 55.9 | 69.9 | 114 |
| Crude Protein (g) | 131 | 128 | 130 | 131 | 121 | 123 | 122 | 130 |
| Crude Protein (% of DM) | 12.7 | 12.7 | 13 | 13.6 | 13.4 | 13.9 | 14 | 15.5 |
| Crude protein loss (%) | - | -2.2 | -0.7 | 0 | -7.6 | -6.1 | -6.8 | -0.7 |

Source: Cuddeford (1989), based on data obtained by Peer and Leeson (1985).

**Economic Viability**

The cost of the hydroponics fodder is mainly influenced by the cost of seed and the type of system used for hydroponics fodder production (Naik et al., 2012). In low cost devices the cost of the hydroponics fodder is quite reasonable. Barley is considered the best choice for hydroponics fodder production because of the following reasons: the seeds are easily available, less costly and has a high water use efficiency (Al-Karaki and Al-Hashimi, 2011). In an experiment done by Naik et al., (2014), milk yield was improved by 13.7% after feeding dairy cattle on hydroponics fodder and this is due to the higher nutrient digestibility of the fodder.

In order to produce sufficient fodder for 2 cows in a hydroponics system, 360 Kgs of seed and 42 aluminium trays are required. A shade net is used in hydroponics fodder production to control

temperature. Table 2.2 summarizes the requirements for growing sufficient fodder for two dairy cows in a $12M^2$ room for one month.

**Table 2.2. Requirements for growing hydroponics fodder for two dairy cows per month**

| Requirements | No. of units required | Unit cost (KES) | Total cost |
|---|---|---|---|
| Barley seed | 360 kg/month | 45.00/Kg | 16,200 |
| Nutrient solution | 3.5 litres | 1,500.00/litre | 5,250 |
| Aluminium Trays | 42trays | 1,000.00/tray | 42,000 |
| Shade net | $12M^2$ | 135.00/meter | 1,620 |
| **Total** | | | **65,070** |

*Source:* www.panaac.org, 2015

Naik and Singh (2013) reported that 1 kg of seed produced 5-6 kg of fodder. Less labour is required under hydroponics fodder production. According to Naik and Singh (2013) one person is sufficient to work in the hydroponics system to produce 600 kg hydroponics fodder daily. Jensen (1999) stated that in order to achieve a sustainable green fodder production throughout the year, then technology will be the key driver towards this goal.

**Marginal Land Use**

Hydroponics fodder production requires minimum land in comparison with conventional fodder production. In land area equivalent to $12M^2$, a farmer can grow adequate fodder to feed 2 dairy cows daily, this is equivalent to 600 acres of pasture in the open field. Naik and Singh (2013) stated that less land is required as the fodder is grown in trays in a vertical growing process and this optimizes the land use. "In an area of $50M^2$ under hydroponics fodder production, approximately 600 kg of fodder can be produced daily while to produce the same amount of fodder, about 1 ha land is required" (Naik and Singh, 2013).

**Hydroponics fodder Production in India**

In India, livestock is an important sector which provides livelihoods to more than 60% of the rural population. Over the recent past, the country has continued to receive inadequate rains and this has negatively affected livestock production (Biradar and Kumar, 2013). The increase in the

livestock population along with the intensive rearing system has resulted in the increase in demands for feeds and fodder in India (Naik and Singh, 2013). Inadequate green fodder is a major contributor to the poor performance of the livestock in terms of production in India (Naik and Singh, 2013). Additionally, the demand for forages is increasing due to rearing of high yielding livestock breeds by the farm households. Fodder availability needs to be ensured if livestock is to be sustained at farm level. Efficient planning of fodder and feed resources needs to be attended to in order to sustain the livestock and the livelihood of majority smallholder dairy farmers (Biradar and Kumar, 2013).

Hydroponics technology was introduced in Goa, India in 2011 by establishing a number of hydroponics fodder production units at different dairy cooperative societies (Naik *et al*., 2015). This technology is coming up as an alternative to grow fodder for farm animals (Naik *et al*., 2011; Naik, 2012; Naik *et al.,* 2013).

**Hydroponics Fodder Production in Kenya**

Hydroponics fodder technology is a fairly new concept in Kenya with majority of smallholder farmers barely having any information about the technology. Youths are slowly adopting the hydroponics fodder technology after realizing the economic efficiency of the technology. Much is needed in terms of awareness creation to smallholder dairy farmers on the hydroponics fodder technology. This technology if adopted would addresses the challenges faced by smallholder farmers which include; unavailability of land for fodder cultivation, scarcity of water, non-availability of good quality fodder seeds, high inputs and labour costs and longer growth period of fodder (Naik *et al.,* 2013). Due to the above constraints in the conventional fodder production, hydroponics is now emerging as an alternative technology to grow fodder for farm animals (Naik, 2012).

**Dairy Production in Kiambu Sub-county**

Kiambu Sub-county covers an area of 189.1 $km^2$ and lies within the southern part of central province. It is one of the ten sub counties in Kiambu County. It borders Githunguri Sub-county to the North, Kasarani and Ruiru sub counties to the East, Westland and Kikuyu sub counties to the South and Limuru Sub-county to the West. The sub-county has 4 divisions Kiambaa, Tinganga, Kiambu municipality and Kihara. The Sub-county comprises two constituencies; Kiambu and Kiambaa and has 9 electoral wards.

The area receives bimodal rainfall, long rains in April-June and short rains in October to December. According to the released 2009 population and households census the district hosts a population of 253,751 persons (125796 males and 127955 females), in 75342 households. The population density is 1342 persons per sq. km. Some parts of the district like Gachie which borders Westland have a density of as high as 8452 persons per sq. km while others like Kamiti have as low as 181. Some of the areas that border Nairobi are quickly being turned into residential estates.

Table 2.3 shows a summary of dairy cattle population and milk production in Kiambu Sub-county for year 2013.

**Table 2.3. Dairy cattle Population and the estimated milk production for year 2013**

| Population of Dairy cattle | Mature Dairy cattle | No. of Dairy cattle in milk | Average milk production per day (litres) | Total Annual milk production (litres) |
|---|---|---|---|---|
| 25,000 | 17,500 | 14,000 | 11.5 | 60,732,608 |

*Source MoALFD, 2013*

Farmers in Kiambu Sub-county continue to face a challenge of rising costs of inputs especially those who heavily rely on commercial feeds. This raises the cost of production which is supported by a corresponding increase in producer price at the farm level (MOALFD, 2013). Most smallholder dairy farmers in Kiambu Sub-county feed their dairy cattle on napier grass and crop residues (Wambugu et al, 2006). The inadequate fodder challenge prevents the farmers from achieving the optimum milk production in Kiambu Sub-county.

## 2.3 Demographic characteristics influencing production of hydroponic fodder

Education level, age, household size, land size, farming experience, gender and farmers' attitude were cited as the demographic factors that influence the adoption of dairy technologies (Ayinde et al., 2010, Idrisa et al, 2012, Kudi et al., 2011, Oladele, 2006; Deressa et al. 2010; Quddus, 2013 ). Age has a positive influence on adoption of farming technologies meaning that youths are more likely to adopt new technologies compared to the elderly. On the contrary, Hassan and Nhemachena (2008), reported that age has no influence on technology adoption. As education level increases, the probability for adopting technology also increases because farmers become

aware of new technologies and their added value (Ayinde et al., 2010; Quddus, 2013; Shapiro and Brorsen 1988; Gould *et al.* 1989). There is mixed literature on land size as an influence on technology adoption. Deressa et al. (2010) reported that farmers with big parcels of land are less likely to adopt new technologies, this contrasts with findings from Gbetibouo, (2009), who reported that farmers with big parcels of land are more likely to adopt technologies because it is assumed that they have the resources required. According to Frank (1995) farming experience positively influences farmer adoption of farming technologies. Male headed households have a higher probability of adoption compared to female (Deressa et al., 2010). This could be because the males have access to resources as compared to their female counterparts. Farmer's attitude towards a technology positively affects the adoption (Oladele, 2006).

## 2.4 Influence of management practices on production of hydroponic fodder

The quality of hydroponics fodder is greatly influenced by the management of the hydroponic system. Some of the best practices that must be observed in the hydroponics fodder production are; use of clean planting materials, maintaining the correct moisture, PH and temperature in the greenhouse and disinfecting the trays using chlorine solution (Sneath and McIntosh, 2003). Mould growth is a major challenge in hydroponics fodder production and it negatively affects the fodder and livestock health. The mould growth can be minimised by use of clean planting materials, maintaining the correct moisture, PH and temperature in the greenhouse and disinfecting the trays using chlorine solution.

## 2.5 Influences of marketing factors on production of hydroponic fodder

Market access is key towards accelerating the commercialization of smallholder dairy farming. Farmers who are closer to the market are most likely to adopt technology adoption (Thorpe et al., 2000; Mekonnen et al. 2009; Redda, 2001). On the contrary, Makokha (2005) reported that market access has no influence on the adoption of technology by smallholder dairy farmers. Staal et al. (1997) noted that smallholder dairy farmers with no access to market are less likely to adopt new farming technologies. Government policies can positively and negatively influence technology adoption (Baltenweck, 2000). The Government can come up with policies that can either encourage or discourage adoption.

## 2.6 Influences of extension service on production of hydroponic fodder

Agricultural extension has been used in developing countries to transfer farming technologies to the farmers. Farmers who have been visited by extension staff are more likely to adopt technologies. (Nhemachena and Hassan, 2007; Gbetibouo, 2009; Deressa et al., 2010). "The probability of adopting dairy technology increases by 43% for at least a onetime visit by the extension service per year" (Amelaku, et al. 2012). Extension agents use participatory training methods by demonstrating how the technologies work, this enables the farmer to understand these technologies thereby increasing the likelihood of adoption. According to Deressa et al., (2010), peer to peer extension has a positive influence on adoption. This can be explained by the fact that farmers learn better from other farmers and are likely to adopt the technologies which have worked in other farms.

## 2.7 Influences of access to credit on production of hydroponic fodder

Most farming technologies require a huge initial capital which makes adoption difficult especially for the financially constrained smallholder farmers (Ouma et al., 2006). Access to credit especially for the resource constrained farmers increases the probability of technology adoption (Lawal et al., 2004). New technologies comes with a fair share of risk. To reduce the level of risk, the technologies can be advanced to farmers in form of credit which can be coupled with insurance (Idrisa and Ogunbameru, 2008).

## 2.8 Theoretical Framework

This study focused on the Roger' diffusion theory to explain the adoption of hydroponics fodder production by the smallholder dairy farmers in Kiambu Sub-county.

### Rogers' diffusion of Technology Theory

This model postulates that technology transfer follows a communication channel mostly from extension to farmer (Rogers, 2003). Further, the farmers decision to adopt a technology or not is influenced by; ease of use, cost and the expected returns on investment. The theory also explains that technology adoption is influenced by farmers' attitude towards the technology. Farmers may have all the resources required to buy a technology but reject adoption if they have a negative attitude towards the technology. The role of extension is to educate the farmers in order to acquire the desired attitude and behaviour change. The theory was used in this study in order to understand the technology adoption process and the role of extension in technology transfer.

## 2.9 Conceptual Framework

The Conceptual framework illustrates the relationship between the independent and dependent variables identified in the study. For the purpose of this study the hydroponics fodder production is the dependent variable while demographic factors, management practices, extension services and the credit access are the independent variables. The government policies is the moderating variable while culture and attitude are the intervening variables. The conceptual framework is shown in Figure 1.

## 2.10 Explanation of relationships of variables in the Conceptual Framework

Age is hypothesised to have a negative influence on technology adoption. Young farmers are more likely to adopt new farming technologies. Recent studies say that in order to make Agriculture attractive to the youth, then farming has to be integrated to technology. Households which are headed by males are more likely to adopt technologies because they are have resources. On land size, farmers with large land are more likely to adopt technology because most of them are commercialised and are looking for efficient farming technologies. Education is expected to positively increase adoption, as the level of education increases the likelihood of adoption also increases. Credit access is expected to have a positive influence on adoption. Most of the smallholder farmers are cash constrained and this reduces their purchasing power. On access to market, the farmers who are closer to the market are likely to adopt technologies. The type of hydroponics system and seed type is expected to have a positive influence on technology. Government policies are indeterminate, they can influence adoption positively or negatively.

## 2.11 Gaps in Literature Reviewed

From the review of past studies, there was lack of comprehension of the real issues that restrain enhanced adoption of hydroponics fodder production by the smallholder dairy farmers especially in developing countries. A study of the factors influencing adoption of hydroponics fodder production technology by smallholder dairy farmers could help measure the farmers' assertiveness in the decision to adopt new technologies. To furnish such knowledge, this study sought to assess the factors influencing the production of hydroponics fodder among the smallholder dairy farmers in Kiambu Sub-county.

## 2.12 Summary of Literature Review

Hydroponics fodder technology is a fairly new concept in Kenya with majority of smallholder farmers barely having any information about the technology. Youths are slowly adopting the hydroponics fodder technology after realizing the economic efficiency of the technology. The cost of the hydroponics fodder is mainly influenced by the cost of seeds and the type of system used for hydroponics fodder production (Naik et al., 2012). Farmers in Kiambu Sub-county continue to face a challenge of rising costs of inputs especially those who heavily rely on commercial feeds. This raises the cost of production which is supported by a corresponding increase in producer price at the farm level (MOALFD, 2013). Education level, age, household size, land size, farming experience, gender and farmers' attitude were cited as the demographic factors that influence the adoption of dairy (Ayinde et al., 2010; Idrisa et al, 2012; Kudi et al., 2011; Oladele, 2006; Deressa et al. 2010; Quddus, 2013 ). The quality of hydroponics fodder is greatly influenced by the management of the hydroponic system. Some of the best practices that must be observed in the hydroponics fodder production are; use of clean planting materials, maintaining the correct moisture, PH and temperature in the greenhouse and disinfecting the trays using chlorine solution (Sneath and McIntosh, 2003). Market access is key towards accelerating the commercialization of smallholder dairy farming. Farmers who are closer to the market are most likely to adopt technology (Thorpe et al., 2000; Mekonnen et al. 2009; Redda, 2001). Farmers who have been visited by extension staff are more likely to adopt technologies. (Nhemachena and Hassan, 2007; Gbetibouo, 2009; Deressa et al., 2010). Most farming technologies require a huge initial capital which makes adoption difficult especially for the financially constrained smallholder farmers (Ouma et al., 2006). Access to credit especially for the resource constrained farmers increase the probability of technology adoption (Lawal et al., 2004).

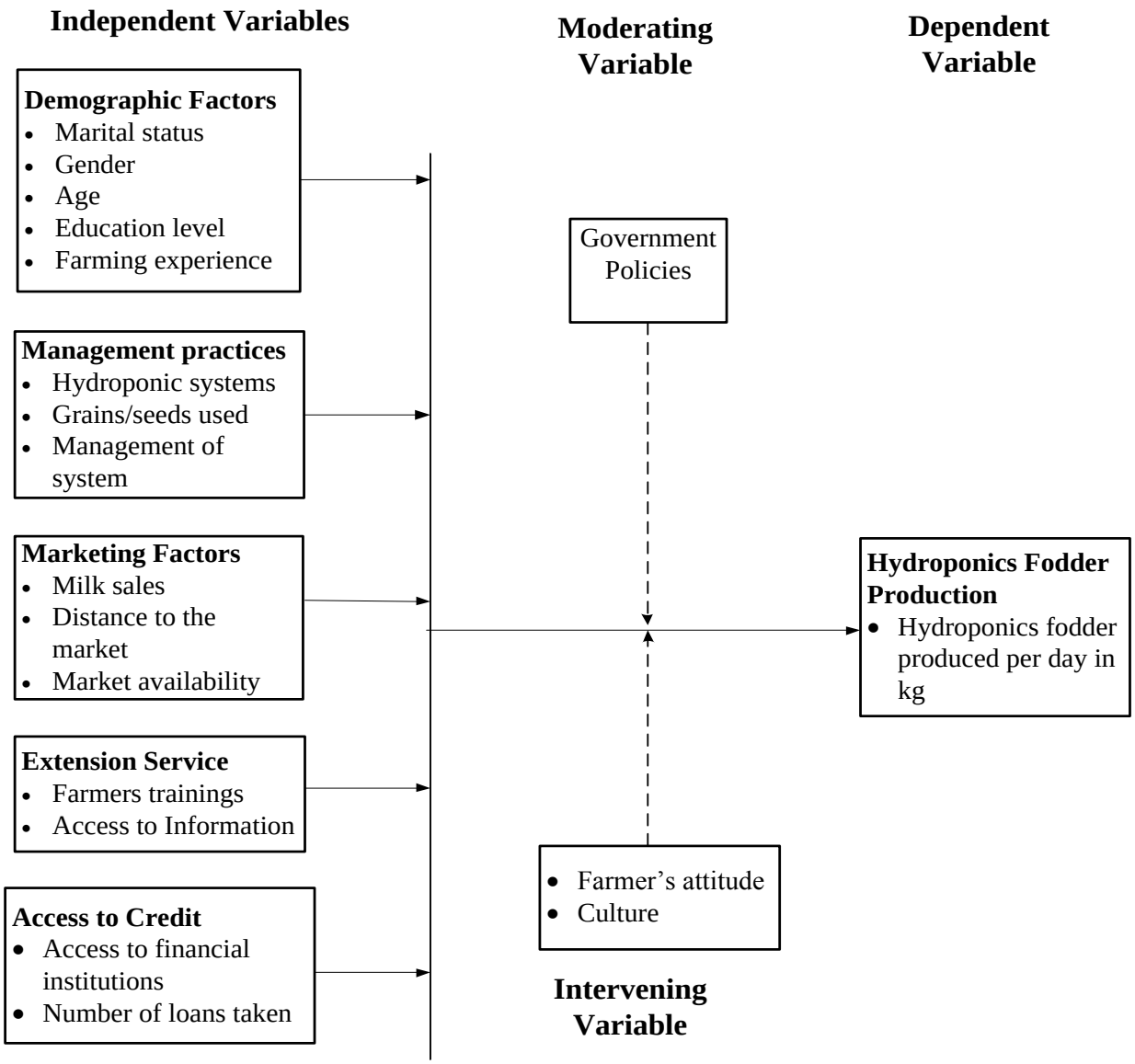


**Figure 1. Conceptual Framework**

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter contains the research methodology which was used in the study. The chapter details the research design, target population, sample and sampling procedures, description of research instruments, validity and reliability of instruments, data collection procedures, data analysis techniques, ethical considerations and the operational definition of variables.

## 3.2 Research Design

This study adopted a descriptive survey research design which is defined by Orodho (2003) as a method of collecting data from a sample of respondents by asking questions. This research technique collects in-depth insights from the respondents by using questionnaires and interview schedules (Jaeger, 1988).

## 3.3 Target Population

Ogula (2005) defined a population as a group individuals or objects who display similar characteristics. The target population for this study constituted 20,000 smallholder dairy farmers in Kiambu Sub-county.

## 3.4 Sample and Sampling Techniques

A sample is a sub-group selected from a group of individuals or objects which display similar characteristics (Mugenda and Mugenda, 2003). The sub-group is cautiously selected in order to be a representative of the entire population. “Each member in the sample is referred to as a respondent”. “Sampling is the process of selecting individuals to participate in a study in such a way that the individuals selected represent the large group from which they were selected” (Ogula, 2005). The sample frame of the study includes a representative sample of the dairy farmers in Kiambu Sub-County. The sample size was calculated using the Yamane’s Table as shown in Appendix 5 where a sample size of 204 was found as appropriate when the target group was estimated from a population of 20,000 (Yamane, 1967). The sample was selected using stratified and random sampling techniques.

### 3.5 Data Collection Instruments

Questionnaires and interview schedules were used to collect primary data. Some advantages of questionnaires include; it is possible to interview more people within a short time, interviewees' confidentiality is ensured, and it's free of bias. (Owens, 2002). The questionnaire was organized following the research objectives. Interview schedule was an appropriate instrument as the number of key informants were few.

### 3.6 Pilot Testing of the instrument

Questionnaires were administered to 10 respondents selected in Githunguri Sub-county which neighbours Kiambu Sub-county. According to Kothari (2004) this sample was statistically significant. The respondents were selected randomly, at least a week before the main study. The researcher observed whether each question measured what it is supposed to measure, time taken to interview one respondent and whether the tool collected the information needed among other things.

### 3.7 Validity of Research Instruments

Validity is the degree of accuracy of a research instrument (Kothari, 2004). A content validity test was used to measure instrument validity. An expert in hydroponics production was given the instruments to assess the degree to which they could measure and determine the content of a particular concept. Minor changes were made to the questionnaire based on the recommendation from hydroponics expert.

### 3.8 Reliability of Research Instruments

Reliability refers to the ability of a research instrument to consistently measure characteristics of interest over time. Reliability of a research instrument is obtained when the same results are obtained after administering the same test more than one time to an individual (Mugenda and Mugenda, 2003). Reliability was tested using the Cronbach's alpha which was calculated from questionnaires from a pilot study which was conducted in Githunguri Sub-county so to assess the survey tool before the study; the questionnaire had an alpha of 0.78 which was greater than 0.7 and was considered acceptable.

### 3.9 Data Collection Procedure

The researcher obtained a letter of introduction from the University of Nairobi and a research permit from National Commission for Science, Technology and Innovation. The researcher also consulted the local leaders including the chiefs, elders and opinion leaders. After consultations with all the stakeholders, the enumerators administered the questionnaires to the sampled respondents.

### 3.10 Data Analysis Technique

Quantitative data was analysed using Statistical Package for Social Sciences (SPSS). Descriptive statistical technique such as percentage and frequency were used to describe demographic characteristics of dairy farmers in the study area. A binary logit model was employed in assessing factors influencing hydroponics fodder production. Usually, whether a farmer grows hydroponics fodder or not is exhibited by two alternatives implying that either a farmer grows hydroponics fodder or not. The binary probit model was estimated in a statistical package STATA version 10.

The binary random variable $Y_i$ is the dependent variable and takes the value of $1$ a farmer grows hydroponics fodder and $0$ otherwise. In other words, the dependent variable in this case is growing hydroponics fodder. According to Greene and Hensher (2009), the observable $y_i$ is determined by a latent regression.

$$y_i^* = \gamma' x_i + \varepsilon_i \quad \text{..... (1)}$$

The random variable $y_i$ takes two values, one and two with probabilities following Greene and Hensher (2009) formulation as:

$$\begin{aligned} \Pr ob(y_i = 1/x_i) &= \Pr ob\left(y_i^* > 0/x_i\right) \\ &= prob(y_i^* x_i + \varepsilon_i > 0) \\ &= prob\left(\varepsilon_i > -\gamma_i x_i\right) \quad \text{..... (2)} \end{aligned}$$

For the purposes of completing the model, the probability distribution $\varepsilon_i$ is important. Greene and Hensher (2009) argue that building the internal consistency emphasizes the fact that

probabilities fall within zero and one; consistently increasing with increment in $\gamma' \chi_i$. It is important to note that analysis of drivers of awareness and adoption follows either a binary logit or probit model. Greene & Hensher (2009) posit that parametric probit and logit models by far remain the backbone of empirical research in binary choice.

Therefore, the probability that a farmer is aware or grows hydroponics fodder is formulated as:

$$prob\left[y_i = 1\right] = x_i \beta_i + \varepsilon_i \quad \text{..... (3)}$$

Where $\chi_i$ represents the vector of socio-demographic factors that are envisaged to influence hydroponics production; and $\beta_i$ is the vector of parameters to be estimated. Finally, $\varepsilon_i$ is the specific random term specific to individual farmer.

Additionally, the marginal effect is calculated. In both binary logistic and probit models, the marginal in the expected probability $(\partial E[y]/\partial x)$ are equal to:

$$\partial E[y/x]/\partial x = f\left(\beta' x\right)\beta \quad \text{..... (4)}$$

Where $f$ represents the corresponding probability density function is specified using the formulation.

$$\gamma\left(\beta' x\right) = \Lambda\left(\beta^i x\right)\left(1 - \Lambda\left(\beta_i x\right)\right) \quad \text{..... (5)}$$

The density function $f\left(\beta^i x\right)$ is of as a scale factor that translates raw parameter estimates into marginal effects.

This study carried out a Variance Inflation Factor (VIF) test. The aim was to ensure that the explanatory variables included in the model had no correlation with each other i.e., a test for multicolinearity in the data. As such, a simple Ordinary Least regression (OLS) model with hydroponics fodder production as the dependent variable was estimated. According to Long (1997), empirical estimation of VIF is as:

$$VIF_j = \frac{1}{1 - R_j^2} \quad \text{..... (1)}$$

Where $R_j^2$ is the coefficient of multiple correlation gotten by regressing the independent variable $X_j$ against all the other independent variables.

### 3.11 Ethical Considerations

The researcher obtained consent from the respondents before undertaking to collect data from the field. The researcher informed and explained the objectives of the research in order to solicit informed consent from the respondents. High level of confidentiality on the information provided by respondents through interview or questionnaires was maintained.

### 3.12 Operational definition of variables

The operational definition of variables is given in Table 3.

**Table 3.1. Operational definition of variables**

| Objectives | Type of Variables<br>Independent | Indicator | Measurement scale | Tool of analysis | Type of analysis |
|---|---|---|---|---|---|
| To examine the influence of demographic characteristics of the smallholder dairy farmers on the production of hydroponics fodder production in Kiambu Sub-county | Demographic Factors | • Gender<br>• Marital Status<br>• Age<br>• Level of Education<br>• Farming experience<br>• Land size | Nominal<br>Ratio | Mean percentage | Descriptive<br>Inferential |
| To establish the influence of management practices on the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county | Management practices | • Type of Hydroponic system<br>• Grain type<br>• Management of system | Ratio | Mean percentage | Descriptive |
| To assess how marketing factors influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county | Marketing Factors | • Milk sales<br>• Distance to market<br>• Availability of market | Ratio<br>Ordinal | Mean percentage | Descriptive |
| To assess the role of extension on the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county | Extension services | • Farmers trainings<br>• Access to Information | Ordinal<br>Ratio | Mean percentage | Descriptive |
| To establish how access to credit influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county | Access to credit | • Loan amount<br>• Number of loans taken<br>• Access to financial institutions | Interval<br>Ratio | Mean percentage | Descriptive |
| | **Dependent**<br>Hydroponics fodder production | Kilogrammes of hydroponics fodder produced per day | Ratio | Mean percentage | Descriptive |

# CHAPTER FOUR

# DATA ANALYSIS, PRESENTATION AND INTERPRETATION

## 4.1 Introduction

This chapter gives data analysis, presentation and interpretation of data found in the study. The chapter is presented following the objectives of the study.

## 4.2 Questionnaire Response rate

Questionnaires were administered to 194 smallholder dairy farmers in Kiambu Sub-county. In response, 157 questionnaires which represented 81% return rate were duly filled and returned for analysis which was considered as very good (Mugenda and Mugenda, 2003).

## 4.3 Demographic information of the respondents

The demographic characteristics of the respondents are presented in this section. These are social factors that potentially influence production of hydroponics fodder and they include; gender, age, education level, farm size, and number of dependants among others.

### Age of the respondents

Table 4.1 shows the age distribution of the respondents.

**Table 4.1. Distribution of the respondents by age**

| Age Bracket | Percentage |
|---|---|
| 18-25 yrs | 7.8 |
| 26 - 35 yrs | 23.4 |
| 36 - 45 yrs | 26.6 |
| 46 -50 yrs | 39.6 |
| Above 50 yrs | 2.6 |

N=157

Table 4.1 shows that majority (58 %) of the farmers fall between the ages of 18-45 years. This explains that most farmers in the county are the young people who are not employed and are thus carrying out agriculture as their main source of income and livelihood. Further, 31% of the farmers interviewed are aged between 18-35 years indicating an increase in youth engaging in Agriculture in the Sub-county.

### Gender distribution

Table 4.2 shows the gender distribution of the respondents.

**Table 4.2. Distribution of the respondents by gender**

| Gender | Percentage |
|---|---|
| Male | 62.7 |
| Female | 37.3 |

N =157

The results from Table 4.2 show that majority (62.7%) of the respondents were males and 37.3% were females.

### Education level

Table 4.3 shows the level of education of the respondents.

**Table 4.3. Distribution of the respondents by education level**

| Education level | Percentage |
|---|---|
| None | 0.7 |
| Some primary | 1.3 |
| Completed primary | 4.6 |
| Some secondary | 15.8 |
| Completed secondary | 52.6 |
| Tertiary | 13.8 |
| University | 11.2 |

N =157

Majority (78%) of the respondents had completed secondary, tertiary and university education with only 0.7% who had not attended any formal school.

### Marital status

Table 4.4 shows marital status of the respondents.

**Table 4.4. Marital status of the respondents**

| Marital status | Percentage |
|---|---|
| Single | 14.8 |
| Married | 77.4 |
| Separated | 3.2 |
| Widowed | 4.5 |

N =157

The results in Table 4.4 indicate that majority (77 %) of the farmers interviewed were married.

**Farm size**

Table 4.5 shows the farm size of the respondents.

**Table 4.5. Distribution of the respondents by farm size**

| Farm size | Percentage |
|---|---|
| <1 acre | 28.9 |
| 1 - 2 acres | 29.5 |
| 2 - 4 acres | 29.5 |
| >5 acres | 12.1 |

N =157

The results in Table 4.5 show that most (58%) of the respondents have land size of 2 acres and below thus confirming that most dairy farmers in the county carry out production on small scale.

**Number of dependants**

Table 4.6 shows the number of dependants of the respondents.

**Table 4.6. Distribution of the respondents by number of dependants**

| Number of dependants | Percentage |
|---|---|
| One | 3.9 |
| Two | 32.7 |
| Three | 31.4 |
| Four | 17 |
| Five or more | 12.4 |
| None | 2.6 |

N =157

On the question on the number of dependants, 32.7% had 2 dependants followed closely by 31.4% who had 3 dependants.

### 4.4 Influences of marketing factors on production of hydroponic fodder

The objective sought to investigate the influence of marketing on hydroponics fodder production, respondents were asked to answer a few questions regarding the access, distance from nearest market and rating of the access to market. The results are presented in a series of frequency distribution Tables.

#### Access to market

Table 4.7 shows the market access by the respondents.

**Table 4.7. Distribution of the respondents by access to market**

| Access to market | Percentage | Source of market | Percentage |
|---|---|---|---|
| Yes | 4 | Local | 42 |
| No | 96 | Cooperatives | 58 |

N =157

The descriptive results from Table 4.7 show that majority (96%) of the farmers have access to market. Of this, 42 % sell their milk at the local market while 58 % sell through cooperatives.

#### Distance to the market

Table 4.8 shows the response on distance to the market.

**Table 4.8. Distribution of the respondents by distance to the market**

| Distance to market | Percentage |
|---|---|
| > 1 Km | 47.7 |
| 1 - 2 Km | 39.2 |
| 2 - 3 Km | 11.1 |
| 3 - 5Km | .7 |
| >5Km | 1.3 |

N =157

Majority of the farmers were near market centres with 87% being within 2 kilometres. This proved essential to transportation of milk to the market place for sale as the product would get to

the market place while still in good quality. Distance from the farm to the market place contributed a lot to most farmers choosing the local market and cooperatives as their marketing place for milk. This further explains that farmers in the Sub-county have access to market.

**Rating on market access**

Table 4.8 shows the response on the rating of market access.

**Table 4.8. Distribution of the respondents by rating on access to market**

| Rating on market access | Percentage |
|---|---|
| Good | 7.3 |
| Average | 69.5 |
| Poor | 23.2 |

N =157

Majority (69.5%) of the farmers rated the access to market as average.

## 4.5 Influence of management practices on production of hydroponics fodder

This sub-section describes how management practices influences the production of hydroponics fodder.

**Number of farmers growing enough fodder for the dairy**

Table 4.9 shows the percentage of the respondents growing enough fodder.

**Table 4.9. Percentage of farmers growing enough feeds**

| Characteristic | Response | Percentage |
|---|---|---|
| Grow fodder | Yes | 89 |
| | No | 11 |
| Grow enough fodder | Yes | 33 |
| | No | 67 |

N =157

Of the 157 farmers surveyed, 89% grow fodder for their dairy cows and of this, 92% grow Napier grass in their farms. The results further indicated that only 33% of the farmers

interviewed grow enough fodder for their cows, the remaining 67% get the deficit by buying Napier grass from their neighbours.

**Percentage of farmers growing hydroponics**

Table 4.10 shows the percentage of the respondents growing hydroponics fodder.

**Table 4.10. Percentage of farmers growing hydroponics fodder**

| Characteristic | Response | Percentage |
|---|---|---|
| Grow hydroponics | Yes | 4 |
| | No | 96 |

N =157

The result in Table 4.10 show that only 4% of the farmers interviewed grow hydroponics fodder.

**Reasons for not growing hydroponics fodder**

Table 4.11 shows the response on the reasons not to grow hydroponics fodder.

**Table 4.11. Reasons for not growing hydroponics fodder**

| Characteristic | Percentage |
|---|---|
| Lack of skills | 51 |
| It's expensive | 36 |

N =151

The results in Table 4.11 show that majority (51%) of the respondents do not grow hydroponics fodder because they lack the skills on hydroponics fodder production.

**Source of information on hydroponics fodder production**

Table 4.12 shows where the farmers acquired skills on hydroponics fodder.

**Table 4.12. Distribution of the respondents by source of information on hydroponics fodder production**

| Source of information on hydroponics | Percentage |
|---|---|
| Seminar | 67 |
| Farmer training school | 16 |
| Other | 17 |

N =6

Majority (67%) of the farmers responded that they learnt the skills on hydroponics fodder production in seminars.

**Type of planting material**

Table 4.13 shows the type of planting materials used for hydroponics fodder.

**Table 4.13. Type of planting materials used for hydroponics fodder**

| Planting material | Percentage |
|---|---|
| Barley | 80 |
| Maize | 20 |

N =6

Majority (80%) of the farmers who grow hydroponics use barley as the planting material.

## 4.6 Role of extension service on hydroponics fodder production

The study sought to investigate the role of extension service on the production of hydroponics fodder. This was measured by a number of factors which included; whether or not they accessed extension services and source of information on dairy farming.

**Access to agricultural extension service**

Table 4.14 shows the respondents' response on access to agricultural extension service.

**Table 4.14. Distribution of the respondents by access to Agricultural extension service**

| Access to extension | Percentage |
|---|---|
| Yes | 46 |
| No | 54 |

N =157

The results show that only 46% of the respondents who had access to access to agricultural extension service.

**Source of Agricultural extension service**

Table 4.15 illustrates the respondents' source of Agricultural extension service.

**Table 4.15. Distribution of the respondents by source of Agricultural extension service**

| Source of extension service | Percentage |
|---|---|
| Government | 11 |
| NGO | 13 |
| Private companies | 63 |

N =157

Majority (63%) accessed extension from commercial companies.

**Source of information on dairy production**

Table 4.16 illustrates the respondents' source of information on dairy farming.

**Table 4.15. Distribution of the respondents by source of information on dairy production**

| Source of information | Percentage |
|---|---|
| Radio | 65 |
| Television | 32 |
| Friends | 29 |
| Newspaper | 23 |
| Seminar | 20 |
| Internet | 5 |
| Mobile | 4 |

N =157

The results shows that majority (65%) of the farmers get information on dairy farming through radio.

## 4.7 Influence of credit access on production of hydroponics fodder

The study sought to examine the influence of credit access on the production of hydroponics fodder.

**Access to financial services**

Table 4.17 shows the percentage of respondents with access to financial services.

**Table 4.17. Distribution of the respondents by access to financial services**

| Access to financial services | Percentage |
|---|---|
| Yes | 73 |
| No | 27 |

N =157

The results indicate that 73% of the farmers had access to financial services.

**Type of financial institution**

Table 4.18 shows the percentage of respondents with access to the various financial services which include; SACCO, Village savings and loans schemes, insurance and banks.

**Table 4.18. Distribution of the respondents by type of financial institution**

| Type of institution | Percentage |
|---|---|
| SACCO | 64 |
| Bank | 36 |
| Village savings and loan schemes | 11 |
| Insurance | 4 |

N =157

The results in Table 4.18 show that 64% of the respondents access financial services from SACCO.

**Access to Loans**

Table 4.19 show the percentage of farmers who had accessed loans over the last 1 year.

**Table 4.19. Distribution of the respondents by access to loans**

| Access to loans | Percentage |
|---|---|
| Yes | 50 |
| No | 50 |

N =157

Majority **(**50%) of the farmers had accessed a loan over the last 1 year.

**Loan use**

Table 4.20 shows the responses on the loan use by the respondents.

**Table 4.20. Distribution of the respondents by loan use**

| Loan use | Percentage |
|---|---|
| Food | 7 |
| School fees | 26 |
| Inputs | 60 |
| Business capital | 7 |

N =157

Majority (60%) of the respondents used the loan to purchase farming inputs.

## 4.8 Results for the binary probit model

**Variance Inflation Factor**

Table 4.21 presents the results of the variance inflation factor.

**Table 4.21. Variance inflation factor values**

| Variable | VIF | 1/VIF |
|---|---|---|
| No. of dependants | 1.45 | 0.691521 |
| Household size | 1.44 | 0.696719 |
| Age | 1.3 | 0.770072 |
| Information from seminar | 1.19 | 0.84367 |
| Information from internet | 1.12 | 0.893166 |
| Information from farmers | 1.12 | 0.894512 |
| Information from radio | 1.07 | 0.931148 |
| Loan Access | 1.06 | 0.945677 |
| Mean VIF | 1.22 | |

The mean variance inflation factor is 1.22 while the explanatory variables have VIF's ranging from 1.06 to 1.45. Since the mean VIF's for the independent variables are less than five (<5), the inclusion of the variables in the probit model is justified (Maddala, 2000).

**Results of the binary probit model**

Table 4.22 shows the results of the binary probit model.

**Table 4.22. Results for the binary probit model**

| Variable | Coefficient | P-Value | Marginal effect | P-Value |
|---|---|---|---|---|
| Loan access | 1.042053 | 0.538 | 0.0024367 | 0.673 |
| Age | -0.9622102 | 0.203 | -0.0021867 | 0.533 |
| Household size | 1.052345 | 0.227 | 0.0023916 | 0.563 |
| No. of dependants | -2.071367 | 0.042 | -0.0047074 | 0.536 |
| Information from seminar | 0.2402519 | 0.871 | 0.0005751 | 0.881 |
| Information from internet | -1.567191 | 0.355 | -0.0052587 | 0.577 |
| Information from farmers | 3.481901 | 0.064 | 0.0309907 | 0.381 |
| Information from radio | 4.007213 | 0.077 | 0.0878626 | 0.558 |
| Constant | 0.433 | 0.877 | 0.0024367 | 0.673 |

Pseudo $R^2$: 0.4338

Log Likelihood: -9.4851

Prob > $chi^2$: 0.0688

LR $chi^2$ (8): 14.54

The results show that farmers' number of dependant and information access through seminars and internet were the factors affecting hydroponics fodder production by the smallholder dairy farmers in Kiambu Sub-county. The coefficient on number of dependants was statistically significant at five percent. This result confirms the finding of Kudi et al., 2011. Further, the coefficient for number of dependants was negatively related to hydroponics fodder production implying that as the number of dependant decreases then the possibility of growing hydroponics fodder increases. The coefficient on information access through seminars and internet was statistically significant at ten percent. The information access through seminars and internet had a positive effect on production of hydroponics fodder. The study established that market access and access to credit never influenced the production of hydroponic feeds technology in the area study.

# CHAPTER FIVE

# SUMMARY OF FINDINGS, DISCUSSION, CONCLUSIONS AND RECOMMENDATION

## 5.1 Introduction

This chapter contains a summary of the findings, discussion, conclusions reached and recommendations based on the objectives of the study. The chapter also contains some suggestions for further studies.

## 5.2 Summary of the Findings

The first objective of the study was to determine the influence of demographic characteristic of the smallholder dairy farmers on the production of hydroponics fodder production in Kiambu Sub-county.

Table 5.1 shows the main findings of the study.

**Table 5.1. Summary of findings**

| **Objectives** | **Summary of findings** |
|---|---|
| To examine the influence of demographic characteristics of the smallholder dairy farmers on the production of hydroponics fodder production in Kiambu Sub-county. | • Majority (58 %) of the farmers fall between the ages of 18-45 years<br>• 62.7 percent were male and 37.3 percent were female<br>• Majority (78%) of the respondents had completed secondary, tertiary and university education and only 0.7 percent had not attended formal school.<br>• Majority (77 %) of the farmers interviewed were married<br>• 58% of the respondents have land size of 2 acres and below |

| | |
|---|---|
| | • 32.7% had 2 dependants followed closely by 31.4% who had 3 dependants. |
| To establish the influence of management practices on the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county. | • 89% grow fodder for their dairy cows and of this, 92% grow Napier grass in their farms.<br>• only 33% of the farmers interviewed grow enough fodder for their cows, the remaining 67% get the deficit by buying Napier grass from their neighbours<br>• Only 4% of the farmers interviewed grow hydroponics fodder<br>• Majority (51%) of the respondents do not grow hydroponics fodder because they lack the skills on hydroponics fodder production.<br>• Majority (67%) of the farmers responded that they learnt the skills on hydroponics fodder production in seminars<br>• Majority (80%) of the farmers who grow hydroponics use barley as the planting material. |
| To assess how marketing factors influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county. | • Majority (96%) of the farmers have access to market. Of this, 42 % sell their milk at the local market while 58 % sell through cooperative societies.<br>• Majority of the farmers were near market centres with 87 percent being within 2 kilometres.<br>• Majority (69.5%) of the farmers rated the access to market as average. |
| To assess the role of extension service on the production of hydroponics fodder by the | • Only 46% of the respondents had access to agricultural extension |

| | |
|---|---|
| smallholder dairy farmers in Kiambu Sub-county. | • Majority (63%) accessed extension from commercial companies.<br>• Majority (65%) of the farmers get information on dairy farming through radio. |
| To establish how access to credit influence the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county | • 73% of the farmers had access to financial services<br>• 64% of the respondents access financial services from SACCO.<br>• Majority (50%) of the farmers had accessed a loan over the last 1 year.<br>• Majority (60%) of the respondents used the loan to purchase farming inputs. |

### 5.3 Discussion of findings

This section gives a detailed discussion of findings of the study.

**Influences of demographic characteristics on hydroponics production**

From the findings of the total number of farmers interviewed 62.7% were males and 37.3% were females. The male dominance could be explained by the distribution of land ownership which heavily skewed towards men in Sub-Saharan Africa (FAO, 2011). Majority (58%) of the farmers fall between the ages of 18-45 years. This explains that most farmers in the county are the young people who are not employed and are thus carrying out agriculture as their main source of income and livelihood. Further, 31% of the farmers interviewed are aged between 18-35 years indicating an increase in youth engaging in Agriculture in the Sub-county. It was also noted that majority (78%) of the farmers interviewed had completed secondary, tertiary and university education with only 0.7% having not attended any formal school. The results also indicated that majority (77%) of the farmers interviewed were married. The descriptive results indicated that the average household size was three. The average farm sizes of the 157 farmers was 2 acres thus confirming that most dairy farmers in the county carry out production on small scale. Farmer's number of dependants was found to influence hydroponics fodder production by the smallholder dairy farmers in Kiambu Sub-county. The coefficient on number of dependants was statistically significant at 5%. This

result confirms the finding of Kudi et al., 2011. Further, the coefficient on number of dependants was negatively related to hydroponics fodder production implying that as the number of dependant decreases then the possibility of growing hydroponics fodder increases.

**Influence of management practices on the production of hydroponics fodder**

The findings show that of the 157 farmers surveyed, 89% grow fodder for their dairy cows and of this, 92% grow Napier grass in their farms. The results further indicate that only 33% of the farmers interviewed grow enough feeds for their cows, the remaining 67% get the deficit by buying Napier grass from their neighbours. This can be explained by the fact that most farmers have limited land and use bigger portion of the land to grow food for their family. Only 4% of the farmers interviewed grow hydroponics fodder. The main reason for not growing hydroponics fodder was lack of skills and this can be attributed to the limited access to agricultural extension service which was found to be at 46%. The main reasons for growing hydroponics fodder was low cost and fast maturity. 80% of the farmers who grow hydroponics use barley as the planting material. 67% of the farmers responded that they learnt the skills on hydroponics fodder production in seminars. Mould growth affected 67 % of the farmers growing hydroponics fodder and this resulted to loss in production of fodder Most of the farmers controlled mould growth by maintaining the correct moisture in the hydroponics system.

**Influence of marketing on the production of hydroponics fodder**

From the study 96% of the respondents had access to market, of this 42 % sell their milk at the local market while 58 % sell through cooperative societies. This finding is consistent with that of Wambugu (2000) that reported 60% of farmer being members of a cooperative society. Majority of the farmers were near market centres with 87 percent being within 2 kilometres. This proved essential to transportation of milk to the market place for sale as the product would get to the market place while still in good quality. Distance from the farm to the market place contributed a lot to most farmers choosing the local market and cooperatives as their marketing place for milk. This further explains that farmers in the Sub-county have access to market. The study established that market access never influenced the production of hydroponic feeds technology under study. Majority of the farmers were near market centres with 87 percent being within 2 kilometres indicating that most farmers had access to market and this did not influence them to adopt hydroponics fodder production These agrees to earlier findings by Makokha, 2005) who stated that households choice on whether to adopt technology or not was not influenced by market access.

The findings are contrary to Mekonnen et al (2009) who reported that nearness to market had a positive influence on technologies adoption.

**Role of extension service on the production of hydroponics fodder**

From the findings, only 46% of the farmer had access to agricultural extension service with a mere 11% accessing extension service from the government. Majority (63%) of the farmers accessed extension from commercial companies. Majority (74%) of the farmers rated the extension services as average while 26% rated the services as good. On access to information on dairy farming, 65% of the farmers interviewed accessed information through radio while 32% accessed information through television. The results of the probit model showed that access to information through seminars and internet had an influence on hydroponics fodder production. The coefficient on information access through seminars and internet was statistically significant at ten percent. The information access through seminars and internet had a positive effect on production of hydroponics fodder. This finding is consistent with that of Nhemachena and Hassan, (2007), this implies that increase in information access by farmers through seminars and internet will increase the adoption of hydroponics fodder production. If there is increase in the attendance of dairy farmers in seminars, there is likely to be an increase in the adoption decisions of hydroponics fodder production made by the farmers. Bahta and Bauer, (2007) found out that the more the extension service is provided, the more the farmer is exposed to information about current farming technology. Seminars expose farmers to new information and farming technologies. This can be explained further by the fact that as one gets more and more knowledge on this technology, they are able to understand its advantage. Inadequate skills on hydroponics production is the biggest limitation hindering the hydroponics fodder production by the smallholder dairy farmers. Most (51%) of the respondents indicated that they lacked skills on hydroponic feeds growing.

**Influence of access to credit on production of hydroponics fodder**

The findings indicate that 73% of the farmers had access to financial services, 64% accessing the services from SACCO and 36% through Banks. The results also show that 50% of the farmers had taken a loan from either a SACCO or a bank. Access to credit among respondents was average, 50% of the sampled farmers had borrowed a loan in the last 12 months. Majority (60%) of the farmers used the loans to purchase inputs. In terms of membership to a farmer marketing group, only 48.7 percent belonged to a group and the reason for joining such groups was because of loan access. The study established that loan access never influenced the production of hydroponic feeds

technology under study. The findings contrast that of Lawal et al., (2004) where the level of adoption of farming technologies increases as farmers have access to credit.

### 5.4 Conclusion of the study

The following conclusions were made from the study:

The rate of adoption obtained in the study was 4%. This implies that the adoption rate for the hydroponic fodder production in the area of study is very low and much need to be done by the Government and extension agents in order to motivate the farmers to adopt the technology. The findings show that the number of dependants, information access through seminars and internet were the key influences of hydroponics fodder production. If there is an increase in the access to information by the dairy farmers through seminars and internet, there is likely to be an increase in the adoption decisions made by the farmers on hydroponics fodder production. Seminars and internet expose farmers to new information and technical skills about new farming technologies. The study established that market access and loan access never influenced the production of hydroponic feeds technology under study.

### 5.5 Recommendations

The following recommendations were made from the study:

1. There is a need for farmers' awareness creation. Even though hydroponics feeds production are more economical than conventional feeds in terms of space and unit cost of production, most farmers in the study area who perhaps would have an interest to venture into hydroponics feeds production are completely unaware about the technology. There is to increase awareness to dairy farmers on the potential of hydroponic feeds and this can be done through seminars and mass media like radio.
2. The cost of the hydroponics system is determined by the type of materials used in the construction. Suitable locally available materials should be sourced for constructing the hydroponics system and this will go a long way to reduce the cost.
3. Training of farmers is needed since hydroponics fodder production requires some skills. To enhance the adoption of hydroponics fodder production technology, both the government extension officers and the farmers should be enlightened on hydroponics fodder production.

4. The farmers need to be enlightened on formation of cooperative societies. By joining cooperative societies, the farmers will access market for their produce, training and farm inputs.
5. Limited access to agricultural credit affects the agricultural production and investment. The government should provide grants, subsidy or low interest credit facilities to smallholder dairy farmers who are interested in hydroponics fodder production. The promotion of hydroponic fodder production can lead to employment creation along the entire dairy value chain.

### 5.6 Suggestions for further research

The following areas are suggested for further research:

1. An assessment of the cost benefit analysis of hydroponics fodder against conventional fodder for instance Napier should be carried out.
2. An assessment of effects of using hydroponics solution in the production of hydroponics fodder.

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## APPENDICES

### APPENDIX 1: INTRODUCTION LETTER

Peter Njima
P.O. Box 15234,
NAKURU
TEL 0763987973

**TO WHOM IT MAY CONCERN**

Dear Sir/Madam

**RE; DATA COLLECTION**

I am a postgraduate student in the University of Nairobi, pursuing a Master of Arts degree in Project Planning and Management. I am conducting a research on factors influencing the production of hydroponics fodder by the smallholder dairy farmers in Kiambu Sub-county. You have been selected to help in this study. I do humbly request you to allow me to interview you. The information being sought is meant for research purposes only and will not be used against anyone. The researcher will ensure that a feedback reaches all those who participated.

Findings might greatly inform all stakeholders involved and perhaps make a major contribution to the sustainability of feed security in the Dairy sub sector in the country. Your responses will be treated with confidence. No names of individuals or farms will be needed.

Thank you in advance.

Yours sincerely,

Peter Njima

L50/70346/2013

## APPENDIX 2: QUESTIONNAIRE FOR THE DAIRY FARMERS

**Instructions:** Please tick in the relevant brackets and fill in the relevant blank spaces provided

**Section I-Demographic Characteristics of the Respondent:**

1. Age:

   Below 18yrs [ ] 18-25yrs [ ] 26-35yrs [ ] 36-45yrs [ ] 46-50yrs [ ] Above 50yrs [ ]

2. Gender of respondent: Male [ ] Female [ ]

3. Level of Education:

   None Some Primary [ ] Completed Primary [ ] Some Secondary [ ] Completed Secondary [ ] Tertiary (including village polytechnics) [ ] University [ ]

4. Marital Status:

   Single [ ] Married [ ] Divorced [ ] Separated [ ] Widowed [ ]

5. Occupation of household head

   Full time Farmer [ ] Employed [ ] Casual Worker [ ]

   Any other; please specify_____ [ ]

6. Farming experience of the household head

   Less than 5 years [ ] 5 years [ ] 5 to 10 years [ ] Over 10 years [ ]

7. No. of dependents

   One [ ] Two [ ] Three [ ] Four [ ] Five or more [ ] none [ ]

8. Size of Household

   One [ ] Two [ ] Three [ ] Four [ ] Five or more [ ]

9. How much land do you own in Acres?

   <1acre [ ] 1-2 acres [ ] 2-4 acres [ ] Over 5 acres [ ]

10. What is the nature of land holding?

    Owned with Title deed [ ] Owned without Title deed [ ] Squatter [ ] Communal [ ] Leasing [ ] Occupying government land [ ]

    Any other; Please specify; _____ [ ]

11. How many dairy cattle do you have in your farm?

    One [ ] Two [ ] Three [ ] Four [ ] Five or more [ ]

12. a) Do you grow animal feeds in your farm? Yes [ ] No [ ]

    b) If yes which animal feeds do you grow?

    Napier grass [ ] Rhodes [ ] Kikuyu grass [ ] Barley [ ] Sorghum [ ]

    Others; please list; _____ [ ]

13. What size of land are you cultivating and what are the yields per season?

| **Crop** | **Yes /No** | **Farm area (Acres)** | **Yield (Kg)/ Acre** |
|---|---|---|---|
| Napier grass | | | |
| Rhodes | | | |
| Kikuyu grass | | | |
| Barley | | | |
| Sorghum | | | |
| Others- | | | |

14. Where do you access your inputs like seeds, fertilizers?

Local Markets [ ] Reseeding [ ] Agro stores [ ] Research Institutions [ ]

GoK Relief [ ] NGOs [ ] Others, Please specify [ ]

15. (a) Do you get enough feeds for your dairy cattle from your farm? [ ]Yes No[ ]

(b) If no, where do you get the deficit?

Buy napier grass form neighbours [ ] Buying commercial feeds [ ] Buying hay [ ] Others, specify [ ]

(c) How much do you buy in KES per unit of the feeds?

Napier grass [] Commercial feeds [ ] Hay [ ] others, specify [ ]

**Section II-Management Practices**

16. a) Do you grow hydroponics feeds? Yes [ ] No [ ]

b) If No, why don't you grow hydroponics fodder?

I don't think that it is a better feed compared to others [ ] Prefers to buy rather than grow [ ]

Lack of planting material [ ] Lack of skills on hydroponics fodder production [ ]

It is expensive [ ] Have enough of other fodders to feed the animals [ ]

Others; please specify; _____ [ ]

c) If yes in 11 a), why did you start growing hydroponics fodder?

Fast maturity [ ] Low cost [ ] High nutrients [ ] Less space is needed [ ]

Others; please specify; _____ [ ]

d) If yes in 11 a), where did you learn how to grow hydroponics fodder?

Dairy co-operative extension workers [ ] Seminar [ ]

Extension workers from the ministry of agriculture [ ]

Farmer Training School [ ] Neighbour [ ]

Farmers' field day [ ] Radio [ ]

Read about it in a magazine/book/pamphlet [ ] others (specify) _____ [ ]

e) What was the cost of the hydroponics system?

f) What planting materials do you use for hydroponics feeds production?

Barley [ ] Maize [ ] Sorghum [ ] Others, specify_____ [ ]

g) How much do you buy per kg of the planting materials?

h) Where do you get the planting materials?

Local Markets [ ] Agro stores [ ] Research Institutions [ ]

GoK Relief [ ] NGOs [ ] Others, Please specify [ ]

i) Do you experience mould growth? Yes [ ] No [ ]

j) If Yes, at what stage do you experience the mould growth? Early stage [ ] Mid-stage [ ]

Late stage [ ]

k) If yes, how do you control the mould growth? Clean seeds [ ] pre-treating seeds [ ]

Cleaning of trays [ ] Others, Please specify [ ]

l) Does the mould growth affect the Production? Yes [ ] No [ ]

m) If yes, what is the estimated loss in fodder production? >10% [ ] 10-20% [ ] 20-30% [ ] 30-40% [ ] <50%[ ]

**Section III-Marketing Factors**

17. (a) Do you have access to the market for your milk? [ ] Yes No [ ]

(b) If yes what is the source of your market? Farm gate [ ] Middle men [ ]

Local market [ ] Cooperatives [ ] Group collection centre [ ] Others [ ]

18. How far is the nearest market where your sell your milk?

Less than 1km [] 1km-2km [ ] 2km-3km [ ] 3km-5km [ ] above 5km [ ]

19. How do you rate the access to milk market?

Good [ ] Average [ ] Poor [ ]

**Good**: The farmer has consistent market, finds prices to be fair, and able to sell off they intend to sell

**Average**: The farmer has consistent market but prices fluctuate highly

**Poor**: The farmer hardly has a market for his produce and are often unable to sell all they intend to sell

20. How much do you sell a Kg of milk in KES?

<KES 30 [ ] KES 30-40 [ ] KES 40-50 [ ] Over KES 50 [ ]

21. What is the average milk production per cow per day?

Below 5 litres [] 5-10 litres [ ] 10-15 litres [ ] 15-20 litres [ ] Over 20 litres [ ]

22. (a) Are you a member of any marketing group organization YES [ ] NO [ ]

(b) What benefits do you accrue from being a member (*multiple responses possible*)?

Better prices [ ] Inputs [ ] Loans [ ] Trainings [ ]

Other; please specify_____ [ ]

**Section III-Extension Service:**

23. (a) Do you have access to agricultural extension services?

YES [ ] No [ ] No

(b) If yes, what are the sources of extension services?

| Source | | Monthly, Quarterly, Other (specify) | Poor\|, Average, Good |
|---|---|---|---|
| Government | [ ] | | |
| NGO | [ ] | | |
| Commercial companies (e.g. agro input suppliers) | [ ] | | |
| Others (please state) | [ ] | | |

**Poor:** The farmer does not attribute any improvements in farm, yield and group capacity to the extension services.

**Average:** The farmer attributes improvements on the farm, yields and group capacity to the extension services to a reasonable extent.

**Good:** The farmer attributes improvements on the farm, yields and group capacity to the extension services to a greater extent.

(c) What is the source of information on dairy production on your farm? Tick appropriately.

From other farmers and friends [ ] Leaders and farmers representative [ ]

Radio [ ] T.V [ ] Newspaper [ ] Workshops, Seminars, and meetings [ ]

Internet services [ ] Mobile [ ] Others (specify) [ ]

**Section IV-Access to credit:**

24. (a) Do you have access to financial services like crop insurance, input financing, loans?

YES [ ] No [ ]

(b) If yes; where do you access the financial services like crop insurance, input financing, and loans?

SACCO [ ] Bank [ ] Village Savings and Loans Association []

Insurance companies [ ] Any other; Please specify_____ [ ]

(c) i) Have you accessed any loan from either of these institutions in last 1 year?

YES [ ] No [ ]

ii) If yes; how much _____

iii) How did you spend it?

Buying food [ ] Paying school fees [ ] Buying farm inputs [ ] Business Capital [ ]

Any other; please specify_____ [ ]

25. Give one main challenge on hydroponics feeds production in your farm? (Tick appropriately)

…….

……

26. Give one way in which hydroponics feeds production be improved in this region?

…….

**Thank You for your cooperation in filling up, the information will be very useful to support the sector for your benefit**

## APPENDIX 3: KEY INFORMANTS INTERVIEW SCHEDULE

Good morning/afternoon, Thank you for taking time to talk to us allowing us to ask you a few questions.

1. In your own opinion what are the demographic factors that influence the production of hydroponics fodder in Kiambu Sub-county?
2. What are the management practices that influence the production of hydroponics fodder in Kiambu Sub-county?
3. What do you think are the marketing factors that affect production of hydroponics fodder in Kiambu Sub-county?
4. Do the farmers in Kiambu Sub-county have access to information on hydroponics fodder production?
5. In your opinion how does access to credit affect the production of hydroponics fodder in Kiambu Sub-county?
6. What do you think about the attitude towards the hydroponics fodder technology by the small holder dairy farmers and what needs to be done to increase the adoption of this technology?
7. Any other comments?

**Thank you for your time**

## APPENDIX 3: RESEARCH PERMIT


**NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION**

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9th Floor, Utalii House
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NAIROBI-KENYA

Ref: No. **NACOSTI/P/16/16363/8886**

Date: **11th April, 2016**

Peter Mwaniki Njima
University of Nairobi
P.O. Box 30197-00100
**NAIROBI.**

**RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on ***"Factors influencing the production of hydroponics fodder by smallholder dairy farmers in Kiambu Sub County,"*** I am pleased to inform you that you have been authorized to undertake research in **Kiambu County** for the period ending **2nd April, 2017.**

You are advised to report to **the County Commissioner and the County Director of Education, Kiambu County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

**DR. STEPHEN K. KIBIRU, PhD.**
**FOR: DIRECTOR-GENERAL/CEO**

Copy to:

The County Commissioner
Kiambu County.

The County Director of Education
Kiambu County.

## APPENDIX 4: A SIMPLE HYDROPONICS SYSTEM

Source: Hydroponics Kenya, 2015.

## APPENDIX 5: SAMPLING TABLE

| Size of Population | Sample Size (n) for Precision (e) of: | | | |
|---|---|---|---|---|
| | **±3%** | **±5%** | **±7%** | **±10%** |
| 500 | A | 222 | 145 | 83 |
| 600 | A | 240 | 152 | 86 |
| 700 | A | 255 | 158 | 88 |
| 800 | A | 267 | 163 | 89 |
| 900 | A | 277 | 166 | 90 |
| 1,000 | A | 286 | 169 | 91 |
| 2,000 | 714 | 333 | 185 | 95 |
| 3,000 | 811 | 353 | 191 | 97 |
| 4,000 | 870 | 364 | 194 | 98 |
| 5,000 | 909 | 370 | 196 | 98 |
| 6,000 | 938 | 375 | 197 | 98 |
| 7,000 | 959 | 378 | 198 | 99 |
| 8,000 | 976 | 381 | 199 | 99 |
| 9,000 | 989 | 383 | 200 | 99 |
| 10,000 | 1,000 | 385 | 200 | 99 |
| 15,000 | 1,034 | 390 | 201 | 99 |
| 20,000 | 1,053 | 392 | 204 | 100 |
| 25,000 | 1,064 | 394 | 204 | 100 |
| 50,000 | 1,087 | 397 | 204 | 100 |
| 100,000 | 1,099 | 398 | 204 | 100 |
| >100,000 | 1,111 | 400 | 204 | 100 |

a = Assumption of normal population is poor (Yamane, 1967). The entire population should be sampled.