ASSESSMENT OF PERFORMANCE INDICES OF FRAME HIVE BEEKEEPING AND THE TRADITIONAL TECHNOLOGY IN KENYA

A CASE STUDY OF KITUI COUNTY

BENEDICT M. WAMBUA

(BSc. Agricultural Education and Extension)

A THESIS SUBMITTED TO THE DEPARTMENT OF DRY LAND AGRICULTURE IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL RESOURCE MANAGEMENT

SCHOOL OF AGRICULTURE AND VETERINARY SCIENCES

SOUTH EASTERN KENYA UNIVERSITY (SEKU)

KENYA

APRIL, 2015

DECLARATION

This thesis is my original work and has not been submitted to any other University for Award of a degree. All sources of information have been acknowledged.

________________ ___________

Wambua Benedict Mwendwa Sign Date

This thesis has been submitted for examination with our approval as University supervisors:

______________ _____________

Prof. Nashon K.R. Musimba, Sign Date

Department of Range & Wildlife

South Eastern Kenya University

______________ ______________

Dr. Elliud Muli, Sign Date

Department of Biological Sciences

South Eastern Kenya University

DEDICATION

This work is dedicated to my wife, Bridgid and my sons, Pascal Kiema, Brian Mumo and Brown Ndinda.

ACKNOWLEDGEMENTS

I first acknowledge the support and guidance from my competent supervisors Prof. Nashon K.R. Musimba and Dr.Elliud Muli without whom this study would not have come to a successful conclusion. Their comments, suggestions and constructive criticism throughout the entire period of my study are highly appreciated. My appreciation is extended to the former Dean School of Agriculture and Veterinary Sciences, Prof. Titus. I. Kanui and the academic staff for organizing the seminars, Chairman of the Department, Dry Land Agriculture, Dr. Benjamin Muli and all the staff for their support and encouragement. I cannot forget to thank my colleagues at Kyangunga Secondary School for their constant encouragement particularly when the going became rather tough. Special regards to Miss. Grace Muthoka for assisting in proof reading and editing this document. I am especially grateful for the support and cooperation from my classmates during the study period.

I thank the community members of the different self-help groups for volunteering information on beekeeping activities that they carry out. Also, I wish to acknowledge the support from the officers from the Ministry of Livestock Development in the areas where I conducted the survey. My sincere appreciation goes to Mr. James Muthoka the assistant District Livestock Production Officer (DLPO), Kitui Central District for freely providing his wealth of experience in beekeeping. Last but not least, I sincerely thank my wife Brigit and our children; Pascal, Brian and little Brown whose love and support, contributed to making the study possible. Thank you for cheerfully enduring the stress that occasionally arose as a result of the involvement and demands of my study. May the grace of our Lord be with you.

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ASAL	Arid and Semi-Arid Lands
DF	Degrees of freedom
DLPO	District Livestock Production Officer
EU	European Union
FAO	Food and Agricultural Organisation
GIS	Geographical Information System
GoK	Government of Kenya
GDP	Gross Domestic Product
ICIPE	International Centre of Insect Physiology and Ecology
KNBS	Kenya National Bureau of Statistics
KTBH	Kenya Top Bar Hive
MOLD	Ministry of Livestock Development
MT	Metric Ton
NBS	National Beekeeping Station
NGO	Non-Governmental Organization
SHG	Self-Help Group
SPSS	Statistical Package for Social Sciences
TLH	Traditional Log Hive
TLUs	Tropical Livestock Unit
UK	United Kingdom
USA	United States of America

ABSTRACT

The study was conducted to assess the performance indices of frame hive beekeeping technology. The objectives were to establish the factors influencing the adoption of frame hives within selected beekeeping groups in Kitui County and compare honey production and household incomes among beekeepers using frame and traditional hives. Data were collected through formal interviews by way of a structured questionnaire, in four locations of Kitui County. Systematic random sampling was applied to a selected 30 households each in four locations giving a total of 120 households.

Sixty nine out of the 120 respondents, representing 58% of the respondents were beekeepers, an indication that beekeeping was an important socio-economic undertaking in the area. Out of those who were beekeepers, about 65% of them relied on fixed combs, traditional, log hives of which beekeepers make individually, receive as gift or inherit, while the remaining 35% were using modern technology with mainly the langstroth hives. A number of factors determined the choice of beekeeping technology in the study area including the cost, availability, management regime of a particular type of technology, productivity level and quality of the products. The results revealed that honey production was high with traditional hives compared with Langstroth hives. Subsequently, beekeepers using traditional methods earned high incomes than those using modern technology. Further analysis using binary logistic regression techniques indicated that the gender of a household head, size of a household, size of land holding and access to extension services influenced the adoption of beekeeping technology.

A number of constraints that affected the adoption of the entire beekeeping technology were identified and they included recurrent droughts, attack by pests and predators, low prices, insecurity (theft and vandalism) and inadequate extension services. From the findings of this study, it is recommended that focused extension training should be provided to beekeepers to equip them with the necessary skills on bee management. Appropriate packages targeting women and the youth need to be developed in an effort to encourage modern beekeeping by these groups. Strengthening the capacity of the existing farmer groups and associations in beekeeping activities can increase production.

CHAPTER ONE

1 INTRODUCTION

1.1 Background information

Beekeeping is an old art in Kenya that has been practiced since time immemorial by most communities. In the old days, the production of honey was a major industry in the African economy (Nightingale, 1976). Honey was a vital commodity in the African culture and was used in many ways as an article of trade. In Kenya, the local bee race is nomadic and aggressive. Bees are found in habitats ranging from forests to deserts and flourish in areas where there is sufficient pollen, nectar, shelter and water to fulfill the needs of the colony. They only experience difficulties related to weather in rainforests where humidity and the rains keep them sheltering most of the time (Jones, 1999).

Beekeeping contributes to incomes as well as food security through provision of honey, beeswax and pollen as food and propolis, bees' venom and royal jelly in medicine in addition to pollination services. Beekeeping supports millions of household livelihoods in Sub Sahara Africa (Gidey and Mekonen, 2010). Honey has for centuries been one of the most highly desired commodity among the hunter-gatherer communities, it is the only readily available sweetening agent and tradable commodity. Hive products have been used by mankind for centuries. For instance, bee brood is traditionally eaten as a high protein food while beeswax is used in candle making. Other hive products are now used in the pharmaceutical and cosmetic industries. For instance, propolis is now widely used in apitherapy for its anti-viral and anti- bacterial properties. Pollen on the other hand has found its way to some health food outlets as a protein rich commodity (Paterson, 2006).

Beekeeping has immense benefits in terms of provision of pollinators, which enhance crop yield. It is estimated that one in every three bites of food we eat is a result of pollination of plants in which bees play a very important part (Caroll, 2006). Adequate pollination leads to better quality seeds and fruits and is essential for sustaining biodiversity. Bradbear (2002) observed that although pollination is difficult to quantify, it is the most economically significant value of beekeeping. Pollinators provide critical ecosystem services for agriculture world- wide. Statistics point out that, 60-90% of the world's flowering plants depend on insects for pollination (Buchamann and Nabhan, 1996). The total value of insect pollination to global agriculture is estimated at € 153 billion per year, representing 9.5% of the value of world's agricultural production which was used for human food in 2005 (*Gallai et al., 2009*). Protein content in bean increased from about 17-23% to 19-25% and the sunflower oil increased by 35-45% if insect pollinated. In Africa, native honey bees (*Apis mellifera)* of several different races pollinate 40-70% of indigenous plants, some of which are important in providing micronutrient and phytochemical rich fruits, vegetables and nuts, (Allsopp, 2004). The honey harvested from bee's colonies serves as an important source of nutrition and income for families.

Over the years, however, beekeeping has developed in various aspects and is now an important component of the livestock sector particularly in the arid and semi arid areas. The honey and beeswax production in Kenya is currently estimated at 14,653 and 140 metric tons, respectively, with an estimated total value of Kshs.4.43 billion. The country's potential for apiculture development is estimated at over 100,000 MT of honey and

10,000 MT of beeswax. At the moment only about one fifth of this potential is being exploited (GoK, 2008).

The beekeeping industry contributes to the wider rural economy through trade (Paterson, 2006). Kigatiira (1976) noted that the beekeeping industry in Kenya is worth millions of shillings and plays an important role in the economy of arid areas. The Livestock sub-sector in Kenya of which bees are part, contributes about 10% of Kenya's GDP. Beekeeping alone contributes about 1.89% of this amount (Muya, 2004).

Beekeeping is a family level exercise which has some distinct advantages over other agricultural activities (Crane, 1976). For instance, beekeeping requires very little financial and labor input. It is a flexible and gender friendly enterprise which does not compete for resources such as land with other agricultural activities. Beekeeping is possible in arid areas and places where other crops have a higher chance of failing (Bradbear, 2002), hence a suitable activity where people need to restore their livelihoods or create new opportunities especially the rehabilitation of degraded dry lands.

Honey is used as medicine (treat open wounds and burns, stomach ailments and veterinary medicine). For example, it is used to treat foot and mouth diseases and as food. It is also a non- perishable rich source of energy, which is used in drought and famine prone areas when food is scarce. Honey is also used in the brewing of traditional honey beer (*kaluvu*), which is valued in marriages, and initiation rituals and other traditional ceremonies.

1.2 Statement of the problem

The majority of Kenyan beekeepers still use the traditional systems of beekeeping such as simple hollow log hives. In the last fifteen years improved hives such as Kenya Top Bar and Langstroth frame have been introduced from Europe and America. There is conflicting information between the actual performance of improved hives and their claim of success by its promoters. Information gathered in a number of recent studies indicates limited impact on enhanced production of bee products and on the improvement of livelihoods. Documentation of the adoption rate is scanty, whereas production trends of honey and beeswax data in relation to the improved technology is lacking, yet it needs to be availed so as to assist in policy guidelines. Incomes or returns from sales of bee products are less known, hence the essence of ascertaining the quantity and quality of the honey sold and marketed. This study therefore seeks to assess the performance variables of frame hive technology of beekeepers in Kitui County.

1.3 Justification of the study

Africans have kept bees for millennia, using simple technology like log hives. These technologies were deemed `not fit’ to meet current demands for honey in terms of quality and quantity, hence improved hives were introduced. However, there are limited studies on the determination of the impact of improved hives on livelihoods (income) and production (both quantity and quality), (Gichora, 2003). The recent study of Baringo District in Kenya sought to determine the adoption rate of Kenya Top Bar Hive (KTBH) after nearly fifty years of government involvement in beekeeping improvements. The study found that retention rates or adoption of KTBH use were extremely low, and that many beekeepers were utilizing traditional beekeeping methods while attempting to use the hive (Gichora, 2003).

There are many lingering questions concerning the benefits of modern hive adoption, yet efforts to promote modern technology in Kenya remain unabated. After a fifty- year history of development focused on the introduction and THE use of modern hives, limited evaluations have been undertaken to establish if those efforts were worthwhile. Again questions such as: Is there sufficient data available to draw conclusions about modern hive superiority? Are improved hives increasing honey production? Do beekeepers have access to accessories and necessary skills to manage these hives? To what extent has the success and failures of the technologies been documented and used to advice policy makers? All these questions are yet to be addressed. Therefore, this study sought to investigate the above questions on beekeeping technology in Kenya using a case study of Kitui County.

1.4 Objective of the study

1.4.1 Broad objective

The overall objective of this study was to investigate the performance indexes of frame hive technology on beekeeping production relative to traditional hives in Kitui County, Kenya.

1.4.2 Specific objectives

1. Establish the factors influencing the adoption of frame hives within selected beekeeping groups in Kitui County.
2. Compare honey production and household incomes among beekeepers using frame and traditional hives.

1.4.3 Research questions

1. What are the factors influencing adoption of frame hives beekeeping and the traditional technology in selected beekeeping groups in Kitui County?
2. What is the difference in honey production and income levels among beekeepers using frame and traditional hives?

1.5 Study limitations

This study focused on assessing the performance of frame hive beekeeping technology by sampling beekeepers in four locations in the study area. Due to resource limitations the study was not repeated. In this regard, the results may not entirely be representative of the whole county or the entire country due to the sample size. Similarly, most of the data collected were based on the recall ability of the respondents who may not have given very accurate information. However, the research recommendations may as well be applicable to other areas having similar ecological and socio-economic characteristics.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 History of beekeeping development in Kenya

Beekeeping in Kenya is a traditional art which started since time immemorial with traditional hives playing an important role in the production of honey. The development of modern beekeeping in Kenya was initiated in the late 1960s and has progressively become an important component of livestock sub- sector, particularly in the arid and semi- arid areas where other forms of agriculture production cannot be sustained effectively. Bee keeping is carried out at the rural household level as a part-time income generating activity. Most honey is still harvested from traditional log hives. However, a reasonable amount of hive products is obtained from Kenya Top Bar and Langstroth hives.

There are over 20,000 species of bees in the world all of which belong to the super family-*Apoidea.* Most of them lead solitary lives. A few bees however are social, leading to community life in a colony (Jones, 1999). Social bees make honey which is their food store but *Apinae* (honey bee) and *Meliponinae* (stingless bees) are the only two sub-families that produce more honey than they need, making it worthwhile to keep them for honey production. Further more, *Apis* is the only genus in the *Apinae* sub-family among whose species *Apis mellifera*is of greatest economic importance. The two dominant African races of *A. mellifera* and *A. m. scutellata* found in East Africa (Ethiopia to Southern Africa) while *A. m. adonsonii* found in West Africa. Both species are smaller compared to the European honey bee, and their colonies have more swarms.

As in many other countries of the world where honey bees (*A. mellifera)* naturally occur, some Kenyan communities have had a long history of harvesting honey from the wild or in traditionally managed colonies. The most well known of these communities include those living in and around Mt. Kenya, Aberdare Ranges and Mau Escarpment. Others live in the plains as pastoralists and gather honey from extensive woodlands. Honey has been the most important hive product in all cases. By 1982, the tropics produced 13% of honey in the world market, the subtropics 30%, mostly from Argentina, China and Mexico while temperate regions produced 57% (Bradbear, 1985).

The effort to improve Kenyan apiculture began in 1967 through an Oxfam grant that funded their very first beekeeping development project. In 1970 the Kenyan Government, along with financial and technical aid from the Canadian Government, established a new apiculture section (The National Beekeeping Station) within the Kenyan Ministry of Agriculture. The new branch would pursue the development of Kenyan beekeeping through extension services, research development, and the professional training of Kenyan beekeepers (Kigatiira, 1976). It is at this point in time that western beekeeping technology and knowledge was introduced to Kenyans. Current trends in development remain focused on the improvement of the hive technology and beekeeping training as the first and foremost approach.

The dominant trend in beekeeping development is the endorsement of improved hive technology, be it the Langstroth hive or the Kenya top bar hive (KTBH). However, the adoption and diffusion of beekeeping equipment is certainly not pursued without some significant degree of resistance and failure. The majority of beekeepers still use traditional systems of beekeeping; simple fixed combs, mostly hollow log hives, in spite of 30 years of beekeeping extension carried out by the government and non-government organizations (NGOs) to promote improved hives such as the KTBH, which is an intermediate technology hive. In the last fifteen years there has been a major push by some NGOs and private companies, supported by major donors, to introduce Langstroth frame used in Europe and America. There is conflicting information between the actual impact of these hives and the claim of success by its promoters. Information gathered in a number of recent studies indicates limited impact on enhanced production of bee products and an improvement of livelihood (income). In relation to bee product marketing, research indicates that the Kenyan honey market is under developed due to low volumes. Quantity and quality levels to warrant export have not been achieved. The domestic production is far below the local demand.

2.2 Decision making and technology adoption

Technology adoption is a decision making process in which an individual goes through a number of mental stages before making a final decision to adopt an innovation. Decision making is the process through which an individual passes from acquiring knowledge of an innovation, forming an attitude towards an innovation, decision to adopt or reject implementation of the new idea and confirmation of the decision (Ray, 1999).

Within the farm household, the ability to make decisions regarding resource use and technology adoption varies according to age, gender and other categories. The actual decisions can depend on a complex bargaining process among household members. Beyond the household, group processes and the ability to harness them can also play a crucial role in adoption decisions. Moreover, decisions about new technology are frequently prompted by an intervention in the form of a project (Cramb, 2003).

Lionberger, (1960) noted that the decision to adopt usually takes time. Normally people do not adopt a new practice or idea as soon as they hear about it. They go through a series of distinguishable stages which include awareness, interest, evaluation, trial and adoption. Another classification of innovation decision making is given by Rogers, (1983) who identifies five stages, i.e. knowledge, persuasion, decision, implementation and confirmation.

A new technology alone does not guarantee a wide spread adoption and efficient use (Ehui *et al*., 2004). For efficient utilization of the technology, the fulfilment of specific economic, technical and institutional conditions are required. From the farmers' economic perspective, the new technology should be more profitable than the existing alternatives. Technically, the new technology should be easy to manage and adapt to the surrounding socio-cultural situations. Similarly, the availability of the new technology and all other necessary inputs at the right time and place and in the right quantity and quality should be ensured. In addition, the socio-economic and other demographic factors of a farmer may influence the farmer's decision of either adopting a given technology or not. Hence, the farmer's observed adoption choice for an agricultural technology is likely to be the result of a complex set of interactions between comparable technologies and the farmer's socio-economic and demographic factors.

Wetengere, (2010) observed that when a technology is introduced in a given area, the choices available to farmers are not just adoption or rejection. Some parts of a technology or modification and re-invention may be options too. Farmers' choice whether to adopt an entire package of a recommended technology or just some parts of a technology is influenced by the following factors according to;

- The availability of household resources.
- The degree to which the technology is appropriate for the farmer's farming environment.
- Economic motivation.
- Farmers' characteristics (e.g. belief and gender).
- The farmers' objective for undertaking the activity.

2.2 Review of selected past studies on determination of technology adoption

Many studies on the adoption of agricultural technologies have been undertaken in various disciplines in different parts of the world. Most of these studies however have tended to focus on the adoption of improved technologies such as improved seed varieties, use of fertilizer, soil and water conservation methods but have used variables similar to those used in this study.

In studies on determinants of agricultural technology adoption conducted in Mozambique, Uaiene *et al.*, (2009) reported that households with access to credit and extension advisory services as well as members of agricultural associations are more likely to adopt new agricultural technologies. Households with higher levels of education are also more likely to adopt. Mwanthi (2009) carried out a survey on rangeland resource management technology adoption among agro pastoral households in south eastern Kenya and found out that participation in project activities, gender of household head, and managerial skills had a positive significant effect on adoption. Type of information source and education level of household head had a negative significant effect on adoption.

Research on the determinants of adoption of a recommended package of fish farming was conducted in selected villages in eastern Tanzania (Wetengere, 2010). Access to resources is a key factor that determines the adoption of a recommended package of a technology and farmers allocate resources to activities which contribute to household food and income security. Farmers are likely to adopt a complete package of a recommended technology if household resources such as land, labor, cash income, knowledge and other inputs like feeds, fertilizers, water and seeds are forthcoming from the existing farming system.

Factors influencing adoption of conservation tillage in Australian cropping regions were evaluated by D'Emden *et al. (*2008). Perceptions associated with shorter-term crop production benefits under no-till, such as the relative effectiveness of pre-emergent herbicides and the ability to sow crops earlier on less rainfall were influential. Increased extension activities were also strongly associated with no-till adoption. A study on the determinants of adoption of improved box hive in the Tigray region of Ethiopia, Workneh (2007) found out that use of credit, perception, the education level of household head and practical knowledge of the technology positively influenced adoption.

Demeke (2003) studied the factors influencing adoption of soil conservation practices in north western Ethiopia and observed that farm size and perceptions of benefit from conservation measures positively and significantly affected farmers' decision to adopt conservation structures. The distance of a plot from the homestead, availability of off-farm employment and tenure insecurity were found to be significant and influenced the farmers' adoption decision negatively. Studies on the factors influencing the adoption of improved maize and fertilizer technologies were carried out in Embu District, of Kenya (Ouma *et al., 2002*). Analysis of the results using maximum likelihood estimation logistic regression model indicated that the agro-ecological zone, gender, use of manure and hiring labor influenced adoption.

Degu *et al.* (2000) carried out studies on the adoption of seed and fertilizer packages and the role of credit in smallholder maize production in Sidama and north Omo zones, Ethiopia. The analysis of factors affecting the adoption of improved maize showed that number of tropical livestock units (TLUs), agro- ecological zone, extension services, use of credit, and membership of an organization all significantly influenced the probability of adoption. Significant factors affecting the adoption of fertilizer were off-farm income, the use of hired labor, credit and being a contact farmer.

Makokha *et al.,* (1999) carried out studies on farmers' perception and adoption of soil management technologies in western Kenya and found out that farmers' characteristics such as participation in field days and demonstration, attendance at workshops, seminars and contact with extension workers, and leadership position have significant influence on perception and hence adoption decisions. In their study of adoption of agricultural innovation in developing countries, (Feder *et al*., 1985) have listed the factors that influence technology adoption as credit, farm size, risk, labor availability, human capital and land tenure. The authors too note that education can also directly facilitate technology adoption, by increasing access to information about alternative market opportunities and technologies.

2.4 Beekeeping technologies in kenya

2.4.1Traditional Technology

Majority of beekeepers in Kenya still use traditional production systems which comprise mainly hollow log hives (Caroll, 2006). These hives constitute the largest number of hives in the country estimated at 1,273,000 with 73% of the hives concentrated in the eastern part of the country (Muya, 2004). Other traditional hives include the bark hives made of bark that has been peeled from the trunk of a tree. Traditional honey harvesting is normally undertaken at night and it sometimes involves stripping naked before climbing the trees on which the hives are hanging (Paterson, 2006). However, there are advantages and disadvantages to using traditional style log hives. The commonly cited advantages include; (a) inexpensive to construct due to low initial input, (b) made from local materials, (c) high beeswax production, (d) requires little management or time investment, (e) placement in tree protects hive from predators, (f) skills in place, passed from generation to generation thus no need for training, according to (MacOsore, 2005, Frazier, 2011, Cheng'ole, 2008). Table 2.1 shows recorded honey and beeswax production in Kenya between 1998 and 2002.

Table 2.1: Recorded honey and beeswax production in Kenya

Product	1998	1999	2000	2001	2002
Honey(MT)	24,265	25,120	24,940	24,940	22,000
Beeswax(MT)	2,426	2,412	2,494	2,394	2,200

Source: FAO data base 2004

However, development organizations often pay more attention to the disadvantages of log hives and cite the following drawbacks; (a) produce lower yields of honey (approximately 5 - 15 kg/hive/harvest), (b) quality of honey is poor; often includes brood and debris, (c) harvesting is difficult as it requires beekeeper to climb the tree, (d) bees abscond and swarm more often, (e) poor harvesting technique can result in death of the colony. A variety of indigenous hard wood tree species are used in making of traditional hives. The common ones include *Terminalia brownie, Delonix alata, Cordia africana* and *Albizia gumnifera.* The hives are made of pieces of logs measuring 1.0 to1.5m. They can be of uniform diameter or sometimes narrowing towards one side with the walls made as thin as possible in order to reduce overall weight of the finished product (Nightingale, 1976). In communities like the Kamba and their close neighbors living in eastern Kenya, the whole log is hollowed out from end to end. The openings at both ends are usually closed with wooden planks. One of the planks, normally at the narrower end is provided with bee entrances and fixed while the other is removable and has no entrance holes. This is the opening through which the beekeeper can access the inside of the hive during honey harvesting (Kigatiira, 1976), (Plate 1: Traditional bee hives).

Preparatory activities are necessary to ensure colonization as follows; after the hives are well seasoned, they are usually baited with suitable materials, e.g. beeswax, propolis or leaves of some plants like the *Ocimum kilimandscharium or Ocimum basilicum* before they are placed on trees. Hives are hanged either horizontally or at an angle. The Kamba beekeepers hang their hives at an angle in order to prevent any moisture resulting from condensation collecting at the bottom of the hive. The hives are placed such that the bee entrance faces away from the prevailing wind (Nightingale, 1976).

The traditional hives are placed high up on trees by means of a hooked pole or placing them between suitable tree branches and left to be occupied by wild swarms. Honey harvesting is normally done at night when bees are less aggressive. Hives can be worked up the trees or lowered to the ground by means of a rope. The honey is usually harvested away from the hives entrance. This is the end from which the harvesting starts, moving towards the opposite side. Smoke which has the effect of mollifying the usually aggressive bees is provided by a traditional torch made of dried bark or other suitable material. Once the honey has been removed, the hive is hoisted back to its place. Since this type of hive has only one chamber with fixed combs, the honey, wax, pollen and brood are all removed together during harvesting greatly compromising the quality of the final product. Table 2.2 shows honey seasonality production per region while, Appendices 3 a, b and c show hive population and production in Kenya for the years 2005, 2006 and 2007.

Table 2.2: Honey seasonality production per region

Regions	First honey flow Season	Second honey flow season
Eastern	April to July	November to January
Rift Valley	March to August	September to January
Western	March to August	October to January
Central	April to July	November to January
Coast	March to July	October to December
Nyanza	March to July	September to December
North Eastern	April to June	November to December
Nairobi	April to June	October to December

Source: Ministry of Livestock and Fisheries Development annual report (2004)

Very little or no routine colony management is practiced under the traditional system. Colony management is often limited to harvesting honey and rebating hives with suitable bee lures to enhance occupation. The harvesting method employed by traditional beekeepers may lead to the loss of a substantial number or bees thus reducing the size of individual colonies and the potential number of feral swarms. The marketable honey quantity is affected by quality, which in turn is affected by simple, sometimes crude methods in handling bees (Kigatiira, 1976).

Log hive

Assortment of traditional hives

Hanged log hives

Plate 1: Traditional bee hives

Photo: Wambua B.M. (2012)

2.4.2 Modern Technology

Modern beekeeping practice involves the use of improved technologies which are easy to manipulate and manage. The main types of hives used are the comb hives and the movable frame hives. Other accessories that go together with modern beekeeping include the catcher box, protective clothing, smoker, hive tool, bee brush and the honey extracting and refining equipment (Plates 2 and 3: Bee hive accessories). Some management practices are also considered as part of the improved beekeeping technology which includes seasonal management, routine colony inspection, colony division, artificial feeding and pest control.

Catcher box for Langstroth hive

Catcher box for KTBH

Fully dressed beekeeper in bee suit using a smoker

Plate 2: Bee hive accessories

Photo: Wambua B.M. (2012)

Bee smoker

Bee suit

Hive tool

Bee brush

Plate 3: Beehive accessories

Photo: Wambua B.M. (2012)

2.4.2.1 Movable – comb hives

The intervention of the movable comb hives is the work of the ancient Greek beekeepers that used a basket hive in which a series of bars were used to form the top of the hive (Mann, 1976). These hives are designed to allow the combs to be removed, inspected and returned back to the hive. The Kenya Top Bar Hive (KTBH) designed in the 1970s, is a modification of the Greek basket hive with movable, interchangeable top bars. The hive is basically a one chamber wooden box, with the side sloping inwards at an angle of 120 degrees to the horizontal. This design ensures that the bees do not attach comb to the sides of the hive (Plate 4: Kenya Top Bar Hive).

The hive accommodates 26 top bars which are 48cm long and 3.2cm wide with the underside fitted with a strip of the beeswax to act as a starter comb and guide bees in comb construction. The lid is made of a timber frame covered with a heavy gauge galvanized iron sheet. The KTBH has a number of advantages over the traditional log hive namely that; (a) Combs can be easily removed for inspection and returned to the hive, (b) Honey combs can be removed without interfering with the brood nest, (c) Honey quality is improved since pollen and brood combs are not included with the harvested honey, (d) Improved pest control, (e) The low hanging height makes it easier and faster to carry out various management operations. Despite these advantages, this technology has a number of weaknesses as highlighted below; (a) The attachment of the comb to the top bar is weak and breaks easily, (b) The hive can fill very fast during a good honey flow season leading to overcrowding and swarming of the colony since the volume of the hive is fixed, (c) Control of hive temperature is difficult leading to the low occupation rates in the ASAL due to frequent absconding.

Kenya top bar hive

KTBH hanged in cross pattern (National Beekeeping Station)

Plate 4: Kenya top bar hives

Photo: Wambua B.M. (2012)

2.4.2.2 Movable frame hives

These are the most advanced hives in design and are used by commercial beekeepers in many part of the world (Patterson, 2006). The first movable frame hive was designed by an American clergyman, the Revered Langstroth in 1851. This intervention by Langstroth, and the patenting of the artificial comb foundation by Melhring in 1857, revolutionized beekeeping and put it on a commercial footing (Mann, 1976). The frames can be removed, inspected and when full of honey, extracted returned to the hive for the bees to continue filling with honey. Other frame hives include the Dadant developed in the USA and the Smith hive developed in the UK.

The basic principle in all frame hives is the same in that the frames are movable and the bee brood and the honey are kept in separate chambers (Plate 5: Langstroth hives). The Langstroth hive is the most popular of the frame hives and is used in various part of Kenya. Construction of the Langstroth hive requires an intimate knowledge of the exact dimensions needed to simulate a natural beehive, as well as the proper materials and tools for assembly. The hive consists of brood boxes and supers, large open ended boxes that are stacked on top of one another. Each box holds ten four-sided frames containing a wax or plastic comb foundation. Frames are measured with bee space in mind, so as to mimic the natural environment of a honey beehive. Managing bee colonies in a movable frame Langstroth hive can be time intensive, and requires the attention and diligence of the beekeeper. Harvesting honey from the four- sided frames is extremely efficient and allows the beekeeper to compartmentalize and select specific combs that contain pure honey. The harvesting from such frames requires a centrifuge extractor if the wax comb is to be preserved.

The Langstroth has a number of advantages compared to other types of hives found locally. The frames make the hive strong hence minimizing breakage. Moreover, the honey can be extracted and the frames returned to the hive leading to higher yields and honey quality is enhanced due to the use of a queen excluder. However, they are more expensive than the traditional or top bar hives. The Langstroth hives require more management skills and the comb foundation frames are prone to attack by wax moth (Muriuki, 2010).

Frame hives have been successful in the cooler parts of Africa where there is an abundance of bee forage and are managed by experienced beekeepers. However, they have had limited success in general and in most cases, the yields obtained do not justify the additional capital and management requirements (Patterson, 2006). The last decade has seen a tremendous growth in the number of Langstroth hives in Kenya. However these hives are not necessarily better than either the traditional or top bar hives and their potential for better yields and quality depends very much on good management practices (Caroll, 2006). Nevertheless, use of modern beekeeping technology encourages better bee management and aims at higher success than can be hoped for by exclusive use of traditional methods (Kigatiira, 1976).

Movable frame hives are valued by beekeepers for their ease of accessibility and manageability. The ability to remove frames makes it infinitely easier for beekeepers to inspect for disease and pests, to prevent colonies from swarming, and to increase honey production and harvesting efficiency. For these reasons, the moveable frame hive is a revolutionary technology that has been widely adopted around the globe, largely with the goal of honey production in mind. The advantages of Langstroth hives are as such

(MacOsore, 2005); (a) high quality honey, thus yielding greater economic returns, (b) easily harvested honey, (c) greater yields of honey (approximately 45-60 kg/hive/harvest), (d) easier to inspect for disease and pests, (e) can prevent colony from swarming or absconding, (f) women can participate. There are also disadvantages to the Langstroth hive within the Kenyan context. They are as follows; (a) require a large upfront financial investment, (b) difficult to construct, (c) require a comb foundation and honey extractor, (d) can easily be stolen or attacked by predators, (e) require high level of beekeeper training and management expertise.

Hanged Langstroth hives

A frame with brood comb
Plate 5: Langstroth hives
Photo: Wambua B.M. (2012), courtesy E. Muli (2012)

2.5 Housed Beehives

Rearing bees in houses is a new approach to beekeeping in the ASAL. Bees are kept in houses to protect them from adverse weather, predators and vandals. The bee house can be constructed by use of locally available materials such as (I) grass thatching for roofing (ii) rafters and mud for walls and (iii) any available timber for hive stands. Holes are drilled on the wall (Plate 6: Housed bee hives). Hives are placed on stands with their entrances corresponding with holes (about 1m from ground level) on the walls. Pipes of about 2 inches wide and 6 inches long connect the hive to the outside through the wall and works as bee entrances. According to Patterson, (2006) bees are more manageable when kept in a bee house because the more aggressive guard bees will remain outside the bee house while the hive is being manipulated. Another advantage is that this method of beekeeping has the possibility of increasing the carrying capacity of small pieces of land since a small house can take up to ten hives. However, it should be noted that a secure bee house can be expensive to construct.

Brick constructed bee house in Waita

Mud constructed bee house in National Beekeeping Station

Mud hives inside a bee house

(Inset: Mr. Munyoki inside his bee house- Waita Location)

Langstroth hives inside a bee house in Waita

Plate 6: Housed bee hives

Photo: Wambua B.M. (2012)

CHAPTER THREE

3 RESEARCH METHODOLOGY

3.1 Study area

3.1.1 Geographical location

Kitui County was selected as a study area to assess the performance of frame hive beekeeping technology in Kenya. Limited studies have been undertaken in the area even though records indicate that the region contributes substantially to beekeeping at national level (Ministry of Livestock Development, 2008). Out of the 16 Districts in the County, the study was undertaken in Ikutha, Kitui Central, Mwingi Central and Kyuso Districts (Figure 3.1 shows the study sites). The geographic data of the county is outlined in the Kitui District Development Plan for 1994-1996 (Office of the Vice-President and Ministry of Planning and National Development).

The county is located between Longitudes 37^0 50´ and 39^0 0´ east and Latitudes 0^0 10´ and 3^0 0´ south. The county borders Machakos and Makueni to the west, Embu and Tharaka- Nithi to the north, Tana River to the east and Taita-Taveta to the south. The county covers an area of approximately 20,402km² including 690.3km² occupied by uninhabited Tsavo National Park. The rural population occupies 23,020km^2. of the County (GoK, Kitui District Development Plan, 1994-1996). The County is divided into 10 administrative divisions, 57 locations and 187 sub locations. The County has a population of 1,012,709 (KNBS, 2009 Population Census). The central part of the county is characterized by hilly ridges separated by wide, low lying areas and has slightly lower elevation of between 600m and 900m above sea level. To the eastern side of the county, the main relief feature is the Yatta Pateau, which stretches from the north to the south between rivers Athi and Tana. The plateau is almost plain with wide shallow spaced valleys. The highest areas in the county are Kitui Central, Mutitu Hills and Yatta plateau. Due to the high altitude these areas receive greater rainfall than other areas in the county and are also the most productive areas. There are many seasonal rivers in the county. Only few rivers in the periphery of the county have perennial flows. The Tana River to the north separates Kitui from Embu and Tharaka- Nithi counties and the River Athi to the west and south –west separates Kitui County from Machakos and Makueni counties. River Tana has several tributaries draining the north portion of the county.

3.1.2 Climate of Kitui County

The climate of the county can be classified as hot and dry for most of the year and can be characterised as an arid and semi- arid county with very unreliable rainfall. There is little rainfall during the two planting seasons. The rate of evaporation is so high that many dams and rivers dry up when the rains stop. The high rate of evaporation and unreliable rains are characteristic features of the county that cause severe limitations to intensive and meaningful land use and other related development activities.

The county experiences two rainy seasons, with long rains in April and May and short rains in November to December. The dry periods are August to September and January to February. The amount of rainfall follows topographical features of the landscape. The hills such as Mumoni in Kitui Central and Mutitu in the western part of the county receive 500-1050mm while the eastern and southern areas receive less than 500mm. In general, most of the county experiences less than 750mm of rainfall in a year (GoK, Kitui District Development plan, 1994-1996).The minimum mean annual temperatures in the county vary between 14^{O} C and 18^{O} C in the western parts and 18^{O} C and 22^{O} C in the eastern parts. The maximum mean annual temperatures on the other hand; vary between 26^{O} C and 30^{O} C in the western parts of the county and 30^{O} C and 34^{O} C in the eastern parts (CGoK, County Integrated Development Plan, 2014).

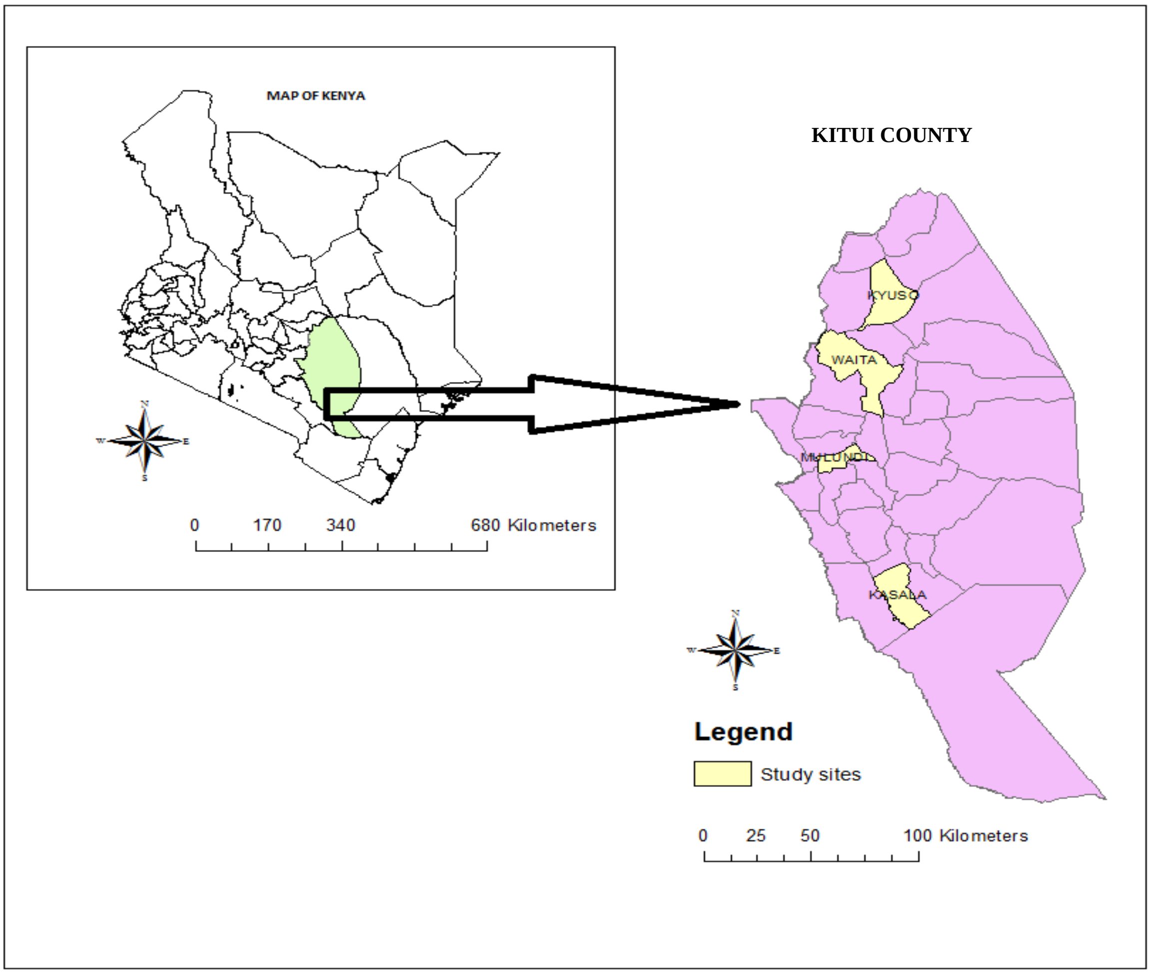

Figure 3.1: Study sites, Kasala, Mulundi, Waita and Kyuso locations. Drawing: C. Kariuki GIS (SEKU) , 2013.

3.1.3 Geology

The geology of the county is characterised by metamorphic and igneous rocks of the basement complex system. The south eastern side of the county is composed of Permian deposits and tertiary volcanic are predominant in the western part. These rocks hold extractable water only in the small cells which generally occur in low areas near stream channels. There is little evidence of large scale mineralization (GoK, Kitui District Development Plan, 1994-1996). The central part of the county is sedimentary plains which are usually low in natural fertility. Because of its higher altitude than surrounding areas, it receives comparatively high precipitation.

Eastern parts of the county have red sandy soils, which are also of low natural fertility. This is worsened by the comparatively low rainfall in the region. These soils are very rich in sodium and are considered by the people of eastern division and neighbouring Tana River district to be the best grazing grounds in the whole county. Towards the western part of the county are clay black cotton soils which are generally low in fertility.

3.1.4 Economic activities

Majority of the people in the county depend on agriculture and livestock related activities for their livelihood. The main food crops include; maize, sorghum, millet, cowpeas and green gram. Tobacco is a major cash crop in the area. Livestock herds are composed of goats, cattle, donkeys and sheep. Rearing of indigenous chicken and beekeeping are also important farm enterprises. This study has established that the majority of farmers (47%) keep goats, a few (16%) keep sheep and about (63%) keep bees using the traditional log hives.

Export Asian vegetables such as Karella, brinjals, guava, okra, turia, tuida, tindori, dudhi and chillies are grown in Ikutha district under irrigation along River Athi. Other local vegetables which are grown mainly under rain fed conditions include cabbages, onions, tomatoes, kales, spinach and capsicums. About 40% of the vegetables are grown under irrigation along river banks such as River Thua, River Athi and other smaller rivers (GoK, Kitui District Development Plan, 1994-1996). Other small scale income generation through charcoal burning is a major activity especially in Kasaala and Kyuso Locations.

3.2 Methods of data collection

3.2.1 Types of data

This survey was conducted in Kasaala, Mulundi, Waita and Kyuso Locations of Ikutha, Kitui Central, Mwingi Central and Kyuso Districts of Kitui County respectively (Figure 3.1). Two types of data namely primary and secondary were taken during the study. Primary data were taken from beekeepers through formal interviews and by administering questionnaires and on the spot field observations. In addition, a focus group discussion was conducted with a group of beekeepers from the four locations and pertinent issues concerning the impact of frame hive beekeeping technology in the study area were delved into. Secondary data were sourced from previous published research reports, NGOs and relevant government departments. Local leaders especially the village elders and assistant chiefs were particularly helpful in the identification of the beekeepers and beekeeping groups for administration of questionnaires

3.2.2 Preparation and administration of questionnaire

A draft questionnaire was prepared and pre-tested in a preliminary survey conducted in 20 households before the main study. These households belonged to the same area of survey were not included in the main study sample. The main reason for the preliminary survey was to test the relevance of the questions. This was in an effort to ensure that only relevant and well phrased questions were to be posed to the interviewees and also give an opportunity to rephrase some of the questions during the main study. Transects used during the main study were also established during the preliminary survey. The questionnaire incorporated dichotomous, multiple choice and open-ended questions. Appendix 1: Shows survey questionnaire. This was necessary due to the diverse nature of the issues that were being investigated.

3.2.3 Recruitment and training of enumerators

Four enumerators with at least Kenya Certificate of Secondary Education (KCSE) ordinary level of education were recruited from the local community to assist in data collection. This was to ensure that there was no language barrier and that the information obtained would be as accurate as possible. Being residents of the area, the enumerators knew the terrain of the study area very well and easily created rapport with the respondents. Training on the subject matter and on techniques of administering questionnaires was provided to the enumerators before embarking on the exercise. The researcher worked with and monitored each enumerator during the entire period of collecting the data.

3.2.4 Interviews

Interviews were conducted in the morning and afternoon sessions for five days a week with a maximum of six respondents per enumerator per day. Efforts were made to keep the interviews as short as possible while at the same time capturing all the desired information. Questions were posed in the local dialect and the answers recorded in English. The sequence of the questions was such that those that would easily establish rapport with the farmers came first while the more sensitive questions came towards the end of the interview.

3.2.5 Sampling technique

A total of 120 households were interviewed from four locations of Kasaala, Mulundi, Waita and Kyuso. The size of the sample depends on various variables. For example, the availability of funds, time, infrastructure and terrain, and not necessarily on the total population. Sampling was such that each location provided about the same number of households. The locations were purposively selected based on the presence of at least one beehive per household irrespective of whether modern or traditional technology. Motor cycle tracks were used as transects with each location constituting about a 30-40 Km long transect. Random sampling was then taken at every other homestead along the identified transects.

3.3 Methods data analysis

3.3.1 Descriptive analysis

Data collected through personal interviews and group discussions were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS) and summarized in terms of percentages, frequencies and charts.

3.3.2 Regression analyses

Investigation on the performance variables or indicators of frame hive beekeeping technology was done by employing regression analysis. The binary logit model was used for determinants of adoption. Logistic regression allows one to predict a discrete outcome, from a set of variables that may be continuous, discrete, dichotomous, or a mix of any of these. Generally, the dependent or response variable is dichotomous, such as adoption or non-adoption. Various adoption studies on crop, livestock, and soil conservation have used probit and logit models for identifying the impact of independent variables on dependent variables. Linear regression analysis is an approach to modeling the relationship between scalar dependant variable (Y) and one or more explanatory variables denoted x_i for i= 1…n, and n is the sample size. This approach usually focuses on the conditional probability distribution of Y and X. The model is usually fitted using least squares method. The model is formulated as shown below

$$Y_i = \beta_0 + \beta_1 X_i + e_i$$

Defined as,

β_0 the intercept of Y dependant,

β_1 the gradient of X explanatory

And

e_i error term associated with i^{th} observation.

$\beta_1 = \Sigma (X_i - E(X)) (Y_i - E(Y)) / \Sigma (X_i - E(X))^2$

$E(X) \& E(Y) = \Sigma X_i/n \& \Sigma Y_i/n$

Where i=1…n

$\beta_0 = E(Y) - \beta_1 E(X)$

$e_i = Y_i - Y$

$E(e_i) = E(Y_i) - E(Y) = 0$

The R^2 (coefficient of determination) shows the amount of deviation on the dependent variable that can be attributed to the particular regression equation.

3.3.3 Chi-square test of independence

H_O: Level of education affects management practices undertaken

H_A: level of education does not affect management practices undertaken

The expected frequency counts are computed separately for each level of one categorical variable at each level of the other categorical variable. Compute (r * c) expected frequencies, according to the following formula.

$E_{r,c} = (n_r * n_c) / n$

where *Er,c* is the expected frequency count for level *r* of Variable A and level *c* of Variable B, *nr* is the total number of sample observations at level *r* of Variable A, *nc* is the total number of sample observations at level c of Variable B, and n is the total sample size.

Test statistic. The test statistic is a chi-square random variable (X^2) defined by the following equation.

$X^2 = \Sigma [(O_{r,c} - E_{r,c})2 / E_{r,c}]$

where Or,c is the observed frequency count at level r of Variable A and level c of Variable B, and Er,c is the expected frequency count at level r of Variable A and level c of Variable B.

The P-value is the probability of observing a sample statistic as extreme as the test statistic. Since the test statistic is a chi-square, use the Chi-Square Distribution Calculator to assess the probability associated with the test statistic. Use the degrees of freedom computed above, (Appendix 2, Chi- squared distribution table of values).

3.3.4 Selection of variables used in the logit model

Adoption is considered discrete rather than continuous in nature such that the dependent variable takes a limited set of values. The dependent variable in this case can be characterized as binary, taking the value of 0 or 1. The dependent variable thus takes the value of 1 if technology has been adopted and 0 if not. The independent variables that influence the adoption of beekeeping technology were selected based on literature, survey results and personal experience. The hypothesized variables are briefly discussed below.

i. Age of household head

This is a continuous variable and was measured by ranking on a scale of 1-3 with the highest figure representing the oldest category. Literature reveals that aged persons are less prone to change and reluctant to adopt new technology in their farms while young people are more flexible (Rahman, 2007). Therefore, it was anticipated that younger people would adopt beekeeping more than the elderly.

ii. Level of education of household head

Education improves the decision making process (Feder *et al*., 1985). Education level was therefore hypothesized to positively influence the adoption of technologies. This variable was measured by ranking using ranges from 1-4, with the largest representing the highest level of education attained.

iii. Gender of household head

Depending on the nature of the technology, female and male beekeepers are likely to play different roles in technology adoption. The effect of this variable may either be positive or negative. The variable was measured by allocating male-headed households a value of one and female-headed a value of zero. It was hypothesized that male-headed household would have a higher adoption rate than female-headed households.

iv. Household size

This variable was measured by the total number of household resident members. Beekeepers with large family size might significantly adopt the technology, to satisfy the needs of their families. They are also able to provide the extra labor that the technology may demand. Hence, it was hypothesized that the larger the household size, the higher the likelihood of beekeeping adoption.

v. Land holding

Land was measured by ranking on a scale of 1-3, with the largest representing the highest acreage. Beekeepers with big tracts of land are considered wealthy and can therefore afford to invest in new ventures in an effort to fully utilize their land and to diversify their income base.

4 CHAPTER FOUR

4 RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the results of the study are presented and discussed in two parts. The first section covers the general descriptive statistics of the beekeeping situation in the study area. The second part is on the regression analysis focused on estimation of productivity levels and the reasons for or against the adoption of beekeeping technology.

4.2 Descriptive analysis

4.2.1 Demographic characteristics of the respondents

Of the 120 respondents, 69% and 31% were males and females respectively. In terms of age 77% of the respondents were in the 18-55 years age bracket. On education, 64% of the respondents had attained at least primary level of education (table 4.1). Further the study revealed that most respondents were agro-pastoralists with 75% involved in crop and livestock production. A majority of the respondents (77%) own between 1 and 9 acres of land. The household size averaged FIVE people with 75% of the respondents indicating that working on their farms on a full time basis was their main occupation. Self-help groups were active in the study area with 61% of the respondents being members of such groups. However, it was observed that more men were members of these groups compared to women. Men who were members accounted for 59% compared to women whose membership in self-help groups stood at 41%. Table 4.1 summarizes some main socio economic characteristics of the sampled households.

Table 4.1: The number (n) and percentage distribution of age (years), education and occupation of respondents per location

	Kyuso	Kasaala	Waita	Mulundi	Total Frequency	Total Percent
Age(years)						
Below 18	3	0	0	0	3	3
18 – 35	12	3	5	6	26	22
36 – 45	5	10	16	7	38	32
46 – 55	2	6	7	13	28	23
56 and above	8	10	3	4	25	20
Education						
None	7	9	5	6	27	23
Primary	17	20	18	23	78	64
Secondary	5	0	3	1	9	8
Tertiary	1	0	5	0	6	5
Occupation						
Farming	9	29	22	30	90	75
Business/charcoal burner	7	0	3	0	10	8
Employment	7	0	0	0	7	6
Civil service	3	0	2	0	5	4
Others	4	0	4	0	8	7
Total	30	29	31	30	120	100

4.2.2 Socio-economic characteristics and adoption of beekeeping technology

The link between household socio-economic characteristics and beekeeping technology adoption was examined with respect to characteristics such as age, gender of a household head, level of education of a household head, farm size, access to extension services, and access to credit and membership to self-help groups. About 58% regarded beekeeping as a major economic activity. This is an indication that beekeeping was still regarded as an important socio- economic undertaking in the area.

4.2.2.1 Age of household head

Most of the beekeepers (77%) were in the age bracket of 18-55 years. The rest were above 56 years (20%), while those below 18 year were 3% (table 4.1). from the study, adoption of beehive technology had an inverse relationship with age. Those aged 18-30 years were the least adopters. This implies that age positively influences the adoption of hive technology. The likely explanation is that the youth in the 18-30 year age bracket may often have a negative attitude towards beekeeping and are reluctant to take up the practice. In most cases, these age brackets are often looking for white collar jobs. This has been suggested as one of the reasons why beekeeping is on the decline in many parts of the country.

4.2.2.2 Level of education of household head

According to the survey results about 23% of the respondents had no formal education, 64% had attained basic primary education, and 8% had secondary education while the remaining 5% had tertiary level education (table 4.1). Among those who had acquired primary level education, 53% of them were involved in beekeeping while 47% were non-beekeepers. For those who had attained secondary education, 89% of them were involved in beekeeping while 11% were non-beekeepers. This indicated that adoption rate was high at higher education level. In none and primary education levels, the rate of adoption was relatively low. Since beekeeping is a traditional art among the local community, adoption is based on skills which are passed-on from generation to generation rather than through formal education.

4.2.2.3 Household farm size and frequency of beekeeping technologies

Farmers were grouped into three categories based on the sizes of their individual land parcels. These parcels of land ranged from 1 acre at the lowest to 70 acres on the highest. A majority of the respondents 41% owned between 5 and 9 acres. Those owning between 1 and 4 acres were 36% while only 23 % owned tracts of land larger than 10 acres. This analysis showed that land size is an important factor when it comes to the number of hives a farmer could keep as shown in tables 4.2 (a) and 4.2 (b) as the total number of Traditional (T) and Langstroth (L) hives in each of the four locations. These tables show that farmers had more traditional hives in the four Locations while the Langstroth were few and even absent in Kasaala. It also shows that kasaala had the largest number of 23 hives which were of the traditional type.

Table 4.2 (a): Effect of land size (acres) and the number of beekeeping at various locations

Land size (acres)	Kyuso	Kasaala	Waita	Mulundi	Total Frequency	Total Percent
1.0 – 4.0	5	5	4	11	25	36
5.0 - 9.0	8	15	4	1	28	41
10.0 and above	9	3	4	0	16	23
Total	22	23	12	12	69	100

Table 4.2 (b): The total number of Traditional (T) and Langstroth (L) hives in various locations

Land (Acres)	Kyuso		Kasaala		Waita		Mulundi		Total
	T	L	T	L	T	L	T	L	
1- 4	4	1	5	0	1	3	2	10	26
5- 9	6	2	15	0	4	1	0	1	29
10 and above	4	1	3	0	4	2	0	0	13
Total	14	4	23	0	9	6	2	11	68

4.2.2.4 Membership of self-help groups

The survey results showed that a total of 48 beekeepers representing 70% were members of Self Help Groups (SHG) and were traditional beekeepers while 21 beekeepers representing 30% were members of Self Help Groups and using Langstroth hives in the four Locations. This is an indication that being a member of a SHG does not influence the adoption of traditional beekeeping but it may have a significant influence on the adoption of modern beekeeping as shown in table 4.3. This is because modern beekeeping is usually introduced through groups as opposed to traditional beekeeping which is passed-on from one generation to the next along family lines as shown by the situation in Kasaala which was found to have large number of traditional hives and no modern Langstroth. Degu *et al*., (2002) noted that membership to an association or group is an important factor in technology adoption. Membership to groups enhances cooperation and interaction within the group and also between the group and other players such as donors and extension service providers. The study results indicate that self-help groups were also involved in social and financial activities which help in building the capacity of their members.

Table 4.3: Membership of Self-Help Groups and beekeeping technology per study site

Hive technology	Kyuso	Kasaala	Waita	Mulundi	Total Frequency	Total Percent
Traditional hives	14	23	9	2	48	70
Langstroth	4	0	6	11	21	30
Total	18	23	15	13	69	100

4.2.2.5 Gender of household head

Most of the households sampled were male-headed (75%) with (25%) female-headed. These results indicate that a larger proportion of beekeepers were among the male-headed households compared to the female-headed households. This may be attributed to the cultural norms among the local community where beekeeping is still strongly regarded as a man's job, and more so among the traditional beekeepers. The hives are normally placed high up the trees and the owner climbs up to harvest the honey usually at night. This operation would under normal circumstances be viewed as not suitable to the female gender.

It can, therefore, be concluded that the gender of the household head is a likely determinant of beekeeping technology adoption. This observation is consistent with the findings of Volenzo (2006), who did some work on the factors affecting organic farming in Western Kenya. Also, Ouma *et al.*, (2002) found out that gender was significant in explaining the adoption of improved maize variety in Embu District, Eastern Kenya.

4.2.2.6 Access to extension services

Almost all the beekeepers visited indicated that they had not accessed extension services in the previous one year. The lack of access for extension could have probably contributed towards lack of adoption of modern beekeeping technology. In the traditional beekeeping method beekeepers got knowledge from experienced beekeepers with the knowledge being passed from generation to generation. For modern beekeeping to succeed, the beekeepers must have access to extension service providers who would train the beekeepers on the aspects of hive management. This conforms to observations by *(*Ouma *et al., 2002*) that access to extension services plays an important role in influencing the adoption of agricultural innovations.

4.2.2.7 Access to credit

About 4% of the beekeepers had received credit for beekeeping activities in the previous one year. This is a clear indication that lack of credit could be one of the constraints to the adoption of modern beekeeping technology in the area. Table 4.4 shows the number of farmers who had access to credit for beekeeping per study site. Feder *et al.* (1985) observed that credit programs enable farmers to purchase inputs or acquire physical capital needed for technology adoption. Credit may be essential to acquire farm technologies like modern beekeeping which the farmers perceive to be a costly activity to engage in (Workneh, 2007).

Table 4.4: The number of farmers who had access to credit on beekeeping per study site

Hive technology	Kyuso	Kasaala	Waita	Mulundi	Total Frequency	Total Percent
Traditional	2	0	1	0	3	100
Langstroth	0	0	0	0	0	0
Total	2	0	1	0	3	100

4.2.2.8 Access to market

Marketing plays an important role in agricultural production and adoption of technology (Mwanthi, 2009). Lack of market or low prices may act as a disincentive towards the adoption of technology. Results of this study showed that the main market outlet for honey was the middle-men accounting for 53%. While the remaining 47% were local consumers and deliveries to the local refinery, tables 4.5 shows the number of farmers who had access to market in the four locations for traditional and Langstroth technologies

Table 4.5: The number of farmers who had access to market in the four locations for traditional and Langstroth technologies

Market type	Kyuso		Kasaala		Waita		Mulundi		Total	Percent
	T	L	T	L	T	L	T	L		
Local consumer	9	1	2	0	6	2	1	1	22	46
Middle men	0	0	23	0	1	1	1	0	26	54
Total	9	1	25	0	7	3	2	1	48	100

T= Traditional,
L= Langstroth(Modern)

4.2.2.9 Training on bee management

Among the sampled beekeepers, only 14% had received some training in bee management in the previous one year. Of those who had been trained, 5% were adopters of traditional technology while the majority (8%) had adopted modern technology. The figures in table 4.6 show the number of farmers who had received some training on beekeeping in the various locations. The beekeepers in modern technology received training as part of the package from the NGOs who supplied them with the hives in their beekeeping projects. These results suggest that acquisition of technical skills and knowledge on bee farming were likely to influence the adoption of modern beekeeping technology. This observation is consistent with that of Zegaye *et al*., (2001) who reported that training contributed positively to farmers' adoption decision.

Table 4.6: Number of beekeepers who had received training on bee keeping per study site

Hive technology	Kyuso	Kasaala	Waita	Mulundi	Total	Percent
Traditional	2	0	1	1	4	57
Langstroth	1	0	1	1	3	43
Total	3	0	2	2	7	100

4.2.3 Types of beekeeping technologies

Beekeepers in Kitui use traditional and modern beekeeping technologies. Although traditional beekeeping using log hives has been practiced in the area for hundreds of years, modern practices of rearing bees in improved hives was first introduced in the area in the 1970's through women groups by the Council for Human Ecology and Action Aid Kenya (Kigatiira, 1976). The results obtained from this study showed that sixty five percent of the beekeepers used traditional technology, while 35% were using modern technology. Among adopters of modern technology, 48% used Langstroth hives while 4% used Kenya Top Bar Hives (KTBH). This finding confirmed field observations which indicated the growing unpopularity of the KTBH, especially in hot areas, due to high rates of bees absconding associated with this type of hive as a result of unbearable hive temperatures.

4.2.4 Factors affecting choice of various technologies

Respondents gave varied reasons why they prefer a particular type of hive technology. These included affordability, availability, management regime, productivity level and quality of the hive products. Low cost of a technology environmentally friendly, easy to construct and low maintenance cost were the most important considerations for beekeepers of traditional technology. Beekeepers of modern technology cited ease of management, high yield, easy to construct and quality of hive products as the major reasons for choosing the technology.

4.2.5 Traditional technology

Beekeepers cited various reasons for using the traditional technology. Figure 4.1 shows the factors that were responsible for the choice of selection of traditional beehives technology. About 29% of the beekeepers cited affordability and availability as the main advantages of this technology. Since the materials and skills for making log hives are locally available; a log hive costing three times less than a modern hive. Another 18% of the beekeepers gave environmental friendliness as a reason for choosing the hive. Other factors included ease of construction of the log hives (15%) and low maintenance cost of traditional hives (9%). Mutungi, (1998) noted that tree apiaries are safe from fires, floods and attacks from pests and predators. Bees from such hives cause less disturbance to pedestrians, traffic and farming activities. Hives placed high on trees are cooler during the day which enhances occupation by bees than those closer to the ground. Figure 4.1 illustrates the major considerations on the choice of technology type.

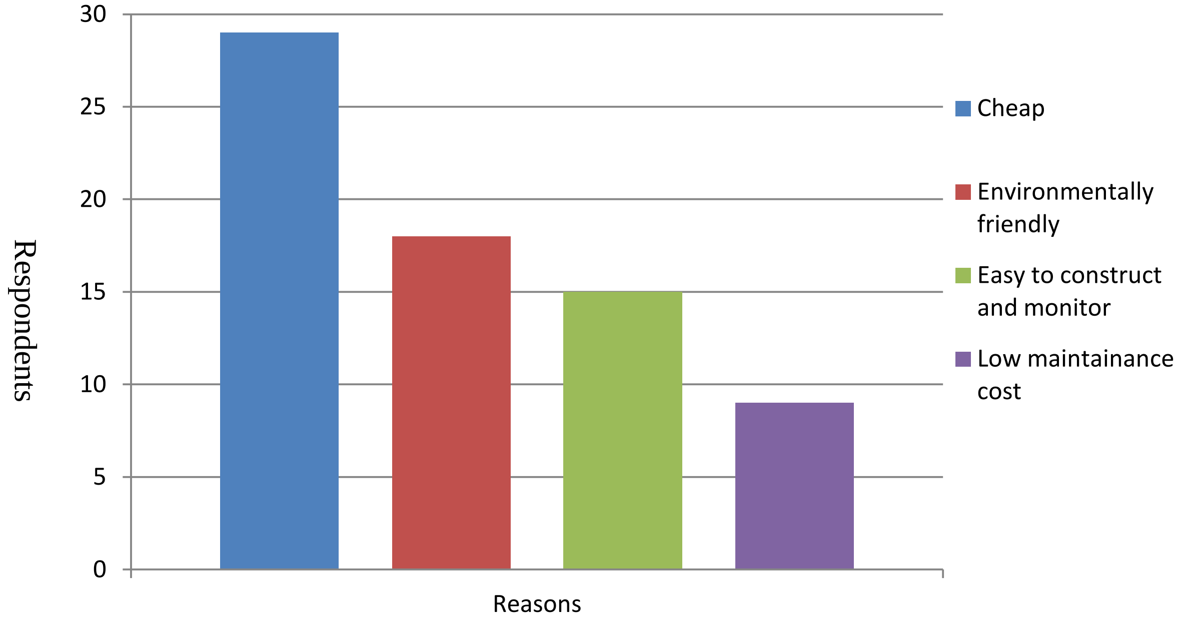

Figure 4.1: households reasons for choosing traditional log hive (%)

4.2.6 Modern technology

In this study, adoption of modern beekeeping technology was marked by use of improved hives. For instance, the Kenya Top Bar Hive (KTBH), the Langstroth hive and accessories, such as bee protective clothing, smoker, bee-brush and hive tool. Among the beekeepers, about 59% were practicing modern beekeeping with 20% in this category citing high yield combined with ease of colony management/ inspection as the major advantages of the technology. Farmers reported that since these hives are placed only about two meters from the ground, they find it much easier and more convenient to access and monitor the hives (17%) compared to the traditional hives, which are hung high up the trees. Those reporting improved quality of products as reasons for choosing the technology accounted for 15%. Table 4.7 shows a simplified cost benefit ratio for the two technologies which indicated that beekeeping by traditional hives gave a high return than the Langstroth hives for the last one year.

Table 4.7: A simplified cost benefit analysis of the two technologies

Type of beehive	Cost of production	Price of honey per Kg	Yield of honey (Kgs) per harvest	No. of harvests per year	Return per investment 1st year
Traditional	800	600	7	2	10.5
Langstroth	5000	600	15	2	3.6

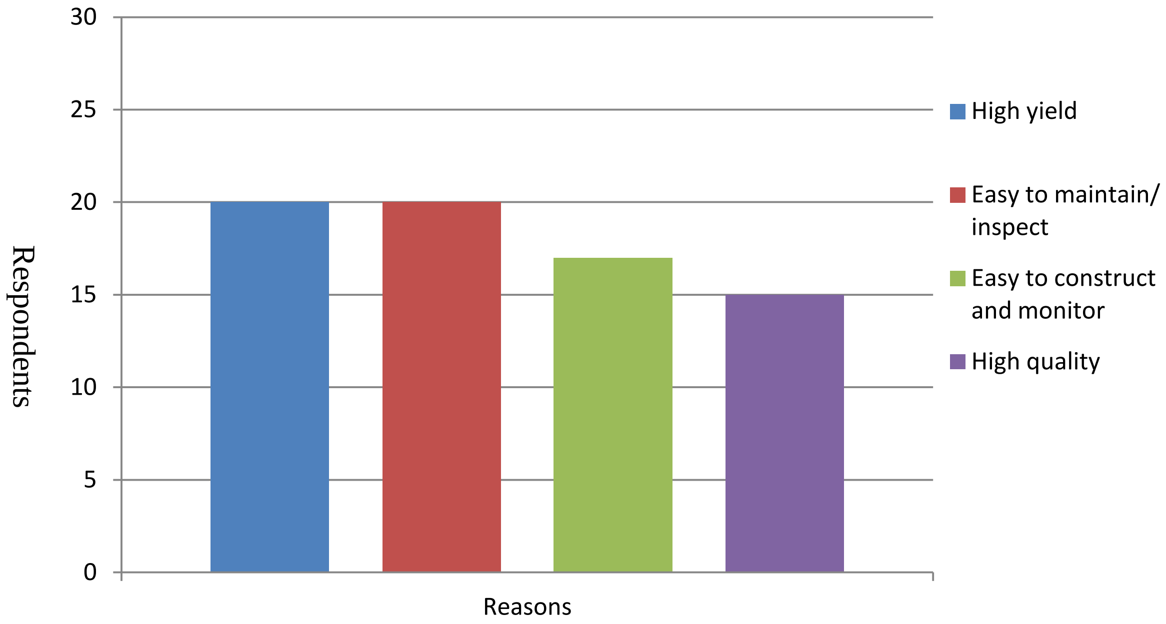

Figure 4.2: Households reporting reasons for choosing Langstroth hive.

4.2.7 Number of hives as per adoption of beekeeping technology

Men owned more bee hives regardless of the type compared to women with an average of 21 bee hives against 6 respectively. Most of male beekeepers had more log hives than the modern hives unlike women who had more modern than traditional log hives. Women had more modern hives because they were assisted to acquire the hives while in the self-help groups. However, more men were in the self-help groups than women but most of their beekeeping dealt with the traditional hives. This generally showed that there were few modern hives found in the study sites. This is shown in table 4.8 (a) and (b) on the number of households owning bee hives per site per beekeeping technology.

Table 4.8 (a): Number of households owning traditional bee hives per study site

Hives	Kyuso	Kasaala	Waita	Mulundi	Total Frequency	Total Percent
1 - 5	6	0	2	0	8	16
6 - 10	3	3	2	1	9	19
11 - 20	2	6	0	1	9	19
21 and above	3	14	5	0	22	46
Total	14	23	9	2	48	100

Table 4.8(b): Number of households owning Langstroth bee hives per study site

Hives	Kyuso	Kasaala	Waita	Mulundi	Total Frequency	Total Percent
1 - 5	2	0	3	10	15	70
6 - 10	0	0	1	1	2	10
11 - 20	2	0	0	0	2	10
21 and above	0	0	2	0	2	10
Total	4	0	6	11	21	100

4.2.8 Other aspects analyzed using descriptive statistics

The study also analysed other issues pertaining to the beekeeping in the study area. These included bee management, occupation rates of various types of hives, the number of harvests per year and yield; and presence of pests and predators.

4.2.8.1 Bee management practices

The survey results showed that 92% of beekeepers practiced some form of bee management. Approximately 51% and 75% of farmers using modern and traditional technology undertook bee management respectively. The management aspects practiced by 70% of the adopters include apiary management, feeding and pest control. Lack of proper bee management is affecting production of bee products and most of the beekeepers got little income from the sale of the products. Only 5% of the beekeepers practiced colony division. This could be one of the reasons of the observed high rates of swarming by the honey bee colonies.

4.2.8.2 Use of accessories

Effective bee colony management requires use of appropriate accessories, such as the protective clothing, bee smoker, knife, bee brush and hive tool. Lack of these equipment, and especially protective clothing, has been a big hindrance to the adoption of modern beekeeping thus low productivity. In traditional technology, beekeepers were able to acquire the basic accessories needed during harvesting from local materials such as the smoker which could be made by stacking small sticks together then tied with a string, a rope, a knife and a bucket. A bee suit was not considered as being necessary because beekeepers harvested at night. For modern technology, beekeepers needed a bee suit, a modern smoker and a hive tool all of which were expensive and not locally available. This was due to the fact that the local bee species is very aggressive and tends to sting excessively. This aggressive behaviour is the main cause of *api-phobia*, one of the leading drawbacks to beekeeping in the country. The results showed that only 54% of the beekeepers used accessories, with 29% being adopters of modern technology and the rest using the traditional technology. Figure 4.3 showed accessories used per bee keeping technology. The major reason behind the limited use of beekeeping accessories was cited as their high cost which accounted for 75% of the beekeepers. This implied that modern beekeeping was not largely practiced because beekeepers need finance to purchase the Langstroth hives and their accessories.

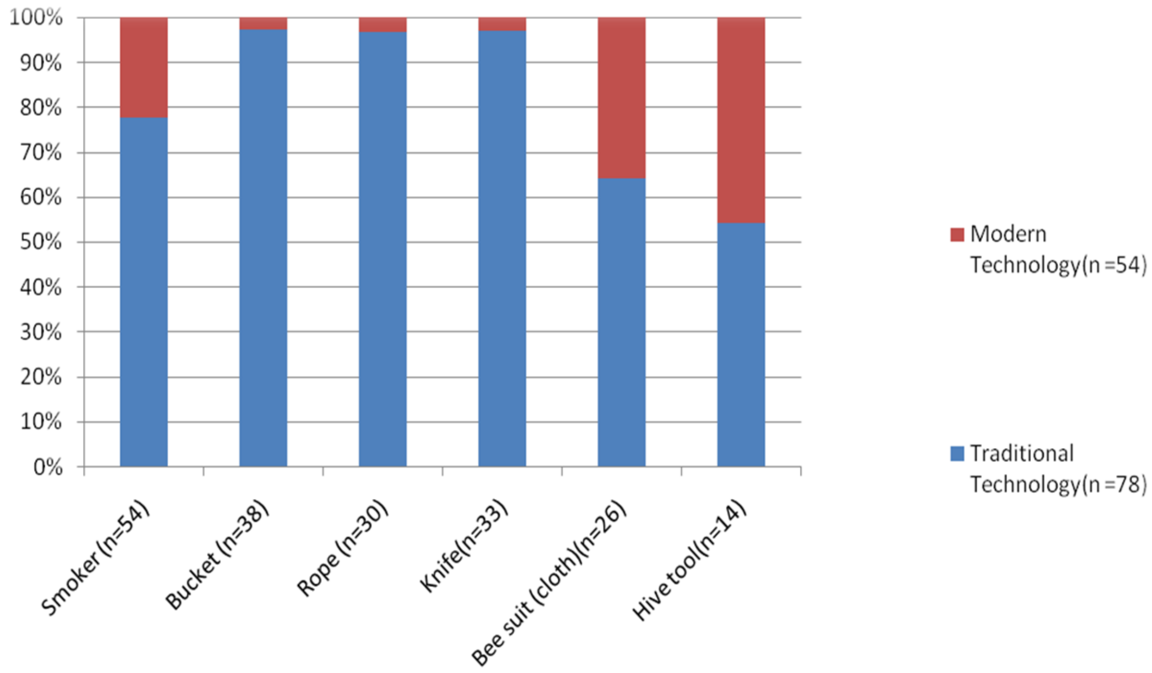

Figure 4.3: Accessories used per beekeeping technology

4.2.8.3 Hive occupation

The study results indicate that 90% of the beekeepers reported having experienced a problem of persistently low occupation of their hives by honey bee colonies during the previous one year. Of those reporting low occupation, 57% and 33% were adopters of traditional and modern technologies respectively. The main factors behind the observed low occupancy were the behavioural aspects of honey bees mostly absconding and migration. Some of these factors have been discussed by Mwangi (1985). About 39% and 30% of the beekeepers reported having lost colonies as a result of drought and lack of enough food respectively. Further analysis of the results indicated that within the type of technology used, modern technology had higher levels of low occupation 44% compared to 41% in the traditional technology. This observation is consistent with field observations which showed that traditional log hives tend to be better occupied by honey bee colonies compared to modern hives. This observation is similar to that of Mutungi

(1998) who observed that, despite advantages associated with modern hives (such as ease of manipulation and higher yields), bees do not like them due to the high temperatures leading to absconding. Among the modern hives, the KTBH had lower occupation compared to the Langstroth. At least out of the 48 traditional beekeepers, 45 representing 94% had their hives occupied for the last one year while out of 21 Langstroth beekeepers only 11 representing 52% had their hives occupied. This means that there is high occupation rate in traditional than the Langstroth hives. Table 4.9 shows beehive occupation rate by beekeeping technology.

Table 4.9: Beehive occupation rate by beekeeping technology

Bee hive	Traditional (Frequency)	Langstroth (Frequency)
5 and below	15 (33)	10 (91)
6 to 10	9 (20)	0 (0)
11 to 20	15 (33)	0 (0)
21 to 30	5 (11)	0 (0)
Above 30	1 (3)	1 (9)
Total	45 (100)	11 (100)

Figures in brackets show percentages.

4.2.8.4 Number of harvests and yield

The number of harvests in the previous one year ranged from zero to a maximum of three times. About 80% of the beekeepers reported having harvested honey at least twice with only 8% harvesting three times in the last one year. Those reporting three harvests per year were all found to be using traditional technology. This could be attributed to the higher occupation rates of the traditional log hives and the many years of experience by traditional beekeepers. On another hand, lack of accessories like the protective suits, smoker, honey extractor contributed to lack of harvesting in the Langstroth hives.

The total honey yield per household for the traditional beekeepers ranged from zero to 1,020kg per year with a mean yield of 88Kgs. Twenty three percent of the beekeepers using traditional technology reported that they did not harvest any honey at all in the previous one year. Fifty eight percent, representing twenty eight traditional beekeepers harvested between (0-20 kg) and 42% got above 20kg. For the adopters of modern technology, a majority of 67% reported no honey harvests at all with only 33% reporting having harvested honey. The mean yield was 47Kgs with the highest beekeeper harvesting 200kg. The low yields reported may be attributed to the long drought that had ravaged the area consecutively in the last two years, leading to the migration of honey bee colonies. In traditional hives beekeepers who harvested between 21- 100 Kg were twenty two while in Langstroth hives were only two.

Regarding average incomes from sale of honey, results showed that the level of income was high with the beekeepers that used traditional hives compared to Langstroth hives received. In traditional beekeeping, the highest honey sale recorded was Kshs.186, 600, while for modern beekeeping; the highest honey sale recorded was Kshs.61, 000. The beekeepers who earned between Kshs.2, 500 - 10,000 in traditional hives were seventeen, while those in Langstroth hives were three only. This meant that use of Langstroth hives did not improve livelihood of beekeepers. Table 4.10 shows the number of farmers receiving variable honey yield (Kg) from the two technologies while table 4.11 shows number of farmers receiving variable incomes (Kshs) for traditional and Langstroth technologies per study site.

Table 4.10: The number of farmers receiving variable honey yield (Kgs) from the two technologies.

Honey (Kgs)	Kyuso		Kasaala		Waita		Mulundi		Total
	T	L	T	L	T	L	T	L	
20 and below	5	3	3	0	5	0	2	1	19
21 - 50	4	1	8	0	0	1	0	0	14
51 - 100	3	0	6	0	1	0	0	0	10
101 - 150	2	0	3	0	1	0	0	0	6
151 - 300	0	0	3	0	1	1	0	0	5
Above 300	0	0	0	0	1	0	0	0	1
Total	14	4	23	0	9	2	2	1	55

T= Traditional,
L= Langstroth(Modern)

Table 4.11: The number of farmers receiving variable incomes (Kshs.)

Income (Kshs.)	Kyuso		Kasaala		Waita		Mulundi		Total
	T	L	T	L	T	L	T	L	
2,500 and below	4	0	11	0	0	0	2	1	18
2,501 – 5,000	2	1	4	0	1	0	0	0	8
5,001 – 10,000	2	2	8	0	0	0	0	0	12
10,001 – 20,000	1	0	0	0	1	1	0	0	3
Above 20,000	0	0	0	0	4	2	0	0	6
Total	9	3	23	0	6	3	2	1	47

T= Traditional,
L= Langstroth (Modern)

4.2.8.5 Presence of pests and predators

The existence of honeybee pests and predators can be an obstacle in the adoption of beekeeping technology. Some pests such as the safari ants attack honeybees and consume the hive products while predators such as the honey badger can cause serious damage to the hives leading to huge losses to the farmer. The beekeepers reported the existence of pests and predators on their farms. Table 4.12 showed the major pests and predators ranked depending on the extent of damage caused to the honey bee colonies.

Table 4.12: Major honey bee pests and predators

Pest and Predator	Rank
Honey badger	1
Safari ants	2
Black ants	3
Birds	4
Termites	5
Tree squirrels	6
Wax moth	7
Lizards	8
Wasps	9

4.2.8.6 Absconding and migration of honey bee colonies

Absconding refers to the sudden departure of the whole colony from a hive while migration is the seasonal movement of bees from one area to another. These two phenomena are not desirable since they lead to loss of bee colonies and hence income by the farmer. About 74% of the beekeepers reported to have lost colonies in the previous one year an indication that it was a major problem in the area. This problem affected all beekeepers regardless of the bee hives used. The main causes of absconding and migration were severe drought, attack by pests and predators, lack of food, lack of water and insecurity accounting for 30%, 24%, 18%, 8% and 6%, respectively.

4.2.8.7 Value addition

The value of primary hive products can be improved by processing, purification, packaging and labelling. Adding value to hive products plays an important role in enterprise development and employment creation. The technologies used in honey processing include extraction, pressing and straining. The majority of producers depend on simple methods such as cloth or net straining. Very few (7%) beekeepers processed their honey. The adoption of modern beekeeping also tended to encourage value-addition and improved quality products which would ultimately translate into better returns to the farmers. Both the adopters of modern technology and those using traditional methods only 11%, processed their honey in each of the hive technologies. The processing methods which were commonly used include heating to melt honey 33%, crashing and straining 25%, use of centrifugal extractor 25% and filtering of raw product 17%. Most of the beekeepers sold their honey in raw form at a price of Ksh.140 per Kg while processed was sold at Ksh.300 per Kg. The latter fetched a lower market price than the processed honey.

4.2.8.8 Non-cash benefits from beekeeping

About 56%of the beekeepers acknowledged that other than cash income, there were many other benefits accruing from beekeeping. 45% mentioned tree planting the primary product of bee nutrition while honey is used as a source of medicine, bees for crop pollination, and honey as an ingredient during socio-cultural events followed. These results are illustrated in Figure 4.4.

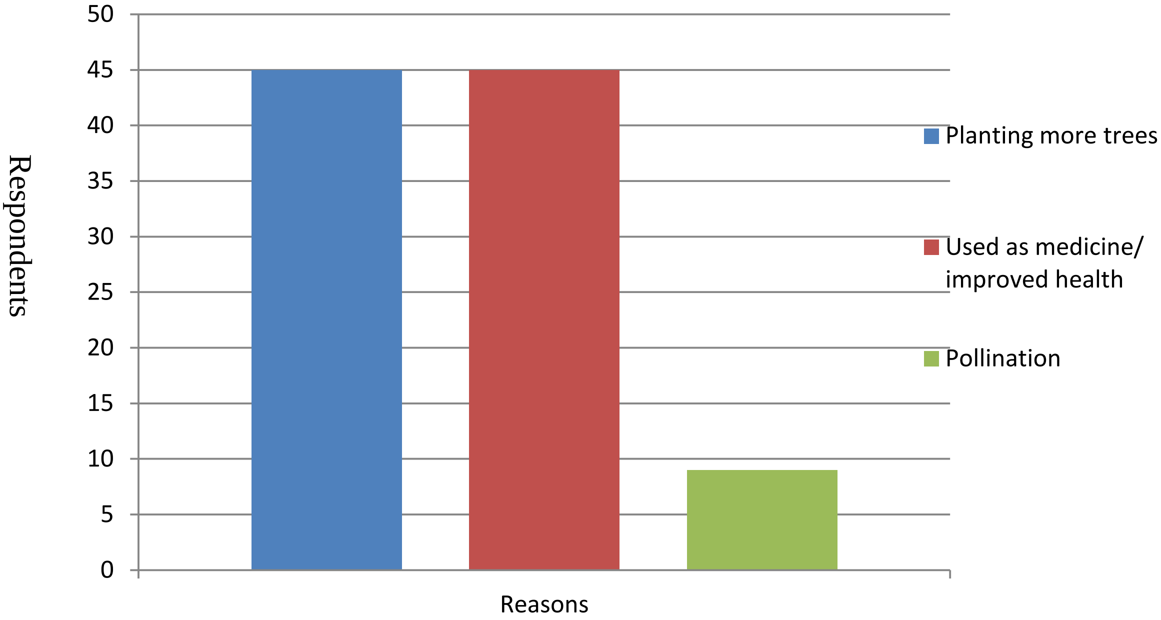

Figure 4.4 : Households reporting on major non-cash benefits of beekeeping

4.2.9 Constraints to the adoption of beekeeping technologies

Although attempts have been made to improve the adoption and productivity of beekeeping by various organizations, some social, ecological and climatic factors, as illustrated in figure 4.5 were identified as constraints which hinder farmers from adopting the available beekeeping technologies and they include the major ones discussed below:

4.2.9.1 Recurrent droughts

Mwanthi (2009) noted that droughts in the study area have increased from once every ten years to once every two years and that they are likely to increase further both in frequency and intensity due to the effects of climate change. The recurrent droughts are associated with scarcity of suitable forage and water for bees leading to absconding and migration of the colonies. This translates to substantial losses to the farmers who may not obtain any honey crop for a number of seasons.

4.2.9.2 Attack by pests and predators

The results indicate that many bee enemies exist in the area and cause considerable damage to both the hives and their products. Respondents who have adopted modern technology reported incurring huge losses as a result of hive damage by the honey badger. Considering that modern hives and accessories are quite expensive, this can hamper the adoption of this technology in the area. The study reveals that the pest and predator control methods usually advocated by extension service providers are not very effective.

4.2.9.3 Insecurity/ theft (vandalism)

Though traditionally uncommon and a taboo in many communities, theft of honey and hives is becoming a major problem in the study sites. In severe cases, vandals at times use poisonous chemicals to subdue the bees before robbing them of the honey, and in some instances carrying away the hives. This problem is often associated with the rising levels of poverty due to unemployment, especially among the youth. Measures to counter vandalism may prove to be expensive as they may include constructing bee houses to secure the hives or investing in extra measures to enhance security. These extra costs and the attendant losses act as a disincentive to the adoption of beekeeping technologies.

4.2.9.4 Low price

The price for bee products was found to be another reason why beekeepers felt it was not paying well for the much work that they did in acquiring bee products. This could have been brought about by the fact that their products were sold while in raw form. Beekeepers lacked processing skills and equipment needed and as such products sold at low price. Nightingale (1976) observed that an increase in human population and the greater freedom of movement of people has become a great enemy to the bees. Field observations and the results of group discussions indicated that in the recent past, the study area had witnessed unprecedented cutting down of valuable bee plants due to increased demand for agriculture, fuel wood and timber. Unfortunately, most of the trees that have been felled included indigenous species that take many decades to mature..

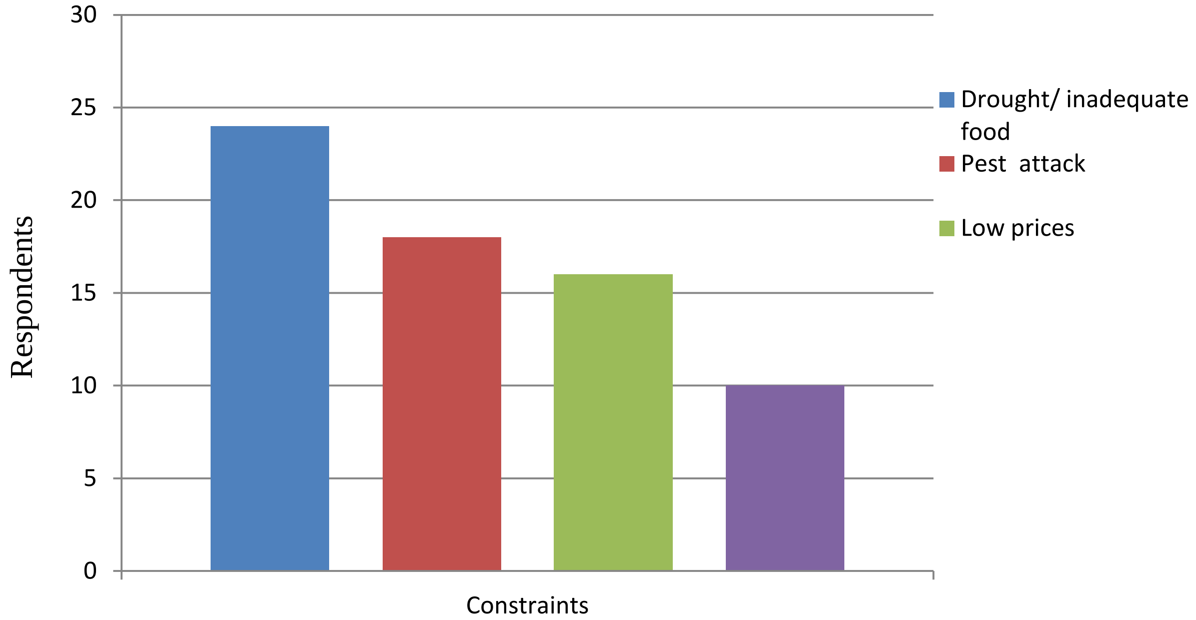

Figure 4.5: Households reporting on beekeeping adoption constraints

4.3 Regression analysis results

4.3.1 Prediction models based on land acreage per beekeeping technology

The predictor model shown can be illustrated as $Y = \beta_0 + \beta_1 X$,

Where $\beta_0 = 20.331$and $\beta_1 = -.111$, with 0.3% of the total deviations being accounted for by the regression equation. Hence the model becomes $Y= -0.111X+20.331$. And Y is the number of bee hives while X is the land acreage. This implies that land acreage may not necessarily influence the number of traditional hives that a beekeeper has.

The predictor model as shown above can be illustrated as $Y = \beta_0 + \beta_1 X$, Where $\beta_0 = 3.651$and $\beta_1 = 0.176$, with 4.3% of the total deviations being accounted for by the regression equation. Hence the model becomes *$Y = 0.176X+3.651$* and Y is the number of Langstroth bee hives while X is the total land acreage. We can conclude that land acreage in modern beekeeping has an influence regarding the number of hives.

Notes: Significant level at 5%, F=0.235, R^2=0.003, Adj. R^2=-0.010

4.3.2 Prediction models based on the number of hives a beekeeper has per bee keeping technology to predict the total harvest

The predictor model shown can be illustrated as $Y = \beta_0 + \beta_1 X$

Where $\beta_0 = -15.828$ and $\beta_1 = 4.660$, with 35.4% of the total deviations being accounted for by the regression equation. Hence the model becomes *$Y = 4.660X -15.828$.* And Y is the total harvest while X is the total number of bee hives. This indicates that number of beehives that traditional beekeeper has is a good predictor of the amount of honey harvested.

Notes: Significant level at 5%, F=35.677, R^2=0.354, Adj. R^2=0.344

The predictor model shown can be illustrated as $Y = \beta_0 + \beta_1 X$,

Where $\beta_0 = 14.047$and $\beta_1 = 3.003$, with 72.2% of the total deviations being accounted for by the regression equation. Hence the model becomes Y= 3.003X+14.047. And Y is the total harvest while X is the total number of bee hives. Hence in modern beekeeping technology, number of beehives is a key indicator of production.

Notes: *Significant level at 5%, F=28.605*, R^2=0.722, Adj. R^2=0.697

4.3.3 Prediction models based on the total harvest a beekeeper has per bee keeping technology to predict the average annual income.

The predictor model shown can be illustrated as $Y = \beta_0 + \beta_1 X$

Where β_0 = -3232.674 and β_1= 167.627, with 78% of the total deviations being accounted for by the regression equation. Hence the model becomes $Y = 167.627X - 3232.674$. And Y is the average annual income while X is the total honey harvest. Relatively amount of honey harvested serves as a good predictor of farmer's average annual income. The predictor model as shown above can be illustrated as $Y = \beta_0 + \beta_1 X$, Where β_0 = 5290.968 and β_1= 335.831, with 76% of the total deviations being accounted for by the regression equation. Hence the model becomes Y= 335.831X+ 5290.968.Y is the average annual income while X is the total honey harvest. The amount of honey harvested in modern beekeeping is found to be a strong predictor of beekeeper's average annual income.

Notes: Significant level at 5%, F=198.050, R^2=0.763, Adj. R^2=0.729

4.3.4 Binary Logistic Regression Analysis

The binary regression analysis was used to test the influence of a number of variables on household beekeeping technology adoption or non-adoption. The Chi-square statistic was found to be significant at 5%, an indication that the model parameters were jointly significantly different from zero for the adoption of beekeeping technology. The results show that age of household, and number of beehives were significant at 5% level as indicated in table4.13

Table 4.13: Maximum likelihood estimates for beekeeping technology adoption model for modern technology.

Variable	B	SE	Wald	Exp(β)
Constant	-2.965	2.346	1.598*	0.052
Age of household head	0.649	0.287	5.111*	1.913
Gender of household head	0.077	0.796	0.009	1.080
Size of household	0.118	0.407	0.083	1.125
Size of land	-0.382	0.413	0.852	0.683
No. of bee hives	1.396	0.599	5.440*	0.247

Notes: *Significant at 5%, -2 Log likelihood=78,584, Model Chi-square= 18.435

4.3.4.1 Age of respondent

Depending on the nature of the technology, age of farmer is likely to play different roles in technology adoption. The effect of this variable may either be positive or negative. Age had a positive influence on adoption of beehive technology an indication that as farmers get old they are likely to adopt beekeeping technologies. This may be due to the fact that old people have gained many years of experience in beekeeping and have cultural ties; therefore they are more confident in adopting modern beekeeping technology to help them do what they know how to do its best.

4.3.4.2 The number of bee hives

The number of bee hives owned by a beekeeper, which had a positive influence, was hypothesized to be positively related to the adoption of bee technologies because it is a representation of wealth status (Freeman *et al.*, 1996). Well-endowed farmers have extra resources to invest in new ventures and to bear any risk that may occur. This observation is in line with the findings of Degu *et al.*, (2000) who carried out studies on the adoption of seed and fertilizer packages and the role of credit in smallholder maize production in Ethiopia.

Table 4.14: Contingency table of values

Management Practices	None	Primary	Secondary/ Tertiary	Total
Routine colony inspection	7	33	6	46
Apiary management(clearing, shading)	23	54	8	85
Division making	2	9	4	15
Swarming control	6	24	4	34
Feeding	13	40	8	61
Pest control	18	40	8	66
Total	69	200	38	307

Degrees of freedom

DF = (r - 1) * (c - 1)

DF = (6 - 1) * (3 - 1)

DF = 10

Where

(r) Is the number of levels for one categorical variable, (c) is the number of levels for the other categorical variable.

Table 4.15: Contingency table of expected values

Management Practices	None	Primary	Secondary/Tertiary
Routine colony inspection	10.3388	29.9674	5.6938
Apiary management (clearing, shading)	19.1042	55.3746	10.5212
Division making	3.3713	9.7720	1.8567
Swarming control	7.6417	22.1498	4.2085
Feeding	13.7101	39.7394	7.5505
Pest control	14.8339	42.9967	8.1694

Formula for calculating Chi – square value,

Chi – square value as follows

$X^2 = \Sigma$ [(Or,c - Er,c)2 / Er,c]

X^2 =7.3982

This is at DF 10

Tabulated X^2 value at 10 DF is 18.307

- The P-value is the probability that a chi-square statistic having 10 degrees of freedom is more extreme than 7.398

  We use the Chi-Square Distribution Calculator to find P (X2 > 7.389) = 0.31.

- Interpret results. Since the P-value (0.31) is greater than the significance level (0.05), we don't reject the null hypothesis. Thus, we conclude that education level and management practice undertaking are independent. tables 4.14 and 4.15 showed contingency table of expected values.

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

The results of descriptive analysis indicated that beekeeping was an important socio-economic undertaking in the area, with 58% of the respondents being beekeepers. The majority of the beekeepers (77%) were in the age category of 18-55 years. Most of the beekeepers had large pieces of land, kept livestock and were members of self-help groups.

Two types of technology namely traditional and modern beekeeping had been adopted by beekeepers in the study area with about 65% of the beekeepers using traditional technology. The main reasons behind the preference of this technology included low cost, environmentally friendly, easy to construct and monitor and low maintenance cost. High cost and unavailability of frame hives in modern technology were the key constraints to its adoption in the area. The other constraints hampering adoption of Langstroth hives in the study area included recurrent droughts, ineffective control measures for bee pests and predators, vandalism, low prices for bee products and lack of protective clothing. The study also revealed that most of the beekeepers had no access to extension services and credit facilities. For instance, only 5% (traditional) of the beekeepers had received any form of beekeeping training. The survey further observed that about 80% of the beekeepers harvested honey at least twice while only 8% had harvested three times in the previous one year. Traditional hives produced high yields of honey with the highest beekeeper harvesting 1020 Kg while in Langstroth hives the highest harvested was 200 Kg per year. Concerning incomes, beekeepers in the traditional technology had highest levels of income Kshs. 186,600 was earned by the beekeeper with the highest yield while for modern technology Kshs. 61,000 was earned by the beekeeper with the highest honey yield. This indicated that use of frame hives did not improve the livelihood of beekeepers as compared with those in traditional technology.

The results of the linear regression analysis indicated that land acreage, the number of bee hives per beekeeper, the total honey harvested and average annual income were related (associated) and with knowledge about one of these variables was easy to predict one of the others. Models to predict the number of bee hives given land acreage, the total honey harvested given number of bee hives and average annual income given total honey harvested were generated per beekeeping technology. The results indicated that the average annual income could be best predicted using the total honey harvested in modern beekeeping. The results of the binary logistic regression indicated that the age of a household head and the number of bee hives per beekeeper had a positive and significant effect on adoption of modern beekeeping. These variables therefore enhance adoption of modern beekeeping technology.

The findings of a social-economic survey conducted in the course of this study revealed that beekeeping is ranked in the second position among the most important farming activities in Kitui County. The sector currently engages people of all educational background and in productive age group of 14-55 years or older. It therefore creates job opportunities and generates additional incomes for people in semi-arid pastoral areas and can be developed further to support rural economy.

In this study the results showed that crude honey is the major hive product that is produced and traded in Kitui County. Beekeepers cannot satisfy the annual demand for the product and do not venture into production of other products. The question of beeswax processing nevertheless should be addressed urgently since at the moment the product is either discarded as waste from honey refining and bee brewing or put into domestic use. A similar situation to the one currently being experienced in Kitui County existed in Tanzania and the suggested way out of it was by prioritizing market development of beeswax (Ntenga, 1976, Wix and Lyatuu, 1981). Kenya can therefore learn useful lessons in developing trade routes for beeswax from the experiences obtained in Tanzania and Ethiopia, two of her neighbors who are currently well established in the trade.

This study has revealed that beekeepers in the traditional system acquire good knowledge of their environment, provide substantial inputs, in the form of labor, technical and entrepreneurial skills. They have a capacity for self organization and posses' social and cultural wealth but they need sufficient opportunity to widen and diversify their resource base through extension and training. For beekeepers in modern technology, they acquired training from NGOs particularly those in Self Help Groups (SHG). Those beekeepers were also supplied with Langstroth hives as a starter package in their beekeeping project. Only a few beekeepers in Kitui County have invested in movable frame hives and even then they do not place much value on accessories. Those Langstroth hives were given to Self Help Groups in Kitui Central District by Community Development Trust Fund. A total of 640 Langstroth hives and two honey extractors were given. Shortly after the NGO left the beekeepers neglected the hives. There was low colony occupation and subsequently low yields were recorded. The beekeepers are not in good contact with extension agents who are expected to train them in the use of such equipment and therefore follow traditional colony management, honey harvesting and the processing methods after the installation of frame hives.

Movable frame hives and their accessories have been recommended for use in situations where beekeeping is viewed as a commercial venture because they make it easier to harvest honey and to apply centrifugal extraction methods that ensure products of high quality (Corner, 1985, Ogetonto and Gathuru, 1985). Besides, such equipment can enable beekeepers to produce high yields of beeswax and a wide range of hive products including pollen, propolis, royal jelly and packaged bees for external markets (Crane, 1990). However,there are disadvantages of frame hives that include their high costs and vulnerability of stored combs to the wax moth when attempts are made in principle, to carry over combs from one season to the next. ICIPE is currently engaged in research to help farmers to adopt frame hives, which are also now promoted by NGOs for use in areas of high beekeeping potential. A comprehensive proposal that was made by Townsend (1969) on how training could proceed in order to improve technical skills of beekeepers is still relevant for the Kenyan situation. Short courses lasting one to four weeks are offered at the National Beekeeping Station while groups collaborating with current beekeeping projects of ICIPE benefit from one-day training session twice a month with representatives attending an additional two months course each year (Mbae, 1997, *Raina et al, 2000).* Such formal training attempts to impart theoretical and practical knowledge concerning movable frame hives and their accessories and how these can be applied to modernize existing beekeeping systems so as to increase hive production.

Much can be learnt from reviewing past experiences in the country and from all the suggestions made about how to advance beekeeping in Kenya. The present situation has partly arisen from the fact that research lags behind the management problems faced by beekeepers. Taking the advice of FAO (1986), research should be undertaken to address issues such as pest and disease control and to adopt new production and processing technology suitable to conditions of particular ecological zones. As research is not a core function of the Ministry of Livestock Development, collaboration with partners who have an established research mandate and capacity are necessary and should be enhanced. The way forward for research and extension in beekeeping for Kitui County will be to strengthen partnerships between the Ministry and relevant institutions of research in forestry and agriculture as well as higher learning, all of which are represented on the ground in the area as was suggested in another study in Baringo by Gichora *et al*., (2001).

5.2 Conclusion

The findings of this study indicated that beekeeping was a suitable farming activity in the study area and had the potential to enhance environmental conservation as well as improve household income, nutrition and health, hence leading to poverty alleviation. The adoption of improved technology was low as the majority of the beekeepers preferred the traditional technology which often led to low quality products. Beeswax was treated as a waste hive product. However, the development of external markets could help to absorb this valuable product. Training was therefore required during harvesting and processing in order to raise the quality and quantity of honey and open the way for new hive products. Lack of an organized marketing structure had also given the middle-men an opportunity to exploit the beekeepers by offering low prices for hive products. Consequently, the government is required to play a more active role in development of external markets, and to take steps to minimize exploitation of beekeepers by middlemen in the industry. Beekeepers for their part need to come together in the form of groups and begin to actively seek solutions to their common marketing problems, which cannot be tackled on individual basis.

Although beekeeping is an important livestock enterprise among the agro pastoral households in the study area, there had been a notable decline in productivity in the last decade. This was attributed to recurrent droughts, deforestation, and inefficiency in the allocation and utilization of resources by the farmers. The existence of self-help groups played a positive role in enhancing the adoption of modern beekeeping technology particularly by women and the youth. Such groups if strengthened would in the long run be instrumental in increasing production, self-employment and food security.

5.3 Recommendations

In view of the study findings, a number of recommendations are suggested as follows:

- There was need to enhance extension services through practical on-farm demonstrations, field-days, exchange visits, information technology, use of cell phones and study tours. Extension services were found to have the highest impact on the adoption of beekeeping technologies. Appropriate packages targeting women and the youth needed to be developed in an effort to encourage adoption by these groups.

- Participatory extension approach should be adopted, drawing staff from target communities and first training them in the use of movable frame hives. They should then be trained as trainers and placed in charge of demonstration apiaries for the purpose of training interested beekeepers. For logistical reasons, demonstration apiaries should be located close to beekeepers so as to give them the opportunity to gain practical experience in modern beekeeping methods under local conditions. Women should be encouraged to participate and receive training in beekeeping following modern methods.

- Hot, dry seasons in ASALs present bees with serious shortage of water, forage and shade. Consequently conservation programs should be undertaken for preserving and propagating plants that flower during critical months. Water resources should also be developed and bee huts promoted for provision of shade thereby enhancing the survival of bees during dearth periods.

- The infrastructure supporting production, processing and the marketing of hive products is poorly developed. Therefore, in need of further expansion to attract investment and facilitate growth in the sector. Beekeeping confidence in cooperatives could be restored by adopting transparent and accountable management styles.

5.4 Suggested areas of future research

1. Intensive studies on the actual hive type performance across different agro-ecological regions of Kenya should be done. The study should cover areas such as occupation, absconding, hive temperatures, honey production and colony performance.

2. Re-evaluate the design of the frame hive to meet the conditions and the biology of the East African honey bee sub- species and races.

3. Investigate current management practices and their impact on honey production.

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APPENDICES

Appendix 1: Survey questionnaire

1. Date of the interview…………………Questionnaire no. ………………………

2. Name of enumerator…………………………………………………………..

3. Name of respondent…………………………………………………………….

4. Relationship of respondent to household head…………………………………

5. District…………………………………Location…………………………………

6. Sub-Location……………………….Village……………………………………

7. Age…………………………………Tel/Mobile No………………………….

8. Gender Male ( ) Female( )

9. Marital status Married ( ) Single ( )

10. Education level of respondent (a) None (b) Primary (c) Secondary (d) Tertiary

11. Number of dependents in the family……………………………………………

12. What is your primary occupation? ……………………………………………

13. What is the total size of your land? Acres…………………………..

14. What are the major activities on the farm?

i)………………………………… ii) ……………………………………………..

iii) …………………………….. iv) ……………………………………………

15. What are the major crops you grew during the cropping season (2010/2011)

Crop type	Acreage	Yield (bags)	Price per bag (Kshs.)

16. What is the type and number of livestock did you keep in the last one year?

Type of Livestock	Breed	Number	Value in Kshs.
Cattle			
Goats			
Sheep			
Poultry			
Donkey			
Others (specify)			

17. Did you belong to a community group in the last one year? Yes/ No

18. If yes, name of the group…………………………………………………………….

19. What have been the main activities of the group in the last one year?

i………………………………ii)………………….. iii)……………………………

20. When did you start keeping bees? (Year)……………………………………………..

21. How many hives did you have in the last one year………………………………..

22. What type (s) of hive (s) did you have in this period?

Type of hive	Number
Traditional	
Kenya Top Bar Hive	
Langstroth	
Clay hive	
Box hive	

23. Why did you prefer this type of hive(s)?

Type of hive	Reasons for choosing type of hive
Traditional	i) ii) iii) iv) v)
Kenya Top Bar Hive	i) ii) iii) iv) v)
Langstroth hive	i) ii) iii) iv) v)
Other (specify)	i) ii) iii) iv) iv)

24. How many of your hives were occupied in the last one year?

Type of hive	Number occupied	Number unoccupied
Traditional		
Kenya Top Bar Hive		
Langstroth		
Clay hive		
Box hive		
Other (specify)		

25. Did you have a persisted problem of low/non occupation in the last one year?

Yes [ ] No [ ]

26. If yes, which hive type(s) were seriously affected?

Hive type	Rank
Traditional	
Kenya Top Bar Hive	
Langstroth	
Clay hive	
Box hive	
Other(specify)	

27. What are the main reasons behind the observed occupation rates amongst the various hives?

Type of hive	Reasons behind observed occupation rate
Traditional	i) ii) iii)
Kenya Top Bar Hive	i) ii) iii)
Langstroth	i) ii) iii)
Other(specify)	i) ii) iii)

28. How many times did you harvest per season during the last one year?........................

29. What are the yields of hive production from each hive type per year?

Type of hive	Total harvested (Kgs)	Honey (kg)	Beeswax (kg)	Other products(specify)
Traditional				
Kenya Top Bar Hive				
Langstroth				
Clay hive				
Box hive				
Other (specify)				

30. Did you undertake any bee management practices in the last one year? Yes / No

Management practice	Undertaken	Not undertaken
Routine colony inspection		
Apiary management(clearing, shading) etc		
Division making		
Swarming control		
Feeding		
Pest control		

31. Do you have any beekeeping accessories?

Yes [ ] No [ ]

If yes, which accessories did you have and use in the last one year?

a) ………………………………………………………………………………

b) ………………………………………………………………………………

c) ………………………………………………………………………………

If No, why did you not have the accessories?

a) ……………………………………………………………………………….

b) ……………………………………………………………………………….

c) ………………………………………………………………………………

32. Was there any absconding? Yes [ ] No [ ]

If yes, what were the main reasons for absconding?

a)………………………….b)……………………..c)……………………………..

d)………………………….e)……………………f)……………………………

33. What bee pest/ predators did you encounter in your apiary/ hives?

Pest/ Predator (local name)	Common name	Botanical name

34. What are the major bee plants in your farm/ area during the last one year?

Local name	Common name	Botanical name

35. Have you had any training on beekeeping? Yes [ ] No [ ]

36. Did you have regular contact with extension service providers promoting beekeeping in the last one year? Yes [ ] No [ ]

37. If yes, how many times did you have contact in the last year? ……………….

38. Are you expanding your beekeeping activities? Yes [ ] No [ ]

39. If yes, how are you doing it?

a) …………………………………………………………………………………

b) …………………………………………………………………………………

c) …………………………………………………………………………………...

d) …………………………………………………………………………………

40. If No, what are the reasons for not expanding?

a) …………………………………………………………………………………

b) …………………………………………………………………………………

c) …………………………………………………………………………………...

d) …………………………………………………………………………………..

e) …………………………………………………………………………………

41. How much honey did you sell in the last year? (Kgs) ……………………….

42. Where did you sell the honey and at what price?

Market	Price per Kg(Kshs.)	Remarks (raw or refined honey)
Local consumers		
Middlemen		

43. How is the demand for honey in your area? High [ ] Low [ ]

44. Did you process your honey in the last year? Yes [ ] No [ ]

45. If yes, which methods did you use?

i. ……………………………………………………………………………….
ii. ……………………………………………………………………………
iii. …………………………………………………………………………..

46. What was your average income from the beekeeping enterprise during the last year?

(Kshs) ……………………………………...............................

47. Are there any other benefits (non cash) that you can attribute to beekeeping enterprise? Yes [ ] No [ ]

48. If yes, which are the major ones?

i. ………………………………………………………………………………..
ii. ……………………………………………………………………………….
iii. ………………………………………………………………………………

49. What constraints did your beekeeping enterprise face in the last one year?

i. ………………………………………………………………………….
ii. …………………………………………………………………………
iii. …………………………………………………………………………..

50. Did you ever receive any credit / loan for your beekeeping project in the last one year? Yes [ ] No [ ]

51 If yes, from which institution did you get the credit? ………………………
i) Government agency [ ]

(ii) Non-Governmental Organization (NGO) [ ]

iii) Group (Merry Go Round) [ ]

(iv) Bank [ ]

(v) Any other source (specify) [ ]

………………………………………………………………………………

52. What is your view on the requirements of practicing modern beekeeping techniques compared to the traditional practices? Modern beekeeping requires:

Requirement	More	Less	Equal
Management time			
Cost			
Knowledge			
Land			
Labor			
Other,(specify)			

Appendix 2: Chi- squared distribution table of values

(Chi - squared) Distribution: Critical Values			
	Significance level		
DF	5%	1%	0.10%
1	3.841 6	.635 10	0.828
2	5.991 9	.210 13	0.816
3	7.815 1	1.345 1	6.266
4	9.488 1	3.277 1	8.467
5	11.07	15.086	20.515
6	12.592	16.812	22.458
7	14.067	18.475	24.322
8	15.507	20.09	26.124
9	16.919	21.666	27.877
10	18.307	23.209	29.588

Source: StaTable.pdf (application/pdf Object)

Appendix 3 (a):Hive population and production in Kenya (2005, 2006, and 2007) Provincial summaries

Province	2005					2006					2007				
	Hives			Products		Hives			Products		Hives			Products	
	Log	KTBH	Lang	Honey Kgs	B/Wax	Log	KTBH	Langs troth	Honey Kgs	Bee Wax	Log	KTBH	Langs troth	Honey Kgs	B/ Wax
Rift Valley	275,029	58,275	8373	6,674.534	667,453	988,165	56,272	8,328	7,079,072	101,368	358,668	71,977	31,491	5,561,616	71,581
Eastern	856,724	18,815	8,379	18,226,079	15,833	814,827	21,251	5,560	9,237,691	19,286	942,643	18,815	17,752	7,192,181	38,547
Central	31,980	21,276	3,735	1,069,110	106,911	18,051	22,073	9,615	1,080,758	-	33,371	23,107	3,855	589,767	12,369
Western	9,271	7,069	3,316	386,165	39,816	1932	7,059	1342	389,165	1982	18,706	13,868	9,615	386,505	3,244
Nyanza	1,781	8,583	1,838	189,629	18,962	16,869	8,394	102,351	205,933	9504	2,214	8,583	1,838	212,226	13,720
Coast	19,790	6,518	6,591	691,390	717	2,175	7493	51	584,199	126	19,790	6,518	6,591	691,390	623
North Eastern	5,669	1,102	57	136,073	13,307	25	120	208	4,819	-	4819	609	52	13,300	4
Nairobi	150	356	263	6500	620	150	356	268	6,202	551	150	356	263	6500	567
Grand Total	1,205,614	122,003	28,917	27,379,481	863,619	1,053,296	60,853	127,455	18,587,839	132,817	1,350,361	143,833	81,784	14,653,485	140,661

Source: National Beekeeping Station quarterly and annual reports 2007

Appendix 3 (b): Hive population and production in Kenya (2005, 2006, and 2007), Eastern Province

District	2005					2006					2007				
	Hives			Products		Hives			Products		Hives			Products	
	Log	KTBH	Langs troth	Honey Kgs	B/Wax	Log	KTBH	Langs troth	Honey Kgs	Bee Wax	Log	KTBH	Langs troth	Honey Kgs	B/ Wax
Embu	4280	1065	650	47,120	4800	3880	1270	650	47,356	3785	4280	1065	650	47,120	-
Mbeere	37306	148	267	741,359	-	36170	141	196	890,020	8900	37306	148	267	76,020	-
Meru North	10850	1395	133	26,240	-	10850	1395	133	149,951	1495	10850	1395	133	38,440	-
Meru Central	21595	1409	16	54,000	-	21595	1409	16	540,000	-	21595	1409	16	540,000	-
Meru South	24604	255	61	42,790	-	23344	268	202	380,000	-	23344	265	226	427,900	-
Tharaka	21392	86	7	-	-	21392	86	7	32,900	-	21392	86	7	217,000	-
Machakos	30339	11089	3000	21,700	-	30339	11089	3000	51,063	-	30339	1089	3000	57,800	8180
Kitui	295760	742	1879	-	-	369111	1069	2540	2,747,121	-	401488	1268	2833	2,747,121	30347
Mwingi	162850	139	397	503,826	8900	162850	139	397	3,421,000	5106	162850	139	397	3,421,000	-
Makueni	680	693	544	51,063	-	132422	698	766	974,990	245	140406	708	7466	101,000	-
Isiolo	2582	115	8	-	-	2582	115	42	3,290	-	2582	115	60	4680	-
Marsabit	387	920	-	-	-	387	920	10	-	-	387	920	14	-	-
Moyale	292	205	-	-	-	292	205	4	-	-	292	205	10	-	-
Total	856,724	18,815	8,379	18,226,079	15,833	814,827	21,251	7,963	9,237,691	19,286	942,643	18,815	17,752	7,192,181	38,547

Appendix 3 (c): Beekeeping comparative Districts

District	Log hive	KTBH	Langstroth	Honey Production (Kg)
Kakamenga	1987	900	799	18000
Taita taveta	3797	2413	2713	28112
Bungoma	2630	3010	665	118400
West Pokot	14643	860	50	165440
Mwingi	162892	139	397	503826
Laikipia	42092	13006	1308	637967
Kitui	295760	742	1879	2747121

Source: National Beekeeping Station quarterly and annual reports 2007