

**EVALUATION OF APICULTURE IN THE CONTEXT OF FOOD  
SECURITY AND ENVIRONMENTAL MANAGEMENT IN  
KATHONZWENI DIVISION, MAKUENI COUNTY, KENYA**

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## DECLARATION

This project is my original work, and has not been submitted for a degree or any other award in any other university.

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## **DEDICATION**

To my beloved mother Jane Muthuka, my beloved late father Bernard Muthuka, my husband Martin Mutula, my son Andrew Mutula and my daughter Tressie Mutindi. To you all, this work is proudly dedicated.

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## DEFINITION OF TERMS

**Food security-** exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”

**Environmental management-** is organizing different environmental initiatives to address various ecological issues that are affecting the globe.

**Biodiversity-** is the variety of all living things; the different plants, animals and microorganisms, the genetic information they contain and the ecosystems they form.

A **household-** consists of one or more people who live in the same dwelling and also share meals.

**Dry lands-** are characterized by a scarcity of water, which affects both natural and managed ecosystems.

**Deforestation-**is the permanent destruction of forests in order to make the land available for other uses.

**Afforestation-**the act or process of establishing a forest especially on land not previously forested

**Honey-** is a sweet product made from flower nectar, combined with an enzyme secreted by honey bees, then concentrated by reducing moisture in the honeycomb cells.

## **ABBREVIATIONS AND ACRONYMS**

AOAC	Association of Analytical Communities
CBO	Community Based Organisation
FAO	Food and Agricultural Organization
FEWS NET	Famine Early Warning Systems Network
IFAD	International Fund for Agriculture Development
IHC	International Honey Commission
KARI	Kenya Agricultural Research Institute
KIHBS	Kenya Integrated Household Budgetary Survey
KNBS	Kenya National Bureau of Statistics
KSHS	Kenya Shillings
NGO	Non- Governmental Organization
PDNA	Post Disaster Needs Assessment
SRA	Short Rains Assessment
UNEP	United Nations Environmental Programme

## ABSTRACT

Kenya holds a huge honeybee population and the ability of honey production is high due to different ecological conditions. Beekeeping therefore has the potential of promoting economic development by supplementing household incomes from selling of honey and other products from the hive. Investment in bee farming contributes to environmental conservation because it helps reduce pressure cropping exerts on agricultural land. Many dry areas of Kenya usually face acute food and nutrition insecurity and the devastating effects of drought and climate change. Bee farming thus becomes a possible option that is people and environment friendly. This study sought to evaluate the status of apiculture and how to increase its adoption so as to contribute to adequate food availability and environmental management in the famine prone area of Kathonzi Division in Makueni County. The division experiences unreliable rainfall with most of the households practicing crop farming that relies on the rains thus they remain food insecure most of the time. Thus this study sought to evaluate the adoption of apiculture that does not rely on the rains to improve food security and conserve the environment in the division. A descriptive survey design targeting bee farmers and key informants was used to collect data. The key informants included, well established bee farmers, division agricultural officer and county agricultural officer. A sample size of 379 comprising household heads was arrived at using the table for determining sample sizes. Data was analyzed using SPSS Version 20 and Excel spread sheets. Results showed that only 25.8% of farmers in Kathonzi division practiced apiculture. Reasons for practicing apiculture varied with 30.4 % of respondents indicating that that it was a viable source of income as they were able to be food secure throughout the year; about 30% felt that it supplemented other farming activities, while 23.7 % preferred it because it was more economical than tilling the land. Only 6.7% of respondents practiced apiculture for food, while 9.3 % did it as a way of conserving the environment. The challenges facing apiculture according to the respondents were; prolonged dry season , lack of skills on bee keeping by farmers, expensive bee hives, (mean=2.3536), lack of enough sensitization of farmers on bee keeping , and the attack of beehives by honey badgers. In conclusion from the obtained statistics, apiculture contributes to food security (30.4%) and environmental management (9.3%) and therefore it should be well supported by the relevant County and Central government agricultural offices to improve on food security and environmental conservation in Makueni County and other Counties with similar climatic conditions. In order to improve adoption of bee farming, respondents indicated the need to subsidize prices of beehives (25.0%), sensitization of general public on the benefits of apiculture (24.0%), provision of ready market by County Government of Makueni for honey and other beehive products (18.1%), financial support from government (19.2%) and afforestation of the land (13.6%).

## CHAPTER 1: INTRODUCTION

### 1.1 Background to the Study

The world produces adequate food to feed all the people with at least 2,720 kilocalories per day, which is above the Food and Agriculture Organization of the United Nation's (FAO's) required minimum of 2250 kilocalories per day (FAO, 2003a). Ironically food shortage is globally common and severely high (FAO, 2006). In 2003, the FAO estimated that there were 842 million underfed people globally: 798 million (95 %) in the third world, 10 million in industrialized countries and 34 million in countries in transition. In sub-Saharan Africa, the number of underfed people has been growing: from 169 million in 1992 to 206 million in 2003. Three-quarters of those underfed stay in rural areas, those who have been displaced by civil war and also those who earn their living from dry lands (FAO, 2003a; 2006).

Africa and the whole world are faced with two main challenges in the 21<sup>st</sup> century. The first challenge is how to provide food to the increasing population and the second is how to adjust to the changing climate (Seiler, 2013). In 2003, FAO estimated that there were 842 million people worldwide face with acute food shortage: with 798 million (95%) in the third world, 10 million in industrialized countries and 34 million in countries that are undergoing transition. In sub-Saharan Africa, the number of food insecure people has been growing from 169 million in 1992 to 206 million in 2003. Sub-Saharan Africa is the region with the highest occurrence of food shortage in the world at 23.2% (FAO, 2015). The dry lands of Kenya make over 75% of the country's land mass. These dry lands make the least developed parts of the country where household food shortage is common and acute. It is therefore important to find sustainable ways to solve the recurring food shortage problem in these dry lands.

The situation of food in Kenya is an issue of great concern with trends showing an ever increasing demand for food accompanied by a less proportionate increase in food supply. Whereas some regions do not commonly experience food shortage problems, famine and food insecurity are common in other regions of the country. Agriculture is the major economic activity which most of rural people depend on for agricultural production and income generation (FAO, 2004).

Food security cannot be achieved without stable income (Koirala and Thapa, 1997). Apiculture is one of the good practices that have been known to better livelihood of poor farming people without much cost (Baptist and Punchihewa, 1983). Apiculture is possible in dry areas and other areas where food crop farming have not succeeded (Bradbear, 2002).

Apiculture is the science of bee keeping. Beekeeping contributes to food security, poverty reduction, employment creation and income generation in not only in the arid and semi-arid areas in Kenya but in majority of the sub-Sahara Africa rural areas (Abellán, 2002). Apiculture in Kenya is majorly practiced in ecological areas where chances for crop farming are limited and the natural vegetation is made up of many plants varieties suitable for bees to collect nectar from (Nightingale, 1976). The areas most affected are among the 80% arid and semi-arid lands which include Kathonzi division. Beekeeping offers direct and indirect benefits to the rural people. Directly, beekeeping subsidizes household income from hive product sales, provides food, safe medicines and raw materials for industries. These income benefits have been reported to have high impact among marginalized and small income earners such as women, orphans and other vulnerable groups within the society.

Indirectly, beekeeping contributes to water shed-management, forest conservation and crop pollination. In their studies, Chaplin-Kramer, Dombeck (2011) found that bees are responsible for one third of food crops planted and produced by humans. Honeybee pollination improves quality, quantity and market value of food crops. Maurice (2006) argues that beekeeping can help to conserve environment mainly in three interconnected ways: increasing the number of honeybees in an area should improve the pollination success of numerous flowering plant species; the income generated from beekeeping can help to alleviate pressure on the local resource base; and there is a potential to alter the way the people view their local environment. With all the above benefits, it is believed that beekeeping can improve living standards of the rural poor.

## **1.2 Problem Statement and Justification**

In recent times, Kenya has been having serious food shortage challenges, especially in dryland areas. These are shown by a high number of the population not having accessibility to food in the right quantity and quality (GoK, 2011). The food insecurity problem cuts across to regional levels where agricultural potential is lowered and leads to famines in the dry land ecosystems. (Muyanga, 2004).

In an attempt to combat global food insecurity situation and ensure environmental conservation, the United Nations General Assembly in 2015 made resolutions to finish food shortage, have food security and better nutrition, encourage reliable agriculture, take urgent action to combat climate change and its impacts and stop and reclaim degraded land and stop the loss of biodiversity. The Kenyan government, in its Vision 2030, also targets to transform Kenya into “a new industrialized middle income country by providing a high quality of life to all its people in a clean and safe environment”.

The achievement of these goals is largely pegged on the agricultural sector. The sector contributes directly 24% of the Gross Domestic Product (GDP) and 27% of GDP indirectly through manufacturing, distribution and other service similar sectors.

However, even with these realizations, the World Bank (2014) observes that, an almost total dependence on crop and livestock farming in dryland environment makes households not able to withstand any external shock like drought. There is therefore need to identify and adopt sustainable and environmental friendly agricultural practises, especially in dry lands of Kenya and elsewhere. Bee keeping with its proven income viability, environmental conservation and nutritional cum medicinal benefits are a sustainable alternative in Kathonzwi division with a range of drought resistant trees and many annual crops that give honey flora all year round. Kathonzwi division is a dryland in Kenya that experiences low food security due to over dependence on crop farming and unreliable rainfall. Apiculture is a practice that does not depend on rainfall and thus the households in the division may improve their food security and improve the environment by practicing it. This study therefore aimed at evaluating how adoption of apiculture could be increased for food security and environmental management in Kathonzwi Division.

### **1.3 Objectives of the Study**

The overall objective of this study was to determine the measures of enhancing adoption of apiculture given its potential and proven profitability in order to increase food security and environmental management in Kathonzweni division of Makueni County. The specific objectives were as stated below:

- i. To assess the extent to which apiculture is practiced by households
- ii. To determine the relative contribution of apiculture to food security and environmental conservation
- iii. To examine the challenges facing the adoption of apiculture
- iv. To assess the measures that need to scale-up adoption and sustainance of apiculture

### **1.4 Research Questions**

From the research objectives above, the following research questions were formulated:

- i. To what extent is apiculture practised by households and individuals in Kathonzweni division, Makueni County?
- ii. Has apiculture contributed to improved food security and environmental conservation in Kathonzweni division, Makueni County?
- iii. What are some of the challenges facing the adoption of apiculture in Kathonzweni division, Makueni County?
- iv. How can adoption of apiculture be scaled-up in the study area?

### **1.5 Significance of the study**

The findings of this study may assist the residents of Kathonzweni division to diversify their livelihoods from crop farming that is regularly limited by adverse climate to apiculture which requires less land and water as inputs. The reduced pressure on land by not crop farming will lead to environmental recovery through reduction in land degradation and conservation of biodiversity. Bee keeping contributes to watershed management, forest management and crop pollination as it requires planting of trees and minimal soil disturbance. Increased and predictable income from honey will improve household living standards.



## **CHAPTER 2: LITERATURE REVIEW**

### **2.1 The emerging Issues on Food Security**

The world produces adequate food to feed all the people with at least 2,720 kilocalories per day, which is above the Food and Agriculture Organization of the United Nation's (FAO's) required minimum of 2250 kilocalories per day (FAO, 2003a). Ironically food shortage is globally common and severely high (FAO, 2006). In 2003, the FAO estimated that there were 842 million underfed people globally: 798 million (95 %) in the third world, 10 million in industrialized countries and 34 million in countries in transition. In sub-Saharan Africa, the number of underfed people has been growing: from 169 million in 1992 to 206 million in 2003. Three-quarters of those underfed stay in rural areas, those who have been displaced by civil war and also those who earn their living from dry lands (FAO, 2003a; 2006). In recent years, Kenya has been having acute food shortage challenges. These are shown by a high number of people having no accessibility to food in the right quantities and quality (GoK, 2011).

Current food shortage challenges can be as a result of many factors such as repeated droughts in most parts of the country, high costs of producing household food, displacement of many farmers especially those in fertile agricultural areas and high worldwide food prices due to low buying power for much of the population as a result of high due to high poverty levels. Thus, more than 10 million people face acute food shortage (Republic of Kenya 2011; FAO 2011; Republic of Kenya 2008). Kenya's 2011 National Food & Nutrition Security Policy show that in the past 30 years, per capita food availability had gone down by more than 10% (Republic of Kenya, 2011). In Makueni County, the impact of the drought on agricultural production has been a key factor in the escalating food insecurity. Consecutive failed rainy season's results in failed harvests, thereby reducing local food production and disrupting local market systems.

Africa ensures food supply through local food production and food import. West Africa for example survive on 40% on imports in ensuring adequate rice supply with Thailand as the major rice supplier (FAO, 2010). The net amount of cereal imports in Africa was about 66 tons in 2010 (FAO, 2013a). This means that in the whole of Africa, 39% of its cereals fed on in 2010 were bought overseas. Despite local food production and import efforts, there were 239 million underfed people living in the African continent in 2012 majority of them in Sub Saharan Africa (FAO, 2012). This indicates that food shortage is now of increased importance. Sub Saharan Africa is the area with the highest number of underfed people in the world at 23.2% (FAO, 2015). Reducing food shortage and malnutrition is a major problem for most of the third world countries. Kenya is one of the African countries where millions of people are underfed (FAO, 2013).

The causes of food shortage are very many and interconnected, but poverty is the major driver not only in Kenya, but globally. One way of decreasing food shortage is by bettering the agriculture sector. Agriculture is the backbone of Kenya's economy with over 80% of its people especially those staying in rural areas deriving their means of living mainly from agricultural practises (KARI, 2013). According to FAO Stat (2009), the average person in Kenya consumes 2155 kilocalories of food each day. Of this, 1183 kilocalories (55%) are from staple foods which include maize, wheat, beans, potatoes, plantains and rice. Kenya is classified by the Food and Agriculture Organization as a low income and food deficit country (FAO, 2006). It is among the one third of African countries whose availability of food is such that an average daily caloric availability is below the recommended level of 2100 kilocalories (FAO, 2006). The country has been having severe food shortage as a result of lowered cereal production, livestock diseases, rising food prices and scarce rainfall.

The food shortage status was declared a national disaster in early January 2009 and May 2011 indicating about 10 million people were suffering from serious food shortage (GoK, 2009). The food shortage problems being faced by households in Kenya's dry lands is as a result of poor weather conditions and institutional inability to fully address the food insecurity problem (Lemba J.K.2009).

Food availability is limited by lack of enough resources for production while access is challenged by limited non-farm employment (Muyanga, 2004). Food security in Kenya is closely tied to local agricultural production, the effect of poverty on access to food and basic services, population dynamics, changing climatic patterns and change in demographics (FEWS NET, 2013).

Agricultural production in Kenya is almost totally dependent on rainfall and many farmers are vulnerable to unreliable rainfall and long spell of drought. With climatic change, droughts are likely to occur more frequently and at a higher intensity (FEWS NET, 2010). Drought is the major cause of food insecurity (GoK, 1986; Tiffens, 2002); in addition to inappropriate policies of the government (Kimenyi, 2002; Nyangito et al., 2004) shown by institutional poor performance and economic challenges. Aridity in Kenya has always been a problem to food production. According to a government report (GoK, 1986), only 7% of Kenya has enough and reliable rainfall, soil and topography good for crop production. An additional 5% can sustain crops in years of adequate rainfall while the remaining (88%) makes the dry lands.

## **2.2 Status of Food Security in Makueni County**

The Makueni County in Kenya is found in the arid and semi-arid regions which are characterized by erratic rainfall (ACF-USA, 2012). Makueni County has for most part of the seasons been characterized as being in the emergency phase classification with the availability of basic necessities such as food and water varying greatly as a result of indeterminable changing climatic conditions, which have affected food security, water availability and the livelihood coping options for majority of the vulnerable households (Ombis, 2013). The patterns of food production in Makueni County are characterized by considerable seasonal fluctuations which contribute to widespread food shortages in most households. The overall rainfall performance in the county has been erratic over the past several successive rainfall seasons, which in return affects all livelihood zones, because the county and surrounding regions primarily rely on the short rains season, which have previously been more reliable in terms of their amount and distribution (FEWSNET, 2013).

According to Ombis (2013), 86.1% of the households in Makueni County do not have sufficient food during a drought, while 13.9% of the households do have food. In the county, the factors affecting food security depend on both the agro climatic and socio-economic conditions, the factors also include the ability to get food rather than the production of food.

In Makueni County, the food contribution at the household level stands at Maize – 77%, Kales – 3% and Beans – 20%. The main sources of income at the household level include French beans, kales and bananas, whereas in the mixed farming areas, the main crops grown are maize and beans in order of importance. Tomatoes, kales and onions are also grown under small scale horticulture type of irrigation farming. The area under irrigation usually increases at the onset of a good projected rainfall performance, because the expectation is the good season provides for an equally good recharge of the natural water sources though this is not usually the case during a failed season (Short Rains Assessment, 2013). Maize is the highest contributor to food in the county at 77%, followed by beans at 20 percent and pigeon peas and mangoes at 3 percent each. Maize, mangoes and citrus fruits contribute 58%, 20% and 10% of household cash income respectively. The major livestock types in Makueni County are cattle, goats and sheep; whose production include meat, milk, hides, skins and other by-products all of which contribute to the household income. This sector is usually affected by water scarcity and poor forage conditions during dry seasons, forcing communities to use crop residues as livestock feeds (Behnke and Muthami, 2011).

In Makueni County, the impact of the drought on agricultural production has been a key factor in the escalating food insecurity. Consecutive failed rainy season's results in failed harvests, thereby reducing local food production and disrupting local market systems. Previously, farmers grew their own food and did not rely on the purchase of staple food supplies in the market (David, 2006). This calls for alternative sources of income which are less dependent on rainfall, and which contribute to the protection of vegetation cover. Apiculture is a perfect example of such venture. Apiculture does not require the use of soil directly and it can be a way of living for people with little or no soil.

Moreover, it is viewed as one of the cheapest agricultural activities, and one that offers employment easily (FAO, 1986). Consequently, apiculture is frequently promoted as an income-generating activity for the poor because it is easily accessible to marginalized people of local people. Policies and strategies therefore need to be formulated and implemented on how apiculture can be promoted to safeguard food security and environmental conservation.

### **2.3 Overview of Apiculture for Rural Development in Africa**

Apiculture is the science of bee keeping and brings income and food security by providing honey, beeswax and pollen as food and propolis, bees' venom and royal jelly in medicine apart from pollination services. Honey is a natural sweet tasting substance produced by bees from the nectar. Honey bees collect nectar, change it and combine with their own specific substances, store and leave it in the honey combs to mature (FAO, 2004; Codex Alimentarius Commission, 2001). Honey is the major and basic product of bee-keeping both quantitatively and economically (FAO, 1996). Beehive products have been used by human being for centuries as bee brood which is traditionally taken as a high protein food while beeswax has been used in making of candlewax. Beekeeping therefore is depended upon by millions of people in Sub-Saharan Africa (Gidey and Mekonen, 2010). Bee keeping as a business has improved the livelihoods of so many groups of people and individuals in the world. For example, apiculture is a long practiced economic activity in the rural areas of Ethiopia and is as old as history of the country (Ayalew and Gezahegn, 1991).

Apiculture is an ecologically friendly and a non-farm business activity that has very high contribution to the economies of the society and to a national economy as well. Beekeeping can be practiced together with other agricultural activities like crop production, animal keeping, horticulture and natural resource conservation. The contributions of apiculture to reduction of poverty, sustainable development and conservation of natural resources have been well known and supported by the government and non-governmental Organisation in Ethiopia. Ethiopia is a major honey and beeswax producing country in the world. The collection and selling of honey and other bee products, is the main economic activity.

The country leads in production of honey and beeswax in Africa (Gezahegne, 2012). Globally, Ethiopia is the fourth largest producer of beeswax and the 10th largest producer of honey. Apiculture in south western Ethiopia provides its low income population with an opportunity to supplement their income by selling of harvested bee products like honey and beeswax at a good market (Gallmann and Thomas, 2012).

#### **2.4 Adoption of Apiculture in Kenya**

In Kenya, scientific studies on adoption of farm technology majorly investigated crop, soil and water conservation and dairy technologies (Million and Belay, 2004) with less regard to beekeeping technology adoption, (Melaku, 2005). Apiculture in Kenya is majorly practiced in areas where chances for growing crops are limited and the natural vegetation is made up of many types of plants good for bees to for bees to suck nectar from (Nightingale, 1976). Honey production in Kenya is done mostly through traditional ways like the use of log hive technology (Nightingale, 1976). Apiculture can be practised very well in 80% of the country and is very suitable in arid and semi-arid areas where crop farming is difficult unless under irrigation. Traditional apiculture practice in Kenya has a long history with a variety of bee hives being used in different parts (Nightingale and Crane, 1983). The hives are classified into three main groups as shown in plates 1-3 below:



[Plate 1: Fixed comb hives: clay hives, wall hives, log hives, bark hives and many others](#)



[Plate 2: Movable comb hives: top-bar hives, of which there are many styles](#)



[Plate 3: Movable frame hives: Langstroth, Dadant, Adz, National, Smith, and WBC](#)

However, many of bee farmers in Kenya still use traditional methods of bee keeping which is majorly hollow log hives (Caroll, 2006). These hives make the highest number of bee hives in the country at about 1,273,000 constituting 73% of all the bee hives in the country (Muya, 2004). Apiculture with modern bee hives is quite new, having been introduced in the 1950s by the colonial government and later promoted by the Kenyan government and other development partner (Caroll and Kinsella, 2013). Traditional apiculture methods mainly involve the use of traditional log hives that are hung high in trees and spread over extensive areas far away from people and animals. This traditional method is practiced majorly in the dry lands of Kenya.

In the modern bee keeping methods, bees are kept majorly in top bar of the modern hives in agriculturally productive parts of the country where many of people live (Carroll and Kinsella, 2013). Apiculture is an important source of livelihood for many farmers who are resource poor. However, despite the suitable natural environment and the ability for establishing sustainable livelihoods in rural areas, apiculture lacks the needed financial and technological support to fully exploit its high potential in forests and natural ecosystems conservation. In comparison with other agricultural activities, apiculture is a cheap economic activity with the ability to have huge effect in bettering people's livelihoods and the national economy. However, poor technologies, lack of adequate knowledge, environmental depletion and low production are some of the major constraints that face the sub-sector (Jiwa, 2005; Muga, 2011).

The effort to better Kenyan bee keeping began in 1967 through an Oxfam grant that funded their first apiculture development project. In 1970 the government of Kenya, together with financial and technical support from the government of Canada established The National Beekeeping Station in the Kenyan Ministry of Agriculture. This was to look into the development of Kenyan apiculture through extension services, research development and the professional training of Kenyan beekeepers (Kigatiira, 1976). Currently, apiculture development is focused on bettering of the hive technology and professional. The main bee hive technology improvement is interested in the Langthroth or the Kenya Top Bar Hive (KTBH).

Beekeepers in developing countries e.g. Kenya are also faced with the challenge of poor honey quality due to inadequate information on suitable technologies on harvesting, storage and processing. This in turn influences the rise and demand in internal and external markets technologies for bee product diversity. In these situations, development partners and the government need to come in and assist the farmers improve traditional bee keeping methods or introduce new technologies in new areas of apiculture (Jones, 1999). Although apiculture does not need high technology in practice, constant training is required by beekeepers on improving bee keeping practices.

A study conducted by Tadesse (2011) in Addis Ababa, Ethiopia, revealed that availability of information and knowledge about the related skills required for bee farming are vital in the beekeeping adoption process.

## **2.5 Contribution of Apiculture to Food Security**

The country's ability for apiculture development is close to over 100,000 metric tons of honey and 10,000 metric tons of beeswax. However, at the moment only a fifth of this ability is being realized (GoK, 2008). In Kenya, over 90% of bee farmers use traditional ways of apiculture that leads to low honey quality (Mbae, 1999). Mbae (2000) noted that the beekeepers' earned Kshs.7.2 Million from the sale of honey and this compared favorably with Kshs.6.6 million from the livestock-rearing sector. Apiculture alone contributes about 1.89% of this amount (Muya, 2004). Apiculture needs very little money or labour input. It is a cheap and gender friendly venture which does not need much resources like other agricultural activities. Apiculture is possible in dryland areas and other places where crops have not succeeded (Bradbear, 2002).

In Africa, pollinator dependent crops include numerous indigenous vegetables, such as African nightshades, amaranths, spiderplant, slenderleaf and *Crotalaria brevidens*), African kale, jute mallow and African eggplant and *Solanum gilo*) (Abukutsa-Onyango et al. 2010). Also important are nuts e.g. macadamia, (Johannsmeier, 2001) and wild fruits harvested from natural and semi-natural areas such as shea nuts (*Vitellaria paradoxa*). The vast majority of pollinators for these vitamin rich crops are insects such as bees (Klein et al. 2007), underlying the importance of insects in securing crop pollination services. Pollination services also contribute to other aspects of crop production. For example, strawberry producers and pollination researchers in Kenya demonstrated differences in their crop yields depending on whether the fields were located near beehives. Increased insect pollination/visitation resulted in more uniform and marketable strawberries (Asiko 2012); and runner bean with good exposure to honeybees produced fewer "sickle shaped" pods that horticultural exporters refuse to accept (Vaissière *et al.* 2010).. In the African continent, the area with pollinator-dependent crops has increased by more than 300% in the past 50 years (Aizen et al. 2008; Aizen and Harder 2009).

Current trends linked to the increase in the horticultural sector show vastly greater increases in pollinator-dependent crops in developing regions of the world than in developed countries. Use of controlled honeybee colonies for pollination of crops has been virtually the sole practice to increase levels of pollination service to agricultural production e.g. apples in South Africa, (Johannsmeier, 2001). Honeybees can easily be managed, and their populations increased and moved around to match flowering periods (Radar *et al.* 2009). However, they are not always the most optimal pollinators (Westerkamp, 1991), and can be susceptible to disease and degradation of the natural environment (Johannsmeier, 2001). Recent research has shown that interactions by wild pollinators and managed honeybees may lead to more effective pollination than either alone (Greenleaf and Kremen 2006; Carvalheiro *et al.* 2011). Moreover, the overall economic importance of pollination services, the production value per unit farming area of insect pollinated crops is four times that of crops that require no insect pollination (Gallai *et al.* 2009).

Thus farmers can make more money and produce more nutritious foods if they cultivate high-value, often pollinator-dependent, crops. Agricultural development programmes aiming at poverty reduction need to recognize the crucial role sufficient animal pollination plays in maintaining and increasing yields of horticultural crops and thus in improving human nutrition and food security. Animal pollination is being increasingly recognised as an essential ecosystem service, whose sufficient provisioning leads to overall increased and stabilized crop production (Garibaldi *et al.* 2011), and therefore sustained income levels and food security. Crops like avocado and mango benefit from insect pollination in terms of number of fruits produced and/or weight of fruits or seeds. Around three-quarters of food crops in the whole world depend on animal pollination (Klein *et al.* 2007), including primarily vitamin and mineral rich crops such as fruits and vegetables.

## **2.6 Apiculture and environmental conservation**

Beekeeping is possible in arid areas and places where crops or other enterprises have failed; the roots of nectar-bearing trees may still be able to reach the water table far below the surface in these areas. This makes beekeeping feasible in marginal conditions, which is important for people who need to restore their livelihoods or create new ones (Ellis, 2000). Bees provide many benefits to the natural environment and are very important in its sustainability. Their function is not quite noticed even though bees are required for the pollination of many cultivated crops and for biodiversity maintenance. Normally, a honeybee can visit between 50 to 1,000 flowers in one trip. In Europe, a bee can make between 7 to 14 trips a day. A colony with 25,000 forager bees, each making 10 trips a day, is able to pollinate 250 million flowers (FAO, 2009). Beekeeping ensures the continuation of natural assets through pollination of wild and cultivated plants. Flowering plants and bees are interdependent: one cannot exist without the other. As bees visit flowers, they collect food and their pollination activities ensure future generations of food plants, available for future generations of bees and for people too. It is a perfect self-sustaining activity. Pollination is difficult to quantify, but if it could be measured it would be the most economically significant value of beekeeping (Hoshihara & Sasaki, 2008).

Bees are important agents of pollination and many ecological areas rely on the pollination of bees for their survival and for improving their hybrid vigour. A reduction in the number of bees and bee types could therefore affect the survival of plant types that rely on the pollination by bees. About one third of all plants or plant products eaten by humans depend on bees for their pollination (FAO, 2009). Crops pollinated by bees give more outcome and better quality at no extra cost. Agricultural systems, by design or by the nature of their development, may be relatively conducive to sustaining biological processes. This is the case in much of Africa, where due to the extensive nature of most farming systems and the relatively low use of inputs, such as fertilizers, most farmers currently rely on natural pollination services, the presence of natural enemies that control pests, and natural means of restoring soil fertility such as through fallow (Styger and Fernandes, 2006). While yields are typically low, there are strong possibilities to increase yields through biological processes (Pretty *et al.* 2005).

## **2.7 Summary of Knowledge Gaps**

Although very many studies have been done on the benefits and challenges of beekeeping, a few have been conducted in Kenya. Furthermore, those done in Kenya were conducted in other regions but not in the area of study for this project. The current study intended to establish how apiculture can be used to improve food security and environmental conservation, by assessing its level of adoption, challenges facing its adoption and coming up with suggestions on how these challenges can be overcome or minimized. The study therefore, through its findings will add more knowledge to the existing body of knowledge on the bee keeping sub-sector and its linkage to poverty eradication especially in arid and semi-arid areas.

## CHAPTER 3: RESEARCH METHODOLOGY

### 3.1 Study Area

Kathonzweni division in Kathonzweni sub-county is located in Makueni County (Figure 3.1) and occupies an area of 301 square kilometres with a population of about 31,277 people (KNBS, 2010). The study area is majorly a dryland and often experiences droughts. The area gets low rainfall of about 300 mm to 400 mm per annum (Amukono, 2016). The study area rarely supports the main food crops maize and beans. Animal keeping therefore is the common sustainable economic activity practised by the local residents.

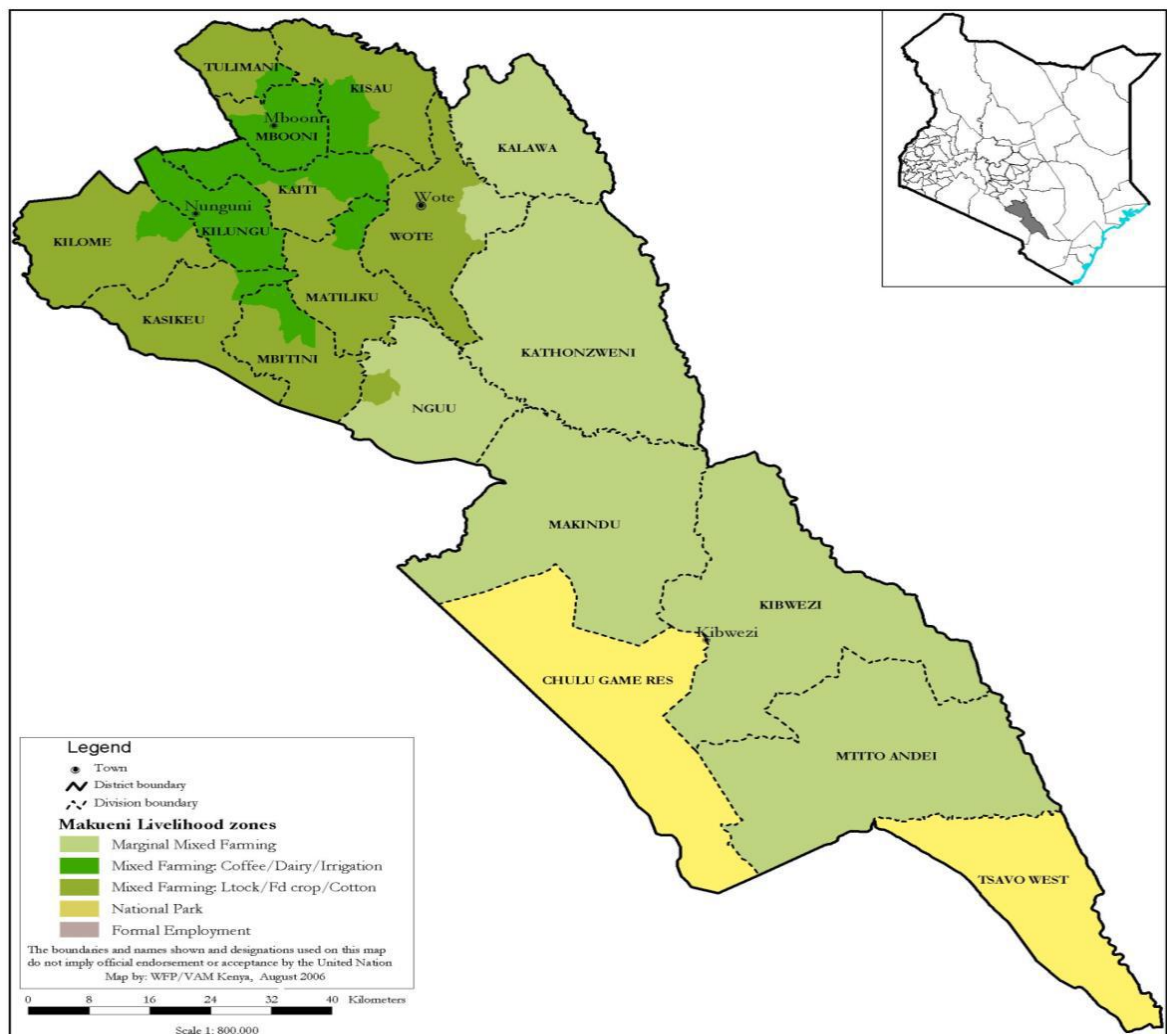


Figure 3.1: Location of Study Area

### 3.2 Research Design

The study was done by use of survey research design, where engagement with respondents through questionnaires and interviews played a crucial role. This design was preferred because tacit knowledge, which is extracted through dialogue, can play a critical role in understanding farmer behaviours and hence inform more pragmatic policy for positive change. Since it leads itself to determining general trends (Bell, 1993), descriptive statistics complemented the research design in data analysis.

### 3.3 Sample Size and Sampling Procedures

The target population for this study included household heads, agricultural extension officers and village elders in Kathonzwani division. Sampling involved identifying a sub group within the population that represents a large group from whom they were identified from (Kathuri *et al*, 1993). Sample size should be optimum where the requirements of efficiency, representativeness, reliability and flexibility are fulfilled (Kothari, 2004). In this regard the researcher selected a sample size of 379 respondents using the table for determining sample size (Appendix 7.6) as suggested by Darley and Robert (1970). The table is based on standardized figures of sample sizes for different population (or proportion of it) at 95% confidence level. By use of a standardized table, the researcher was 95% certain that the results obtained from the sample would be representative enough for the entire population.

**Table 3.1: Sampling Frame for the study**

<b>Category of respondents</b>	<b>Population</b>	<b>Sampling Technique</b>	<b>Sample size</b>
Household heads	31,277	Simple random sampling	379
Local NGO's	1	Automatic inclusion	1
CBO heads	3	Purposive Sampling	3
Focus groups	3	Purposive Sampling	3
Agricultural Extension Officer	1	Automatic inclusion	1
<b>Totals</b>	<b>31,284</b>		<b>387</b>

From table 3.1, the optimal (effective and valid) sample size for a population of 31277 households was 379. Local Non-Governmental Organizations and Agricultural Extension Officers were automatically included in the study because they oversee farming activities in the area hence they acted as key informants on issues concerning the potential of apiculture in the area, the challenges faced by bee farmers, and policy interventions for improvement. The CBO heads and focus group heads were purposively picked because being in constant touch with the farmers, they held crucial information about the reality on the ground; and which was of great interest to the researcher.

### **3.4 Data Collection Methods**

Quantitative data was gathered using household questionnaires (Appendix 7.1) while qualitative data was gathered using qualitative tools or instruments such as; participatory transect surveys (Transect walk), Focus Group Discussions (Appendix 7.2) and Key Informant interviews (Appendix 7.3) as detailed below.

#### **3.4.1 Questionnaires**

For purposes of this study, a household was categorized as a family unit dependent on one head and a common livelihood. Questionnaires were formulated with questions aimed at getting answers to the four research questions. They were given to 379 households to get information, opinions and perceptions about the study objectives at the household level. Questions posed ranged from demographic, social, economic to environmental. Administration of the questionnaire was done by the researcher with the aid of one research assistant.

#### **3.4.2 Key Informant Interviews**

The study relied on Key Informant Interviews to give more and clear information especially on the technical knowledge on about the study topic and area. The major Key Informants included representatives of relevant Ministries at the local level and county government's official, local NGOs and CBOs heads.

### **3.4.3 Focus Group Discussions**

Three focus group discussions were selected randomly in the area of study. The semi-formal discussions were conducted at the chiefs' camps and nearby local churches with the assistance of a moderator.

### **3.4.4 Participatory Transect Survey**

It's an information gathering exercise where, the only knowledge needed is key informant advice on finding out the transect line routes and a few selected local analysts. This study made use of three transects walks. Each transect walk was done with about 5-10 local analysts taking about 2 to 3 hours. The walk started from one end of a define area and ended at the end of that administrative unit. The distribution of bee farmers including the status of the hives was mapped and documented.

## **3.5 Data Analysis Methods**

### **3.5.1 Questionnaire Data**

Questionnaire data from all the 379 households was analyzed quantitatively for all quantifiable data under research. This data was first coded and fed in Statistical Package for Social Sciences (SPSS) Version 20 and Excel spread sheets. The outcome was then analyzed through cross tabulations, rankings, percentages, frequency counts mean, and standard deviations. The analyzed data was then presented in form of tables, graphs and pie charts.

The rest of the data in this study was then analyzed qualitatively since it involved measurements that would not be quantified. All data collected using qualitative methods such as focus group discussions, key informant interviews and participatory transect survey was analyzed qualitatively and presented in form of ranks and scores of perception and descriptions. Cross-tabulations were also used to show trends, patterns and extent of influence of two variables on each other.

### **3.5.2 Focus Group Discussion and Key Respondent Data**

Data collected using qualitative methods such as focus group discussions and key informant interviews was analyzed qualitatively and presented in form of ranks and scores of perception and descriptions. Cross-tabulations were also used to show trends, patterns and extent of influence of two variables on each other.

### **3.5.3 Participatory Transect Survey Data**

This study made use of three transects walks. Each transect walk was done with about 5-10 local analysts taking about 2 to 3 hours. Each walk started from one end of a define area (a road) and ended at the end of that administrative unit. All data collected using qualitative methods such as participatory transect survey was analyzed qualitatively and presented in form of a participatory transect diagram.

### **3.5.4 Sampling and Analyzing On Farm Honey Quality**

A total of ten (10) samples of honey were randomly taken from 10 different farmers in the study area of Kathonzwani division and taken to a reputable laboratory (Egerton University) where they were carefully analyzed. The honey parameters analyzed included; Hydroxy-Methyl Furfural (HMF), Sugar (Brix) Content, Moisture Content, PH and Free Acidity. Each of the ten samples was tested three times per honey quality parameter and an average value obtained. Below is the procedure for determining each honey quality parameter;

#### **i. Free Acidity**

The free acidity of honey is the total number of free acids, given in milliequivalents/kg honey. It was determined by the following procedure. A 10 g sample of honey was added to 75 ml of distilled water in 250 ml beaker. The solution was placed in calibrated pH/reference meter and stirred. The solution was then titrated at pH 8.5 with 0.05M NaOH and results recorded. 10ml of 0.05M NaOH was added to the resulting solution and back titrated at Ph 8.3 using 0.05M HCl from a second burette and results recorded. A blank determination procedure of 75ml of distilled water at Ph8.5 was run and results recorded. These measurements were taken in triplicates.

### **Calculation**

Free Acidity= [(ml of 0.05M NaOH used\*NaOH Molarity)]-(ml of 0.05M NaOH titrated blank)\*NaOH Molarity\*(1000/Sample weight).

### **ii. HMF (Hydroxymethylfurfural)**

It is used to evaluate honey freshness. It was determined by the White Method (White, 1970, Bogdanov, 2002). This spectrophotometric method involves measurement of UV absorbance of clarified aqueous honey solutions with and without sodium metabisulphite.

### **Procedure**

A quantity as close as possible to 5g of honey(Exactly weighted) was dissolved in 25ml of distilled water and transferred quantitatively into 50ml volumetric flask, then proteins were precipitated by adding 0.5 ml of Carrez solution 1(15g of Potassium Ferrocyanide in 100ml distilled water) and 0.5ml of Carrez 2(30g Zinc acetate in 100ml distilled water). The content was made up to 50ml with distilled water and the solution was filtered through a filter paper. After rejecting the first 10ml of the filtrate, aliquots of 5ml were put into two test tubes; 5ml of distilled water were added to one test tube(sample solution); 5ml of fresh sodium metabisulphite solution of 0.2%(reference solution) were added to the second test tube. The absorbance of the solutions at 284 and 336 nm was determined using spectrophotometer. Dilutions (D) of both sample and reference solution was used if the absorbance at 284nm exceeded a value of about 0.6. These measurements were taken in triplicates.

### **Calculation**

HMF content in mg/1000g was calculated as

$$(A_{284}-A_{336}) * 149.7 * 5 * D/W.$$

Where:

A<sub>284</sub>- absorbance at 284nm

A<sub>336</sub>-absorbance at 336nm

D-Dilution factor; incase dilution is necessary

W- Sample weight in g of the honey sample.

5- Theoretical nominal sample weight.

149.7-Constant

### **iii. Moisture Content**

Honey moisture determines for how long honey remains stable and without being spoilt by yeast through fermentation. The more the moisture, the more the chances that the honey will be spoilt when stored (International Honey Commission, 2009).

Moisture determination in the honey samples was done using a refractometer.

### **Procedure**

A sample of 20-50g of the honey is placed in a beaker and stirred with a plastic spoon. 2 drops of the honey were placed onto the prism area of the refractometer and the daylight plate closed to spread the sample evenly over the prism surface. Looking through the eyepiece of the refractometer, there was a boundary line where a blue and a white colour met. The reading there is the Brix %. These measurements were taken in triplicates. To obtain the value of moisture content in %;

$100\% - \text{Brix content} = \% \text{ Moisture}$

### **iv. Acid Content (pH) of honey**

The average PH of honey is 3.9. However, the Ph can be between 3.4 to 6.1. Honey has many types of acids both organic and amino acids. These acids may be aromatic or non-aromatic. The non-aromatic acids give the good taste of honey by interacting with the flavor of other ingredients. Gluconic acid for example is good at improving honey taste. The aromatic acids like malic acid mainly from the flowers add to the aroma and taste of the honey (Standifier, 2007). The pH of honey was determined by a pH meter, which had been calibrated using commercial buffer solutions of pH 4.0, 7.0 and 9.0. A 10 g of honey sample was taken and added to 75 ml of carbon free distilled water in a 250 ml beaker, thoroughly stirred and its pH recorded at 20 °C. Three readings were taken and averaged (AOAC, 1990).

#### **v. Sugar Content (Fructose/Glucose)**

The Lane-Eynon hot titration method was used to measure the content of reducing sugars (mainly glucose and fructose) (COVENIN, 1984a). A sample of 20-50g of the honey is placed in a beaker and stirred with a plastic spoon. 2 drops of the honey were placed onto the prism surface of the refractometer and the daylight plate closed to spread the sample evenly over the prism surface. Looking through the eyepiece of the refractometer, there was a boundary line where a blue and a white colour met. These measurements were taken in triplicates. The reading there is the Brix % ( %fructose/glucose). These measurements were taken in triplicates.

### **3.6 Validity and Reliability of Instruments**

Validity means the ability of a research tools to measures what it is designed to measure (Gay, Mills & Airasian, 2009). To test the validity of the instruments the researcher carried out a pilot study in two villages in the neighbouring sub County (Nzau sub County) with identical characteristics to the sample. The sample of the pilot study comprised 20 household heads from each location. Through the pilot study, the researcher was able to find out the complexity in the research questions. The research questions that didn't measure the variables of interest were adjusted.

Reliability is a measure of the ability of a research tool to give same results after repeated trials (Mugenda and Mugenda, 1999). To test how reliable the research tool is, the researcher employed the test re-test in the pilot study. During the test, the researcher gave the questionnaires to the pilot sample, and after one week, the researcher conducted a re-test by the administering the same instruments to the same respondents. The results of the test-retest method helped the researcher to perfect the questionnaire concepts, ensure that wordings are clear, and that respondents interpreted the questions in the same way. The researcher then used Pearson product moment correlation formula to correlate the scores from both test periods to obtain the correlation coefficient, Pearson's product moment Correlation Coefficient Formula is shown:

$$r = \frac{N\sum xy - \sum x \sum y}{\sqrt{(N\sum x^2 - (\sum x)^2)(N\sum y^2 - (\sum y)^2)}}$$

Where,  $\sum xy$  = Sum of the gross product of the values of each variables.

$N$  = Number of total items.

$(\sum x) (\sum y)$  = Product of sum of  $x$  and the sum of  $y$ .

(Best & Kahn, 2006).

Pearson product moment correlation establishes the extent to which instruments are consistent in eliciting the same responses every time the instrument is administered (Jwan, 2010). For this study, a correlation coefficient of 0.89 was obtained; implying that the instruments were highly reliable because statistically, a correlation coefficient of 0.8 to 1 is considered enough to judge the instruments as reliable for a study.

### **3.7 Ethical Considerations**

In adhering to the ethical issues, the research proposal had to be approved by the school of Environmental Studies, Kenyatta University. The researcher sought permission from the local administration before commencing the study. The researcher also had to make sure that participants are informed of the nature and requirements of the study. The researcher too guaranteed the respondents of the confidentiality of the information given. Anonymity of the respondents was achieved by not asking participants to write their names on the questionnaire.

## **CHAPTER 4: RESULTS AND DISCUSSION**

### **4.1 Introduction**

This chapter looks into questionnaire return rate, demographic information, data presentation, interpretation and discussion of research outcome. The presentations and discussions were done based on the research questions, emerging trends in findings and the reviewed literature so as to ensure that any knowledge gaps identified are properly filled.

### **4.2 Questionnaire Return Rate**

Questionnaire return rate is the number of the questionnaires that are brought back after they have been answered by the respondents. All the questionnaires administered to the respondents in this study were returned (100% return rate). This was possible because, the researcher, together with the research assistants went from one household to another soliciting response. This was necessary because some of the items in the questionnaire required the researcher to read loudly to the respondents, clarify ambiguities and make corrections on any misinterpretations. According to Mugenda and Mugenda (2003), any questionnaire return rate above 90% is considered representative enough for a study.

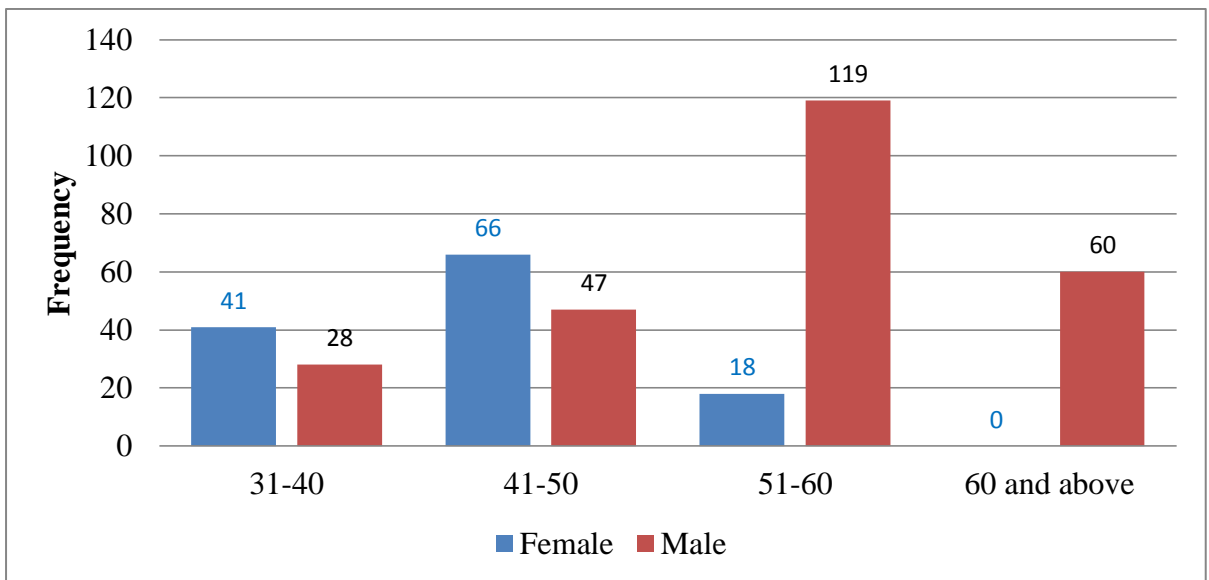
### **4.3 Demographic Information of Respondents**

This part deals with the demographic information of the respondents like age, gender and education level of respondents. It also looks at how these factors influence both food security and the adoption of apiculture in the division.

#### **4.3.1 Gender and Age Bracket of Household Heads**

The study established that, up to 67% of the respondents were males while females comprised 33%. The study also established that all the household heads were adults above 30 years of age. Majority of them were in the age brackets of 51-60 years and 41-50 years, while those in the age bracket 31 and 40 years constituted a small percentage. Those above 60 years of age were men only (Figure 4.1). The analysis also showed that some household heads were below 60 years of age implying that age was not a limitation to the adoption and practice of apiculture.

The findings also show that bee keeping was not a preserve of a particular gender as it was practiced by both men and women. This can be attributed to the fact that men are under normal circumstances, the heads of the family and hence bear the responsibility of fending food to their families. The small percentage of women practicing apiculture could be those who were separated, divorced or widowed, and hence were the sole breadwinners for their children.



**Figure 4.1: Household Heads Distribution by gender and age bracket**

To validate the above statement, a cross tabulation between the marital status and the reasons for practicing bee keeping was done. Table 4.1 below summarizes the responses obtained.

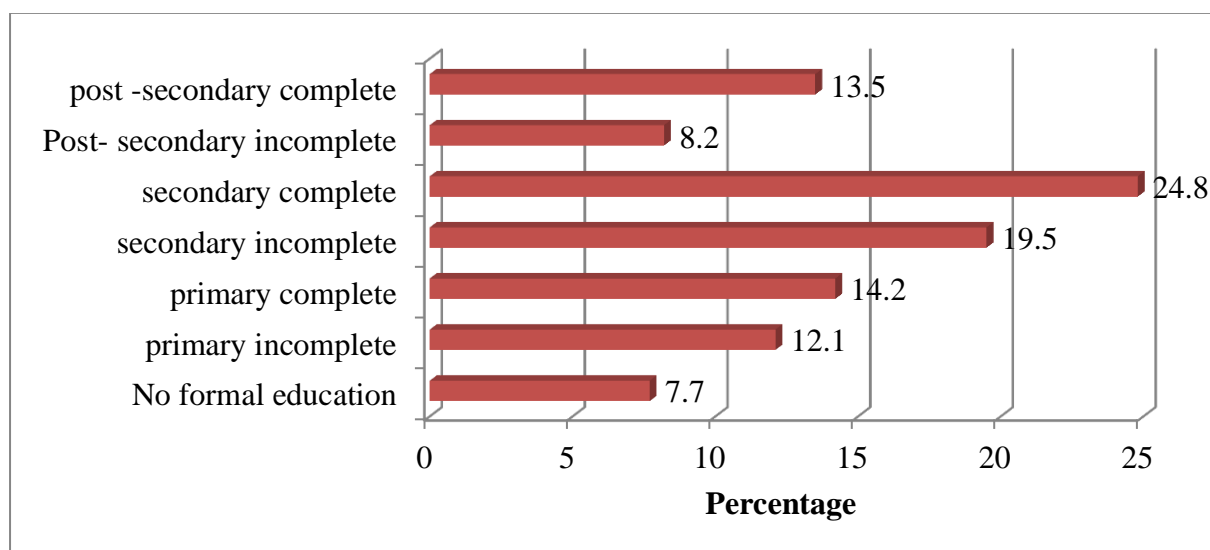
**Table 4.1: Cross-tabulation between the marital status of women and the reasons for bee keeping**

Marital Status	Reasons for bee keeping					Total
	Is a source of income	Is a source of food	To supplement other farming activities	Cheaper than tilling land	Conserves the environment	
Divorced	10	1	2	1	1	15
Separated	16	1	3	2	3	25
Widow	16	2	4	2	2	26

Majority of the women across the three marital status said that they practiced bee keeping as a main source of income. Other reasons given were; to supplement other farming activities, to conserves the environment, was cheaper than tilling land, and as a source of food in that order.

#### 4.3.2 Level of Education

Study findings revealed that less than half of the respondents had post- secondary education while majority had fully or partially completed their secondary and primary education respectively. This is shown in figure 4.2



**Figure 4.2: Level of Education of Household heads**

Source; Fieldwork

The analysis in Fig. 4.2 above suggests that, the level of illiteracy among household heads was low and this could boost the adoption of modern practices and technologies of apiculture. However, the fact that a good number of them had attained secondary and tertiary education means that, with little training and capacity building on aspects relating beehive types, modern harvesting techniques, honeys processing, storage, marketing and valuation, bee keeping could be up-scaled in Kathonzweni division.

Cross- tabulation between the age of the respondents and their levels of education showed that, majority of respondents with secondary education were between the ages of 31-40 years (27) and 41-50 years (15). Likewise, majority of those with post-secondary education (42) were below 50 years of age, while majority of those with primary and incomplete secondary education were between 41-50 years of age. More than three quarters of respondents with no formal education were above 50 years of age. The results of the cross-tabulation are captured in table 4.2 below.

**Table 4.2: Cross tabulation between the age and education of respondents**

Level of education	Age bracket				Total
	31-40	41-50	51-60	60 and above	
No formal education	7	0	15	7	29
primary incomplete	6	22	18	0	46
primary complete	9	26	6	13	54
secondary incomplete	0	42	9	23	74
secondary complete	20	6	65	0	94
Post-secondary incomplete	0	14	0	17	31
post-secondary complete	27	15	9	0	51
<b>Total</b>	<b>69</b>	<b>113</b>	<b>137</b>	<b>60</b>	<b>379</b>

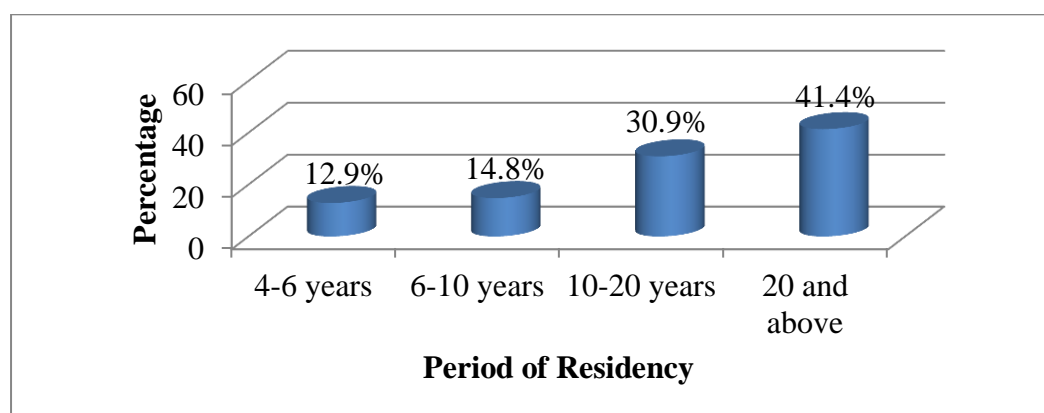
The levels of education of farmers influence their level of adoption of apiculture and up-take on new technologies. Most farmers had completed their secondary school education (94%) with 65% of them aged 51-60 years. At the same time, 15% of the 50-60 year old bee farmers had no formal education. According to of Mujuni and Natukunda (2008) more educated farmers were more likely to adopt beekeeping since education stimulates their acceptance of new technologies. He attributed this to increased knowledge, access to related information such as the right time for harvesting and improved understanding of the related best management technologies. Furthermore, Adgaba N, *et al*, (2014) noted that age and level of education positively influenced adoption decision of beekeeping training. They argue that most farmers who attend trainings are always young people below 35 years and have formal education and are predominantly from rural backgrounds with agriculture as their main occupation. However in the study area, apiculture is mainly practiced by the people aged 51-60 years and therefore the young people need to be encouraged to practice apiculture.

#### 4.3.3 Length of residency in the Division

The study established that, 30.9% and 41.4% of the respondents had been residing in the location for a period of 10-20years and 20 years and above respectively.

Only a small percentage (27.7%) had been there for a period less than ten years.

Figure 4.3 below summarizes the period of residency (in years) of the respondents.



**Figure 4.3: Period of residency in the Division**

Source; Fieldwork

Bee keeping has an incubation period stretching into years, hence, for close monitoring and maintenance of the hives and bees, one has to be a resident of the area. This means that any interventions that are put in place to uplift the standards of apiculture in the location can bear fruit, and can be sustained by longer period of time because majority of the farmers are permanent residents.

#### **4.4 Extent to which Apiculture is practiced in Kathonzwi Division**

The first objective of this study was to determine to what extent apiculture was practiced in Kathonzwi division. In so doing, the respondents were asked to state their major sources of income. From their responses, the study established that 34.2% of the people in Kathonzwi relied on animal and crop production as their main sources of income. Those who practiced apiculture constituted 25.8%, while the rest pegged their living from poultry farming (13.6%), wages/salaries from casual labour or formal employment (13.9%), and remittances from working members of the family (12.6%). Information from the key informant interviews in the division showed that, out of 379 households interviewed, only 98 (25.8%) practiced bee-keeping. The findings are summarized in table 4.3 below.

**Table 4.3: Sources of Income for Households in the study area**

Sources of income	Responses	
	N	%
1. Poultry keeping	136	13.6
2. Both animal and crop production	343	34.2
3. Apiculture	259	25.8
4. Salary/wages	139	13.9
5. Remittances from working family members	126	12.6
<b>Total</b>	<b>1003</b>	<b>100.0</b>

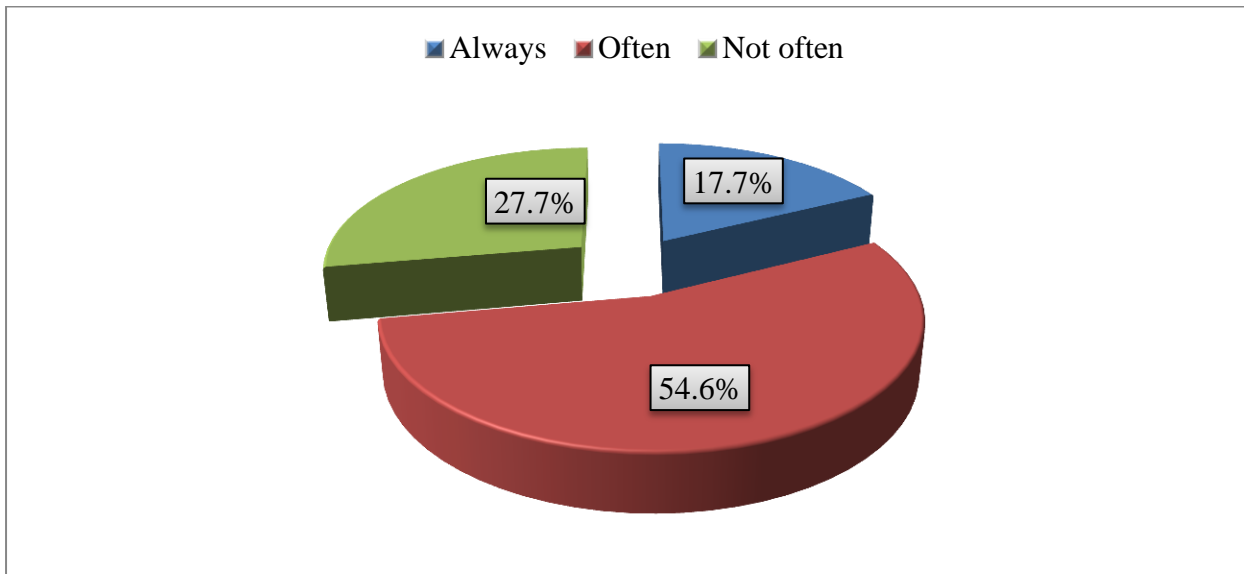
Source; Fieldwork

The findings in table 4.3, shows that bee keeping plays a significant role in as far as food security is concerned. According to Nightingale and Crane, (1983), apiculture can be practiced successfully in 80% of the country; more so in dryland areas where crop farming is difficult unless under irrigation. The findings of this study show that apiculture contributes to about 25.8% of all the farming activities in Kathonzweni division and thus the need to sensitise people on the importance of its adoption.

#### **4.5 Contribution of Apiculture to Food Security**

With two subsequent poor rainy seasons, the population facing acute food shortage in Kenya has risen to over 2 million up from 1.25 million in January 2017. This is according to National Disaster Management Authority (NDMA). The mostly affected counties are: Garissa, Isiolo, Kilifi, Kwale, Lamu, Mandera, Marsabit, Samburu, Tana River, Turkana, West Pokot and Wajir. The other 11 counties of the drylands are in the “alert” drought phase as drought situations are currently deteriorating.

The national government through the Hunger Safety Net Programme (HSNP), in conjunction with the county governments is assisting with relief food, water, fodder distribution and monthly money transfers to around 100,000 households in the drought stricken counties. An assessment of food insecurity situation in Kathonzweni division revealed that, food insecurity often occurred in the area. This was as attested by 54.6% of the respondents. 17.7% of them felt that food scarcity was a daily affair, while 27.7% said that food shortage occurred less often. Fig. 4.4 below presents these findings.



**Figure 4.4: Frequency of Food Insecurity in Kathonzwani Division**

Source; Fieldwork

The data in Fig. 4.4 suggest that, food insecurity was rampant in Kathonzwani division. The participants of the focus group discussions attributed this scarcity to unreliability of rainfall; continuous planting of trees that are not drought resistant, and poverty of the people who cannot afford other alternative means of livelihood.

**Table 4.4: Yearly quantity of honey harvested, sold and the income generated**

Farmer	Quantity of pure honey harvested (kg)	Quantity of pure honey sold (kg)	Income generated in Ksh.
1	88	60	15000
2	200	120	30000
3	92	65	16250
4	75	50	12500
5	122	80	20000
6	55	40	10000
7	60	30	7500
8	84	70	17500
9	40	25	6250
10	73	60	15000
11	50	45	11250
12	105	90	22500
13	65	45	11250
14	96	90	22500
15	48	40	10000
<b>N=15</b>	<b>1253</b>	<b>910</b>	<b>227500</b>

Source; Fieldwork

From the data in the table 4.4, it follows that a kilogram of honey sells for as much as Ksh.250 which is far much more than a kilogram of most crop and animal products. This means that, the practice of apiculture could be a game changer in as far as food security is concerned. Most farmers sell their honey individually especially to people during market days and a few sell their honey in supermarkets. The honey that is not sold is consumed at household level as food or in dowry payment. However, the farmers face a challenge in selling individually because of the low prices offered to their unprocessed honey or poorly processed honey.

The members of the focus discussion group were in acceptance that, the serious bee keepers in the division had remained food secure throughout the year unlike those who relied on other crop and animal farming. To add more evidence to this statement a comparison between the income from bee keeping and land tilling was performed.

The respondents were presented with statements on a five point scale of 1-Strongly Agree, 2-Agree, 3-Not Sure, 4-Disagree and 5-Strongly disagree, against which they were to rate. Table 4.5 below presents the means and the standard deviations of the responses

**Table 4.5: Comparisons between bee keeping and land tilling as income sources (N=379)**

Statement	Min.	Max.	Mean	Std. Dev
1. Bee keeping has better income than tilling the land	1.00	4.00	1.7942	.91424
2. Tilling the land has better income than bee keeping	2.00	5.00	4.1979	.86703
3. Both bee keeping and land tilling have almost the same income	2.00	5.00	4.0950	.95477

From the means of the responses, it is evident that, many of the residents either agreed or strongly agreed with the fact that bee keeping had better income than tilling of land (mean=1.7942). This is because, from the rating key, 1 represents strong agreement. The respondents however were in disagreement with the statements that tilling the land had better outcome than bee keeping (mean=4.1979) and that both bee keeping and land tilling had almost the same income (mean=4.0950).

The key informants also affirmed that bee keepers were more food secure than non-bee keepers because animal and crop production were generally doing poorly in the area as a result of unreliable rains. Nyangito et al. (2004) noted that, food shortage is linked to lowered agricultural production and general poverty. Muyanga, (2004) also observed that, rural people in the dry lands of Kenya such as Kathonzwi, experience resource constraints, which bring about low farm production, non-farm incomes and thus, high food shortage levels. The poor and those experiencing food shortages in general have limited economic resource and therefore have base few options for improving their incomes either from their farming activities or away from their farming activities.

A cross tabulation between the average monthly income from apiculture and the income from other sources showed that, apiculture had relatively higher and reliable monthly income. This was as attested by 41 respondents who indicated that apiculture netted between Ksh 30,000-40,000 per month as compared to the income from both animal and crop production. Other sources of income e.g. salaries/wages and remittances could not attract as much income as apiculture. Table 4.6 below summarizes the results obtained.

**Table 4.6: Cross tabulation between sources of Household income and total monthly earning**

<b>Earning/month</b>	<b>Sources of Household Income</b>				<b>Total</b>
	Both animal and crop production	Apiculture	Salary/wages	Remittances	
2001-5000	27	0	0	0	<b>27</b>
5001-10000	7	38	0	7	<b>52</b>
10001-20000	28	88	20	7	<b>143</b>
20001-30,000	23	27	35	7	<b>92</b>
30001-40000	24	41	0	0	<b>65</b>
<b>Total</b>	<b>109</b>	<b>194</b>	<b>55</b>	<b>21</b>	<b>379</b>

**Source;** Fieldwork

It emerges from the analysis in Table 4.6 that, majority of people in the division relies highly on farming; - whether crop, animal or bee keeping. It is also clearly evident that, the income from apiculture as stand-alone supersedes the income from other sources. The findings concur with that of Mbae (2000) who observed that the beekeepers earned Kshs.7.2 Million annually from the sale of honey; as compared to Kshs.6.6 million annual incomes from livestock, and crop farming in the same geographical area. This shows that bee keeping is quite profitable and a reliable source of income. This is why, when asked why they practised apiculture, 30.4 % of respondents said that it was a viable source of income; 29.9 % said that they did it to supplement other farming activities, 23.7 % preferred it because it was more economical than tilling the land, 6.7% do it for food, while 9.3 % do it as a way of conserving the environment. Similar sentiments were posted by the key informants who were particularly in harmony to the fact that, bee keepers had land which was better conserved than non-bee keepers. Table 4.7 below summarizes the above findings.

**Table 4.7: Reasons why farmers practice apiculture**

<b>Reason</b>	<b>Frequency</b>	<b>Valid %</b>	<b>Importance Rank</b>
1. Is a source of income	59	30.4	1
2. Is a source of food	13	6.7	5
3. To supplement other farming activities	58	29.9	2
4. Cheaper than tilling land	46	23.7	3
5. Conserves the environment	18	9.3	4
<b>Total</b>	<b>194</b>	<b>100</b>	

**Source;** Fieldwork

From the table, the reasons why farmers practise bee keeping can be summarised into two, i.e. for economic purposes and environmental conservation. Gidey and Mekonen, (2010) opinion is that, beekeeping generally supports very many households in Sub-Saharan Africa. Pretty et al. (2005), also observes that bee hives are hung on to of trees means that, means that as many trees as possible are required and this promote afforestation. Bee keeping requires good vegetation for the requirements of nectar, hence need to avoid deforestation. Fernandes (2006) further argues that, unlike other farming systems that require chemical reinforcements such as fertilizers, pesticides, and etc. bee keeping thrive by nature hence do not contribute to environmental pollution.

#### **4.6 Challenges facing the adoption of apiculture**

From the analysis of honey samples, the quality of honey from Kathonzweni division was generally found to be of good quality. However, not all parameters analyzed conformed exactly to the optimal standards of the European Union. The study therefore sought to find out some of the constraints affecting the quality of honey, and bee keeping in general. On this regard, the respondents were asked to state their level of agreement or disagreement with some statements on a five point scale of 1-Strongly Agree, 2-Agree, 3-Not Sure, 4-Disagree and 5-Strongly Disagree. The analysis of the results is in table 4.8 below.

**Table 4.8: Challenges Facing Apiculture in Kathonzwani Division (N = 379)**

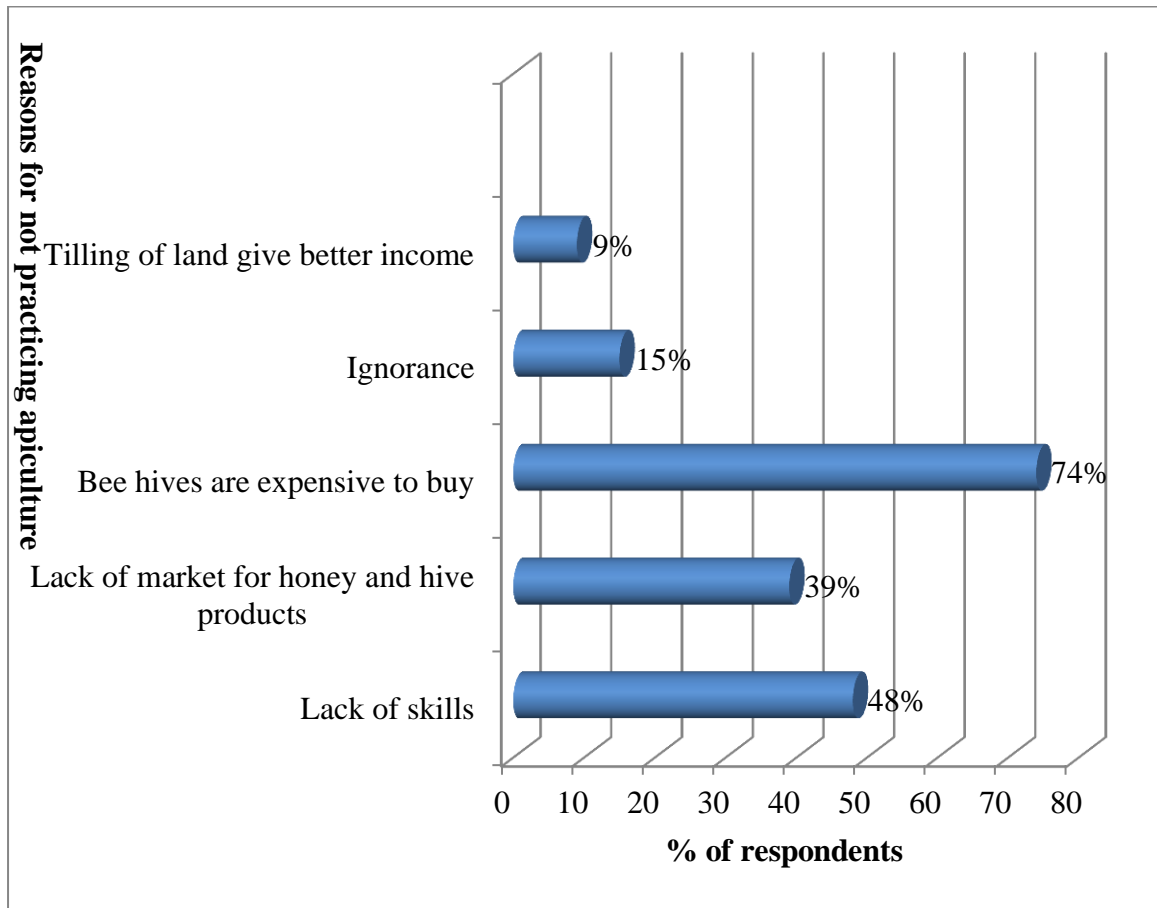
<b>Challenge</b>	<b>Min.</b>	<b>Max.</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Importance</b>
1. There is poor market for honey and hive products	2.00	5.00	3.6834	1.10315	3
2. Most farmers lack skills on bee keeping	1.00	5.00	2.5594	1.30467	4
3. Bee hives are expensive to buy	1.00	5.00	2.3536	.99286	5
4. Prolonged dry season affect bee keeping	1.00	4.00	1.8813	1.02825	8
5. Bee hives are often attacked by honey Badgers	1.00	4.00	2.2507	1.09253	7
6. Honey harvesting is difficult	2.00	5.00	3.8892	.99648	2
7. There is no enough sensitization on bee keeping	1.00	4.00	2.0290	.91530	6
8. Tree species for nectar collection are not locally available	2.00	5.00	3.9710	1.00090	1

**Source;** Fieldwork

From table 4.8 many of the respondents strongly agreed with the statement that prolonged dry season affected bee keeping (mean=1.8813). They were also in agreement with the statements that, most farmers lack skills on bee keeping (mean=2.5594), bee hives are expensive to buy (mean=2.3536), there was no enough sensitization on bee keeping (mean=2.0290), and that, bee hives were often attacked by honey badgers (mean 2.2507). They however seemed to have had mixed reactions on the statements that, there is poor market for honey and hive products (mean=3.6834), honey harvesting is difficult (mean=3.8892) and that, tree species for nectar collection are not locally available (mean=3.971).

According to the key informants interviewed, and the participants of the focus group discussions, the major challenges facing the quality of honey were poor harvesting methods which result in the mashing of honey, pollen, honey combs and dead bees; excess smoking which changes the flavor of honey; lack of processing machines, and poor storage methods. The general constraints to successful adoption of apiculture were low sensitization of the farmers on the importance of bee keeping, high prices of bee hives and their accessories, un-coordinated market for honey and hive products, and lack of adequate skills on bee keeping. These findings mirror those from a study by Lim (1994), who observed that, the main challenges facing bee farmers in developing countries in the tropics are lack of income, shortage of the right technical know-how, inadequate information on right local or regional markets, and the absence of relevant processing technologies for product variety.

When asked why most farmers were not practicing bee-keeping in the division, 74% of the respondents said that bee hives were expensive to buy; 48% blamed it on lack of skills on bee keeping by farmers; 39% attributed it to lack of market for honey and hive products, 15% blamed ignorance of farmers, while 9% thought that tilling of land gave better income than bee keeping. Fig. 4.5 below summarizes the findings.

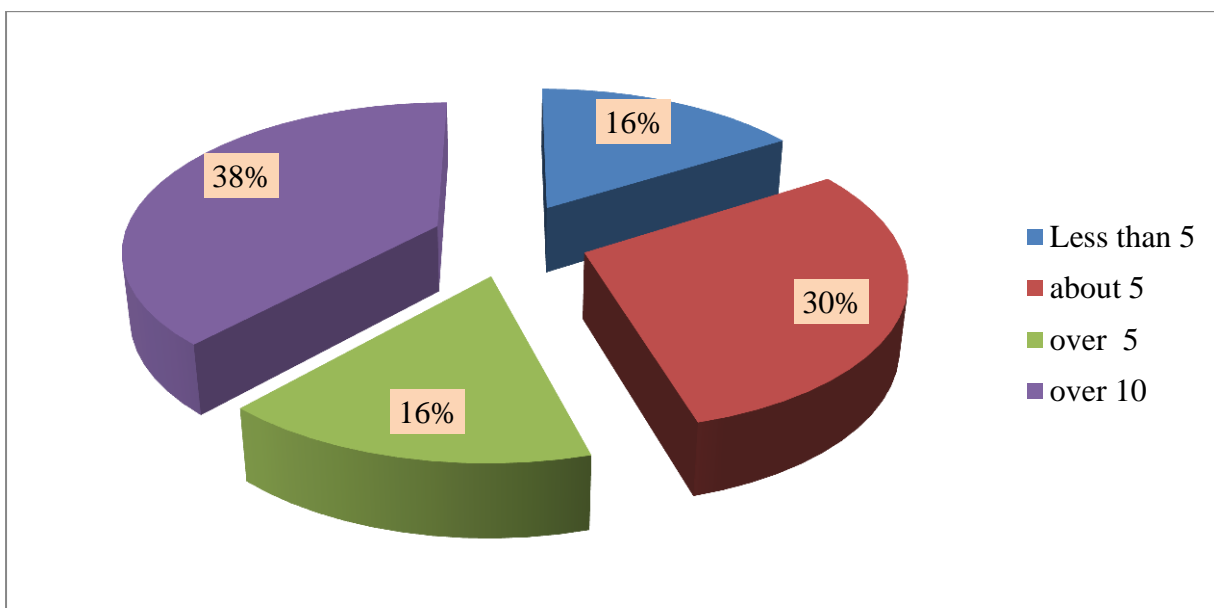


**Figure 4.5: Reasons why some farmers do not practice apiculture**

**Source;** Fieldwork

It is evident from the responses in figure 4.5 that, the residents of Kathonzwani location do not deliberately refuse to practice apiculture but rather because of numerous capital, social or economic constraints facing them. According to studies by Gebreyohannes (2010), financial assets that significantly influence adoption of beekeeping are farmers' income, savings, access to credit, farm structures and access to beekeeping equipment/tools, access to credit eases the production and marketing processes by facilitating the purchase of tools, equipment, packaging materials and transport to the market. Lack of start-up capital to buy beehives, inefficient technologies, inadequate knowledge, environmental depletion and low production are some of the major constraints negatively affecting the adoption by prospective beekeepers (Jiwa, 2005; Muga, 2011). This means that, given necessary support through the addressing of the above concerns and coming up with other interventions, then apiculture can become the solution to the problem of food shortage in the division.

The study went further to establish whether the size of land could be a limiting factor in the adoption of apiculture. In so doing, the respondents were asked to indicate the average sizes (in hectares) of the land they owned, and from the findings, 38% of households owned more than 10 hectares of land; 30% had about 5 hectares while 16% of households had just over or less than five hectares. Figs 4.6 summarize the results.



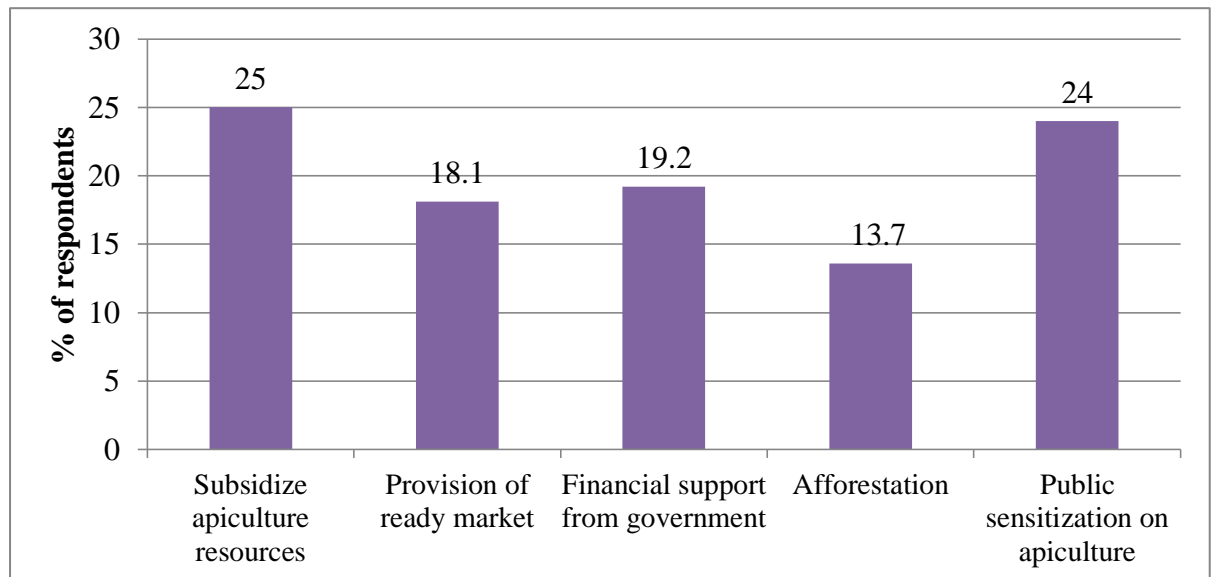
**Figure 4.6: Size of land (in hectares) owned by households**

**Source;** Fieldwork

Given that bee keeping does not require a very large space, then land size is not a major hindrance to the adoption of apiculture in Kathonzweni division. Bekele (2015) established that land is the main natural capital influencing bee farming. He observed that, the amount of land owned, the quality of land and the presence of land investments are all considered during adoption process. Generally, farm sizes have ambiguous relationship with adoption rates of most agricultural technologies depending on the characteristics of the technology and the institutional setting. Apiculture is an agricultural activity that needs little or no land except a space to hang a bee-hive, very little labour, no much capital and much of the other requirements can be obtained locally (Crane, 1985; FAO, 1986; Rubio, 2001). This means that, the size of farm is not significant in affecting the practice of apiculture.

#### 4.7 Strategies for Scaling up Apiculture

The fourth and last objective of this study was to identify strategies that could be put in place in order to promote the practice of bee keeping as a sustainable source of income and livelihood to the people of Kathonzweni division. 25% of the respondents suggested that the prices of apiculture resources such as beehives needed to be subsidized. Another 24.0% felt that the general public should be sensitized on the benefits of apiculture. Other recommendations given include the provision of ready market (18.1%), financial support from government (19.2%) and afforestation (13.6%). The responses given are summarized in Fig. 4.7 below



**Figure 4.7: Suggestions on how to improve apiculture**

**Source;** Fieldwork

Responses from the focus group discussions suggested that, buyers in the honey industry in the area felt that, apiculture had very good potential in the area but there was need for farmers to obtain honey extraction machines to improve the quality of honey. They also advocate for good coordination in the marketing of honey and other hive products. While still on the same issue, the researcher read some statements to the respondents and asked them to rate the statements based on a scale of 1-Strongly Agree, 2-Agree, 3-Not Sure, 4-Disagree and 5-Strongly Disagree to represent their level of agreement or disagreement with them. Table 4.9 below represents a summary of the responses in terms of their frequency, mean and standard deviations.

**Table 4.9: Strategies for improving Apiculture in Kathonzwi Division (N=379)**

Statement	Min.	Max.	Mean	Std. Dev
1. Public sensitization on bee keeping will improve bee keeping	1.00	4.00	1.8364	1.02851
2. Provision of ready market will improve bee keeping	1.00	4.00	1.9446	1.05137
3. Subsidizing on hive prices will improve bee keeping	1.00	4.00	1.9420	.92113
4. Provision of credit facilities will improve bee keeping	1.00	4.00	2.1187	.97544

**Source;** Fieldwork

As evidenced by the means of the responses, apiculture will fully be adopted and appreciated by farmers in Kathonzwi division if public sensitization on bee keeping is done to farmers (mean=1.8364), ready market for honey and hive products is provided (mean=1.9446), hive prices are subsidized (mean=1.9420), and credit facilities are provided to the farmers (mean=2.1187). On their part, the key research informants and the participants of the focus group discussions unilaterally suggested subsidization of bee hive costs provision of sustainable water supply, co-ordination of honey marketing channels, and public sensitization of the people on bee keeping through seminars, workshops or public barazas, as the viable strategies to up-scale apiculture in the division.

The above suggestions resonate with those of Tadesse (2011) in Addis Ababa, Ethiopia, who revealed that the availability of information and knowledge about the related skills required for bee farming are vital in the beekeeping adoption process. According to the study, some of the key sources of information that positively influenced adoption process comprised of fellow farmers, meetings, and social media and extension officers. Furthermore, addressing trade/marketing constraints in beekeeping such price fluctuations and lack of grading systems, absence of organized market channels, low involvement of the private sector in market development and lack of appropriate technologies for processing and packaging bee products were found to up-scale the productivity of honey and honey products (Gallai *et al*, 2009).

#### 4.8 Honey Quality Analysis Results

Honey quality analysis results show the average of three trials for moisture content, free acidity, sugars, PH, and hydroxymethylfurfural (HMF) as shown below in table 4.10

**Table 4.10: Summarized results from qualitative analysis of ten honey samples**

Quality Parameter	Average of Run 1	Average of Run 2	Average of Run 3	Mean of Samples
HydroxyMethylFurfural (HMF) in mg/100g	13.615	14.593	14.467	14.228
Sugar (Brix) Content in g/100g of Honey (%)	91.34	91.26	91.2	91.258
Moisture Content <i>(measured using Refractive index)</i>	8.66	8.74	8.8	8.731
PH Value at 23.5°C	3.801	3.794	3.805	3.7996
Free Acidity in Meq/kg	47.331	45.224	46.769	46.672

Source: Fieldwork

Statistical analysis (Means and Standard deviations) was carried out by the use of Microsoft Excel Statistical Packages and obtained the following average results as shown in table 4.11

**Table 4.11: Results of Physicochemical Analysis of Kathonzweni honey (N=10)**

Parameter	Mean value	Min – Max values	Limits of EU standards	Samples exceeding limits of EU standards
HMF mg/kg	14.23	5.17 – 19.83	Max.40	not detected
Water % (moisture)	8.7	7.3-9.9	Max. 20	not detected
Free Acidity meq/kg	46.67	30.64 – 53.01	Max. 50	3 samples
Frcts + Glcs %	91.25	89.80 – 92.66	Min. 60	Not detected
Ph	3.8	3.4-4.2	3.9	4 samples

The Physical-chemical results were then compared with International Regulatory Standards (Bogdanov *et al.*, 1999) as shown in table 4.12 below.

**Table 4.12; Honey Standard of the Codex Alimentarius and EU Honey Directive.**

Composition Criteria	Value
<b>Sugar Content</b>	-not less than 60g/100g
Fructose and glucose content(sum of both)	-not less than 45g/100g
-blossom honey	
-honeydew honey, blends of honeydew and blossom honey	
<b>Sucrose</b>	-not more than 5g/100g
-in general	-not more than 10g/100g
-false acacia( <i>Robinia pseudoacacia</i> , Alfalfa( <i>Medicago sativa</i> ), Banksia( <i>Banksia menziesii</i> ), French honeysuckle( <i>Hedysarum</i> ), Red gum( <i>Eucalyptus carmadulensis</i> ), leatherwood( <i>Eucryphis lucida</i> , <i>Eucryphis milliganii</i> ), Citrus spp	-not more than 15g/100g
-Lavender( <i>Lavandula spp.</i> ), borage( <i>Borago officinalis</i> )	

<p><b>Moisture Content</b></p> <ul style="list-style-type: none"> <li>-in general</li> <li>-heather(<i>Calluna</i>), EU,CA;baker's,EU</li> <li>-baker's honey from heather(<i>Calluna</i>), EU</li> </ul>	<ul style="list-style-type: none"> <li>-not more than 20%</li> <li>-not more than 22%</li> <li>-not more than 25%</li> </ul>
<p><b>Electrical conductivity</b></p> <ul style="list-style-type: none"> <li>-honey not listed below, and blends of these honeys</li> <li>-honeydew honey and chestnut honey and blends of these except of those listed below</li> <li>-exceptions;strawberrytree(<i>Arbutus unedo</i>),bell heather(<i>Erica</i>) manuka or jelly bush(<i>Leptospermum</i>),tea tree(<i>Melaleuca spp</i>)</li> </ul>	<ul style="list-style-type: none"> <li>-not more than 0.8mS/cm</li> <li>-not less than 0.8mS/cm</li> </ul>
<p><b>Free acidity</b></p> <ul style="list-style-type: none"> <li>-in general</li> <li>-Baker's honey(EU Directive)</li> </ul>	<ul style="list-style-type: none"> <li>-not more than 50meq/kg</li> <li>-not more than 80meq/kg</li> </ul>
<p><b>Diastase activity*(Schade units)</b></p> <ul style="list-style-type: none"> <li>-in general;except baker'shoney(EU)</li> <li>-Honey with low natural enzyme content(e.g citrus honey) and an HMF content of not more than 15mg/kg</li> </ul>	<ul style="list-style-type: none"> <li>-not less than 8</li> <li>-not less than 3</li> </ul>
<p><b>HMF</b></p> <ul style="list-style-type: none"> <li>-in general; except baker's honey(EU Directive)</li> <li>-Honey of declared origin from regions with tropical climates and blends of these honeys</li> </ul>	<ul style="list-style-type: none"> <li>-not more than 40mg/kg</li> <li>-not more than 80mg/kg</li> </ul>

\*-determined after processing and blending

The physico-chemical properties from the 6 honey samples (60 %) studied completely agree with the European Commission and the Codex Alimentarius showing adequate processing, good maturity and freshness. Four samples (40 %) did not meet characteristics established in European and Codex standards. Moisture was low, with an average value of 8.73% and the hydroxymethylfurfural (HMF) content was quite low between 5.16 and 19.83mg kg<sup>-1</sup>. Moisture, HMF and free acidity values showed good maturity. Results from this study, indicate that honey produced in Kathonzweni division show fairly good quality characteristics as per the international standards although it requires some improvement as only 60% of the studied samples are fully compliant. The 40% of the samples that did not meet the standards (Codex Alimentarius) was mainly due to poor harvesting and storage methods.

#### **4.8.1 Specific Sugars (fructose/glucose) Value**

The specific sugars are identifiable sugars in honey such as fructose, glucose, sucrose, maltose, melezitose, maltotriose and raffinose. For blossom honeys (Honey from nectars of plants) the sum of fructose and glucose should be within the minimum permitted limit of 60% (Codex Alimentarius Commission, 2001). All the tested samples of the honey fall under the EU limit standards of 60% minimum percentage with the samples ranging from 89.80%-92.66%. This therefore means that the % content of specific sugars in the honey is good for local consumption and export.

#### **4.8.2 PH and free acidity values**

The pH of honey is important during the extraction and storage as it determines its texture, stability and shelf-life (Terrab *et al.*, 2002). The acidity of honey is as a result of the presence of gluconic acid, formic acid, oxalic acid and lactic acid (Nanda *et al.*, 2003). The recommended pH value is usually 3.9 (IHC, 2002). Only 3 free acidity values are over the right limit of 50 meq/ kg. Difference in free acidity in different honeys could be as a result of floral origin or difference in harvest season (El-Sherbiny and Ritzk, 1979; Pérez- Arquillué *et al.*, 1994). The average free acidity value obtained was 46.67 meq/kg.

#### **4.8.3 The measure of HMF content**

It is used to determine honey freshness. The EU standards show a limit of not more than 40 mg/kg for HMF. In the 10 samples studied, the HMF content is low at 14.23 mg/kg on average and none exceeded the limit of 40 mg/kg.

#### **4.9 Participatory Transect Survey**

The distribution of bee farmers including the status of the hives was mapped and documented as (Appendix 7.6). As per the distribution of bee farmers in the division, the 3 transect walks show that most bee farmer households are near the rivers and tributaries and so is the location of beehives. The main reason for such location of both the beehives and households is for the bees to be able to have easy access to water and to be away from human/animal disturbance. Most of the bee farmers in the division make use of traditional beehives with a few making use of the modern beehives. This is attributed to high prices of the modern beehives.

## **CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS**

### **5.1 Summary of Findings**

This study sought to evaluate the status of apiculture and how to increase its adoption in order to improve food availability and environmental management in drought prone Kathonzweni division in Makueni County. It was guided by four objectives which were; to assess the extent to which apiculture is practiced, to establish the relative contribution of apiculture to food security and environmental conservation, to examine the challenges facing the adoption of apiculture, and to identify measures for scaling up the adoption of apiculture. The study adopted the use of descriptive survey design, and the target population comprised of household heads and key informants in Kathonzweni division.

The study had a sample of 387 respondents; comprising 379 household heads, 3 focus groups, 1 agricultural extension officer, 1 non -governmental organization and 3 CBO heads. The sample size for the household heads was arrived at using the table for determining sample size as suggested by Darley and Robert (1970). Automatic inclusion was used for the agricultural extension officer, while purposive sampling was used for the focus groups and the CBO heads. The study utilized both qualitative and quantitative data.

Quantitative data was gathered using questionnaires for the households while qualitative data was gathered from qualitative tools or instruments such as; participatory transect surveys (Transect walk), focus group discussions and key informant interviews. The questionnaires were administered to the 379 households and were intended to solicit information, opinions and perceptions about the study objectives at the household level. The questionnaires were administered in person by the researcher with the help of research assistants trained on effective data collection procedures. The study relied on key informant interviews to capture the right information, especially the technical information about the study topic. The key informants were represented by the ministry of agriculture at the local level, local NGOs and CBOs heads.

Through data analysis the study established that, those people who practiced apiculture constituted 25.8%. The rest relied on animal and crop production (34.2%), poultry farming (13.6%), wages/salaries from casual labour or formal employment (13.9%), and remittances from working members of the family (12.6%). Information from the key informant interviews showed that, out of 379 households interviewed, only 98 practiced apiculture.

Regarding the contribution of apiculture to food security, the study first did an establishment of the state of food insecurity in the area and found that, food insecurity often occurred in the area. This was as attested by 54.6% of the respondents. 17.7% of them felt that food scarcity was a daily affair, while 27.7% said that food shortage occurred less often. The participants of the focus group discussions attributed this scarcity and unreliability of rainfall; continuous planting of trees that are not drought resistant, and poverty of the people who cannot afford other alternative means of livelihood. Approximately 1253kg of honey are harvested each year; out of which 910kg were sold in the local market. This attracted approximately Ksh. 227,500 per year, and between Ksh 30,000-40,000 per month. The proceeds were then directed towards the purchase of foodstuffs.

A comparison between land tilling and apiculture showed that, majority of the respondents agreed that bee keeping had better income than tilling of land (mean=1.7942). They however disagreed with the statements that tilling the land had better income than bee keeping (mean=4.1979) and that both bee keeping and land tilling had almost the same income (mean=4.0950). The key informants also affirmed that bee keepers were more food secure than non-bee keepers because animal and crop production were generally doing poorly in the area. When asked why they practised apiculture, 30.4 % of respondents said that it was a viable source of income; 29.9 % said that they did it to supplement other farming activities, 23.7 % preferred it because it was more economical than tilling the land, and 6.7% do it for food, while 9.3 % do it as a way of conserving the environment. Similar sentiments were posted by the key informants who were particularly in harmony to the fact that, bee keepers had land which was better conserved than non-bee keepers.

An examination of the challenges facing bee farming revealed that, majority of the respondents strongly agreed with the statement that prolonged dry season affected bee keeping (mean=1.8813). They however thought that, most farmers lacked skills on bee keeping (mean=2.5594), bee hives are expensive to buy (mean=2.3536), there was no enough sensitization on bee keeping (mean=2.0290), and that, bee hives were often attacked by honey badgers (mean 2.2507). They also seem to have disagreed with the statements that; there was poor market for honey and hive products (mean=3.6834), honey harvesting was difficult (mean=3.8892) and that, tree species for nectar collection were not locally available (mean=3.971). According to the key informants interviewed, and the participants of the focus groups, the major challenges facing the quality of honey were poor harvesting methods which resulted in the mashing of honey, pollen, honey combs and dead bees; excess smoking which changes the flavour of honey; lack of processing machines, and poor storage methods.

When asked why most farmers were not practicing bee-keeping in the division, 74% of the respondents said that bee hives were expensive to buy; 48% blamed it on lack of skills on bee keeping by farmers; 39% attributed it lack of market for honey and hive products, 15% blamed ignorance of farmers, while 9% thought that tilling of land gave better income than bee keeping. From the findings, 38% of households owned more than 10 hectares of land; 30% had about 5 hectares while 16% of households had just over or less than five hectares. Given that bee keeping does not require a very large space, then land size was not a hindrance to the adoption of apiculture in Kathonzweni division.

The study also did an assessment of the measures required to promote the adoption and sustenance of apiculture. Several suggestions on possible measures were also presented to the respondents and the means of their responses were obtained. From the means, it was evidently clear that, for apiculture to be fully adopted and appreciated by farmers in Kathonzweni division, the farmers must be equipped with knowledge on bee keeping (mean=1.8364); ready market for honey and hive products be provided (mean=1.9446), hive prices should be subsidized (mean=1.9420), and credit facilities to the farmers should also be provided (mean=2.1187).

On their part, the key research informants and the participants of the focus group discussions agreed that there should be; subsidization of prices of essential apiculture resources such as beehives (25.0%), sensitization of general public on the benefits of apiculture (24.0%), provision of ready market for honey and other beehive products (18.1%), financial support from government (19.2%) and afforestation of the land (13.6%).

The study analyzed the physicochemical characteristics of 10 honey samples whereby, 6 honey samples (60 %) studied completely agree with the European Commission and the Codex Alimentarius showing enough processing, good maturity and freshness. However, 4 samples (40 %) did not meet characteristics established in Codex Alimentarius standards as a result of poor harvesting and storage methods. Moisture (water content) was low, with an average value of 8.73%. The hydroxymethylfurfural (HMF) content was quite low and was between 5.16 and 19.83mg kg<sup>-1</sup>. Moisture, HMF and free acidity values show good maturity. Results obtained in this study, show that honey produced in Kathonzwani division is of good quality according to international standards.

## **5.2 Conclusions**

Food insecurity is a problem that is mostly experienced in areas with declining agricultural potential like Kathonzwani division. From the discussions and evidences provided by the analysis of data, a small portion of farmers in Kathonzwani division practice apiculture. The most dominant practice was crop production. Others include poultry farming, remittances from working members of the family and wages/salaries from casual labour or formal employment. An almost total dependence on crop and livestock farming in high risk areas make residents not able to withstand natural disasters like drought. Bee keeping, with its proven income viability, environmental conservation and nutritional cum medicinal benefits, could therefore be used to remedy the situation. Beekeeping offers direct and indirect benefits to the people.

Directly, beekeeping substantiates household income from hive product sales, provides food, safe medicines and raw materials for industries. These income benefits have been reported to have high impact among marginalized and small income earners such as women, orphans and other vulnerable groups within the society. Indirectly, beekeeping contributes to water shed-management, forest conservation and crop pollination which improve quality, quantity and market value of food crops; thus honeybees are central in ensuring food security.

From the data on the money obtained from the sale of honey, it was evident that honey could fetch a lot of income; only that the supply is limited and the beneficiaries are few (only the bee keepers). A kilogram of honey sold for as much as Ksh.250 which was far much more than a kilogram of most crop and animal products. This meant that, the practice of apiculture could guarantee food security if well utilized and managed. Study findings have clearly shown that, serious bee keepers in the division remained food secure throughout the year unlike those who relied on other crop and animal farming.

It also emerged that, the general constraints to successful adoption of apiculture were; low sensitization of the farmers on the importance of bee keeping, high prices of bee hives and their accessories, unco-ordinated market for honey and hive products, and lack of adequate skills on bee keeping. It is also clear that, the residents of Kathonzwi division do not deliberately refuse to practice apiculture but because of the numerous capital, social or economic constraints facing them. This means that, if appropriate measures are taken, e.g. subsidization of prices of essential apiculture resources such as beehives, financial support from government and other agencies, provision of credit facilities to the farmers, sensitization of farmers on the benefits of apiculture, and provision of ready market for honey and other beehive products; then apiculture can easily be adopted and embraced as a main contributor to food availability and environmental conservation in the area. Sustainable and available extension service will be needed to improve the bee farmers know how on honey quality characteristics, better harvesting, processing and storage methods. Studies on Kathonzwi division honey should look into the local bee flora which has to some extent being affected by climate change.

### **5.3 Recommendations**

In order to increase adoption and benefits of beekeeping in Makueni, this study recommends that:

- Essential bee keeping equipment such as bee hives, smokers be made available, accessible and affordable to farmers. This can be made possible through public-private partnerships between government agencies and Non-Governmental organization. This will ease financial pressure on the farmers, and enable more farmers to practice apiculture
- Trade constraints in beekeeping such price fluctuations, lack of grading systems, absence of organized market channels, low involvement of the private sector in market development and lack of appropriate technologies for processing and packaging bee products need to be addressed by relevant government agencies so as to up-scale the productivity and sale of honey and honey products
- Sensitization of farmers and general public on importance of bee keeping to food security and environmental conservation. This can be done through seminars, workshops or public barazas, so as to bridge the existing production and marketing knowledge gaps. Additionally, beekeepers should be trained on how to produce optimally even with farming systems that integrate crop production with beekeeping. With increased access to ready markets and production knowledge, future honey production will be increased.
- Destruction of vegetation cover in the process of preparing land for cultivation should be discouraged. Instead, afforestation should be encouraged as bees rely on nectar from flowers to make honey. Furthermore, vegetation cover acts as a catchment for rain, and also helps maintain soil moisture.

#### **5.4 Suggestions for Further Research**

The study evaluated apiculture in the context of food security and environmental management without considering other factors which would influence the projects other than factors investigated in this study. Notable areas not investigated included social economic factors and environmental factors. Social economic factors may reveal how the community has managed to cope with food insecurity and the influence of free reliefs on community commitment on food security interventions. This study therefore recommends other studies that will look into;

- (i) How social economic factors and environmental factors affect in success of food security and environment conservation efforts
- (ii) How government policies in place affect success of food security and environment conservation in the division.
- (iii) Why fewer women are practising apiculture.

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## APPENDICES

### Appendix 1: Questionnaire for household heads

#### Instruction

Kindly tick against your preference in the boxes provided

<b>1) Questionnaire identification number (for official use only)</b>				<b>001</b>
<b>Demographics</b> <i>(Please complete this part fully by ticking where applicable) 002)</i> <b>Age</b>	<b>003) Gender</b>	<b>004) Marital status</b>	<b>005) Main occupation</b>	<b>006</b> <b>Classification of earning per month</b>
<i>a) 15 – 23                      b) 23- 30                      c) 31-40                      d) 41-50                      e) 51-60                      f) 60-above</i>	<i>a) Female                      b) Male</i>	<i>a) Married                      b) Single                      c) Divorced                      d) Separated                      e) Widow                      f) Other                      (specify</i>	<i>a) Farmer (subsistence)                      b) Farmer (large scale)                      c) Business person                      d) House wife                      e) Student                      f) Professional worker                      g) Skilled artisan                      h) Jobless</i>	<i>a) Less than 2,000                      b) 2,001-5,000                      c) 5,001-10,000                      d) 10,001-20,000                      e) 20,000-30,000                      f) 30,001-40,000                      g) 40,001 and above</i>
<b>007) Level of education</b>	<b>008) How many people live in this household?</b>	<b>009) How many hectares of land do own</b>	<b>010) Main water source</b>	<b>011) Length of residency</b>

<p>a) <i>No formal education</i></p> <p>b) <i>Primary incomplete</i></p> <p>c) <i>Primary complete</i></p> <p>d) <i>Secondary incomplete</i></p> <p>e) <i>Secondary complete</i></p> <p>f) <i>Post-secondary incomplete</i></p> <p>g) <i>Post-secondary complete</i></p>	<p>a) <i>Less than 5</i></p> <p>b) <i>More than 5</i></p> <p>c) <i>More than 10</i></p> <p>d) <i>Any Other(specify )</i></p> <hr/>	<p>a) <i>Less than 5</i></p> <p>b) <i>About 5</i></p> <p>c) <i>Over 5</i></p> <p>d) <i>Over 10</i></p> <p>e) <i>Any Other (specify)</i></p> <hr/>	<p>a) <i>Tap</i></p> <p>b) <i>Communal tap</i></p> <p>c) <i>Well/borehole</i></p> <p>d) <i>River/stream</i></p> <p>e) <i>Other (specify)</i></p> <hr/>	<p>a) <i>1 yrs</i></p> <p>b) <i>2 yrs</i></p> <p>c) <i>3 yrs</i></p> <p>d) <i>4-6 yrs</i></p> <p>e) <i>6-10 yrs</i></p> <p>f) <i>10-20 yrs</i></p> <p>g) <i>20-above</i></p>
<p><b>1.</b></p>	<p><b>How often is food secure throughout the year?</b></p>			<p><b>012</b></p>
<p>a) <i>Always</i> <input type="checkbox"/></p> <p>b) <i>Often</i> <input type="checkbox"/></p> <p>c) <i>Not often</i> <input type="checkbox"/></p> <p>d) <i>Never</i> <input type="checkbox"/></p>				
<p><b>2.</b></p>	<p><b>What are sources of income for your household?</b></p>			<p><b>013</b></p>

	<p>a) <i>Crop production</i> <input type="checkbox"/></p> <p>b) <i>Animal production</i> <input type="checkbox"/></p> <p>c) <i>Poultry keeping</i> <input type="checkbox"/></p> <p>d) <i>Both crop and animal production</i> <input type="checkbox"/></p> <p>e) <i>Apiculture</i> <input type="checkbox"/></p> <p>f) <i>Salary /wages</i> <input type="checkbox"/></p> <p>g) <i>Remittances(specify source)</i> <input type="checkbox"/></p> <p>h) <i>Others(specify)</i> <input type="checkbox"/></p>	
<b>3.</b>	<p><b>If you practice bee keeping, what is the main reason for bee keeping?</b></p>	<b>014</b>
	<p>a) <i>Source of income</i> <input type="checkbox"/></p> <p>b) <i>Source of food</i> <input type="checkbox"/></p> <p>c) <i>Prestige</i> <input type="checkbox"/></p> <p>d) <i>Supplement other farming activities</i> <input type="checkbox"/></p> <p>e) <i>Cheaper than tilling the land</i> <input type="checkbox"/></p> <p>f) <i>Conserves the environment</i> <input type="checkbox"/></p>	
<b>4.</b>	<p><b>If you do not practice bee keeping, what is the main reason?</b></p>	<b>015</b>
	<p>a) <i>Lack of skills</i> <input type="checkbox"/></p> <p>b) <i>There is no market for honey and hive products</i> <input type="checkbox"/></p> <p>c) <i>Bee hives are expensive to buy</i> <input type="checkbox"/></p> <p>d) <i>Ignorance</i> <input type="checkbox"/></p> <p>e) <i>Tilling the land gives better outcome</i> <input type="checkbox"/></p> <p>f) <i>Any other(specify)</i> <input type="checkbox"/></p>	

5	<b>In your opinion, how can bee keeping be improved in this area?</b>	<b>016</b>
	<p>a) <i>Subsidized apiculture resources</i> <input type="checkbox"/></p> <p>b) <i>Provision of ready market</i> <input type="checkbox"/></p> <p>c) <i>Financial support from the government e.g. loans</i> <input type="checkbox"/></p> <p>d) <i>Afforestation</i> <input type="checkbox"/></p> <p>e) <i>Public sensitization on apiculture</i> <input type="checkbox"/></p> <p>f) <i>Any other(specify)</i> <input type="checkbox"/></p>	
6	<b>I am now going to read out the following statements and would like you to tell me to what extent you agree or disagree with them.</b>	<b>017</b>
	<p><b>1. Strongly agree, 2. Agree, 3. Not sure, 4. Disagree, 5. Strongly disagree</b></p> <p>a) <i>Bee keeping has better outcome than tilling the land</i> <input type="checkbox"/></p> <p>b) <i>Tilling the land has better outcome than bee keeping</i> <input type="checkbox"/></p> <p>c) <i>Both bee keeping and tilling the land practices have almost equal income</i> <input type="checkbox"/></p> <p>d) <i>Any other (specify)</i> <input type="checkbox"/></p>	
7	<b>I am now going to read out the following statements and would like you to tell me to what extent you agree or disagree with them.</b>	<b>018</b>
	<p><b>1. Strongly agree, 2. Agree, 3. Not sure, 4. Disagree, 5. Strongly disagree</b></p> <p>a) <i>There is poor market for honey and hive products</i> <input type="checkbox"/></p> <p>b) <i>Most farmers lack skills on bee keeping</i> <input type="checkbox"/></p> <p>c) <i>Bee hives are expensive to buy</i> <input type="checkbox"/></p> <p>d) <i>Prolonged dry season affect bee keeping</i> <input type="checkbox"/></p> <p>e) <i>Bee hives are often attacked by honey badgers</i> <input type="checkbox"/></p> <p>f) <i>Honey harvesting is difficult</i> <input type="checkbox"/></p> <p>g) <i>No enough sensitization on bee keeping</i> <input type="checkbox"/></p>	

	<i>h) Tree species for nectar collection not available locally</i>	
<b>8</b>	<b>I am now going to read out the following statements and would like you to tell me to what extent you agree or disagree with them.</b>	
	a) <i>Public sensitization on bee keeping will improve the bee keeping</i> b) <i>Provision of ready market will improve bee keeping</i> <input type="checkbox"/> c) <i>Subsidizing on hive prices will improve bee keeping</i> <input type="checkbox"/> d) <i>Provision of credit facilities will improve bee keeping</i> <input type="checkbox"/> e) <i>Any other(specify)</i> <input type="checkbox"/>	

## **Focus Group Discussion Guide**

- 1) How long have you been living in this division?
- 2) What is your main livelihood activity/activities and what is your food security status throughout the year?
- 3) What is the main cause of food insecurity in this area?
- 4) What is the food security status of bee farmers in your area compared to non-bee farmers?
- 5) In your opinion, can adoption of apiculture in this area improve food security?
- 6) What makes most farmers not to practice bee keeping for income and food security?
- 7) Why do farmers in this area continuously till the land every season despite crop failure?
- 8) How do you compare environmental conservation in bee keeping farmers and non-bee keeping farmers?
- 9) In your opinion, what measures are needed to improve adoption of bee keeping in this area?

## **Key Informant Interview Questions**

1. For how long have worked in this area?
2. How many farmers in your area of operation practice bee keeping?
3. How would you rate apiculture practice in your area of operation?
4. How can the above stated situation be improved?
5. What can you say about apiculture in your area of operation in terms of food security improvement and environmental conservation?
6. What main challenges are there in apiculture practice in your area of operation?
7. How can the above stated challenges be overcome?
8. In your opinion, why is apiculture practice so low in your area of operation?
9. In general terms, how would you compare the outcome/food security from apiculture practice to that of tilling the land in your area of operation?
10. In your opinion, what measures are needed to improve adoption of bee keeping in this area?

## Appendix 2: Table on Sample Sizes

*Table for Determining Sample Size from a Given Population*

<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size.  
*S* is sample size.

*Source: Daryle and Robert (1970): Determining Sample size for Research Activities; Educational and Psychological Measurements. University of Minnesota, Duluth*

### Appendix 3: Participatory Transect Survey Diagram

