THE STATUS OF BEEKEEPING AND ITS POTENTIALS FOR DEVELOPMENT IN MANYONI DISTRICT, SINGIDA REGION, TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN THE MANAGEMENT OF NATURAL RESOURCES FOR SUSTAINABLE AGRICULTURE OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

This study was carried out between November 2013 and September 2014 to determine the status of beekeeping industry and its potentials for development in Manyoni District, Singida Region, Tanzania. The methods used included reconnaissance, field and social surveys using questionnaires on the household heads and checklists of probe questions with key informants. Data collected was analysed using SPSS software. The results revealed that the adoption status of beekeeping in the district was currently 70% and although it had started earlier than the 1970s, initially the adoption accelerated in the 1990s and 2000s. Most of the beekeeping activities were based on traditional practices using log and bark hives but the use of the modern bee hives is growing rapidly. Moreover, the results indicated that beekeepers have rich indigenous knowledge on beekeeping activities which they utilize effectively in identifying appropriate local baiting materials, tree species for hive construction and preferable bee forage plants. Most of the beekeepers harvest honey by using fire to calm down the honeybees; processing and storage of honey is locally done. The mean annual honey yield from commercial bee hives was highest followed by log bee hives, gourd hives, bark hives, Tanzania Transitional Hives and stingless bee hives. Beekeeping plays a significant role in the socio-economic development through generation of cash incomes and contribution to food security. Inadequate training and extension services, lack of capital, unreliable markets, long distance from homesteads to apiaries, fear of bees, theft of hives and forest degradation were the main constraints to beekeeping. The study therefore, recommends that the Government should enhance availability of proper beekeeping equipment, training and extension services, accessibility to credit facilities,

formulation of coordinated marketing strategies of the bee products and promotion of beekeeping integration into the agroforestry practices to ensue sustainable supply of bee forage and water resources for enhanced sustainability of productivity and the beekeeping industry.

DECLARATION

I, KASSIM ALLY do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has neither been nor being concurrently submitted for a higher degree award in any other institution.

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25/05/2015

Date

The above declaration is confirmed

Prof. L. L. L. Lulandala
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25/05/2015

Date

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DEDICATION

This work is dedicated to my parents, my late father Ally Ramadhani and my mother Halima Seleman who laid the foundation of my education, my beloved wife, Aziza Lotta and our daughters Aisha and Salma, my brother Ramadhan Ally and my sisters Mariam, Asha and Nadhifa for their love, encouragement and patience throughout the period of my study.

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LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of Variance
BDP	Beekeeping Development Project
BOA	Bureau of Agriculture
CBOs	Community Based Organizations
CIFOR	Center for International Forestry Research
CODIT	The Institute of Community and Organizational Development
CRBD	Completely Randomized Block Design
CSOs	Civil Society Organizations
DBO	District Beekeeping Officer
DFO	District Forest Officer
DRC	Democratic Republic of Congo
EIA	Environmental Impact Assessment
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FBD	Forestry and Beekeeping Division
FGDs	Focused Group Discussions
JAICAF	Japan Association for International Collaboration in Agriculture and Forestry
KTBH	Kenyan Top Bar Hives
LSD	Least Significant Difference
MKUKUTA	Mkakati wa Kukuza Uchumi na Kupunguza Umaskini Tanzania
MS Excel	Microsoft Excel
NGOs	Non Governmental Organizations

NSGRP	National Strategy for Growth and Reduction of Poverty
SED	Standard Error of the Difference
SACCOS	Savings and Credit Cooperative Societies
SIDO	Small Industries Development Organisation
SPSS	Statistical Package for the Social Sciences
TBH	Top Bar Hive
TFS	Tanzania Forest Services Agency
TShs	Tanzanian Shillings
UGX	Ugandan Shilling
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
URT	United Republic of Tanzania
USAID	United States Agency for International Development

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Beekeeping is defined as the art and science of managing honeybees for production of honey, beeswax and other bee products for domestic consumption and commercial purposes (JAICAF, 2009; Ajani *et al.*, 2013; Ajao and Oladimeji, 2013). Beekeeping has been practiced since ancient times and honey has been considered by many cultures as a valuable natural resource that is used as food, medicine, cash crop for both domestic and export markets and as an important part of some traditional rituals (Bradbear, 2009; Ajao and Oladimeji, 2013; Tesfa *et al.*, 2013). Honeybees: *Apis mellifera* (Elisa and Roth, 2008; Bradbear, 2009) and stingless bees of the genera *Meliponula, Hypotrigona, Dactylurina, Liotrigona, Cleptotrigona* and *Plebeina* occurring in Tanzania (Eardley, 2004) are also an essential component of agro-ecosystems (URT, 1998; 2001). As pollinators, they provide an essential ecosystem service that results in the reproduction of many plants (Elisa and Roth, 2008; Bradbear, 2009; Johnson, 2010).

Around half of all plants or plant products consumed by humans depend directly or indirectly on bees for their pollination (Lepetu *et al.*, 2001; FAO, 2006; Bradbear, 2009; Hein, 2009). Studies conducted to evaluate the effect of honeybee pollination reveal that honeybees can increase the yield of sunflowers and water melons by 100%, tomatoes by 50% and oranges by 30% (Lepetu *et al.*, 2001; Hein, 2009; EU, 2013). These indicated that honeybees have a vital role in increasing food production and overall agricultural productivity. Bees and beekeeping contribute to peoples' livelihoods in almost every country on earth.

They benefit society by increasing household food and income livelihoods and also conservation of biological diversity in agricultural and natural ecosystems (Bradbear, 2009; Yirga and Teferi, 2010; Ajao and Oladimeji, 2013).

Beekeeping for honey production has been identified as one of the most lucrative enterprises in many parts of the world (USAID, 2012; Ajao and Oladimeji, 2013) including Tanzania. In 2010, China was the highest global producer of honey followed by Turkey, US, Ukraine and Argentina. Ethiopia is the leading producer of honey in Africa, while Tanzania is the second largest honey producer in Africa but the top African supplier to the EU (USAID, 2012). In Tanzania, bees and beekeeping contribute to income as well as food and nutritional security through provision of honey and pollen as food, beeswax, propolis, royal jelly and bee venom as medicine (URT, 2001; Kihwele, 2003). With the estimated potential of about 138 000 tonnes of honey and 9 200 tonnes of beeswax per annum, the sector has been estimated to generate about US$ 1.2 million each year from sales of honey and beeswax and employs about 2 million rural people (URT, 1998, 2001; Mwakatobe and Mlingwa, 2006). With such economic output, beekeeping gives local people and the government economic incentives for the retention of natural habitats such as forests and therefore it is an ideal activity in any forest conservation programme (Debissa, 2007; CIFOR, 2008; Bradbear, 2009).

Studies conducted in Tanzania have shown that 90% of beekeeping activities are mainly carried out by old men of over 40 years while participation by women and youth is low or non-existent in some areas of the country (Kihwele, 2003). This is attributed to the belief that beekeeping is for old men and is associated with witchcraft (URT, 2001; Kihwele, 2003).

Moreover, the sector is also faced with other major constraints that act as setbacks for its development.

These constraints include: inappropriate harvesting, processing, storage and packaging technologies; increased loss of beekeeping areas due to deforestation and forest degradation (CIFOR, 2008; Bradbear, 2009; FAO, 2012) inadequate and ineffective extension services; lack of market information; inadequate entrepreneurship skills among beekeepers; inaccessibility to markets; inadequate skills in the use of improved technologies, poor use and access to improved production technologies; drought; absence of coordination between research, extension and farmers and lack of adequate statistical information to guide plans and operations for development of the sector (URT, 1998).

Most of the existing information on beekeeping in Tanzania is based on unreliable estimates which are not sufficient enough to justify the prediction of current potential of the sector on the basis of the on-going human activities such as intensive use of monocultural agriculture, increasing massive deforestation (Mickels-Kokwe, 2006; Bradbear, 2009; CIFOR, 2008, 2010) and use of pesticides which are major threats to the sector. Improved production, processing, product quality and marketing of bee products are necessary for improving the income base of communities and will contribute to the achievement of the national goal of poverty reduction (URT, 2001).

1.2 Problem Statement and Justification

In most areas in Tanzania, beekeeping is carried out in the natural forests except for some areas particularly in Kilimanjaro and Arusha regions where it is carried out in Agroforestry areas (URT, 2001).

Stingless bees are also kept within homesteads to ensure sustainable supply of honey and pollination services (URT, 1998; 2001; Bradbear, 2009). However, the most important areas for beekeeping in Tanzania are Tabora, Singida, Dodoma, Shinyanga, Rukwa, Kigoma and Mbeya regions, due to the dominance of the Miombo Woodland vegetation in these areas which is one of the most preferred habitats by honeybees (World Bank, 2008; CIFOR, 2010; URT, 2001, 2011). Among these important beekeeping areas in Tanzania is Manyoni District in Singida Region, which has a potential of producing 8 000 tonnes per annum.

However, despite this high production potential, Manyoni District is actually producing only 600 tonnes per annum, which is less than 10% of its potential (URT, 2001). The proposed study therefore intends to fill this information gap by assessing the status of beekeeping in Manyoni District. The information gained from this study will be used as an input in research and baseline information for future development planning and projection by policy makers to enhance beekeeping as a potential livelihood option to most communities in the district and the country at large.

1.3 Objectives

1.3.1 Main objective

Determining the current status of beekeeping industry and its potentials for future developments in Manyoni District, Singida Region, Tanzania

1.3.2 Specific objectives

i. To determine the current extent of beekeeping and bee hive technologies in use and levels of production in Manyoni District.

ii. To establish its contribution to household food and income livelihood of the communities in Manyoni District.

iii. To identify factors influencing the development of the beekeeping industry and measures required for its upscaling.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Beekeeping Practice and Bee hive Technologies Used in Tanzania

Beekeeping is the most widely spread practice in the farming communities of Miombo woodlands in Tanzania, and has been carried out using traditional methods which involve limited management of bees (Kihwele *et al.*, 2001; Lalika and Machangu, 2005; Bradbear, 2009; CIFOR, 2010; Ajao and Oladimeji, 2013). Generally traditional beekeeping practices involve the use of simple and localy available tools where honey and beeswax can be collected from the forests and homesteads (Elisa and Roth, 2008; Bradbear, 2009; Mujuni *et al.*, 2012; Ajani *et al.*, 2013; Gemeda, 2014). For instance, hives are hung up on tree branches normally far from homesteads (up to 80 kilometres away from villages) and left to attract bee swarms (URT, 2001; Kikula *et al.*, 2003; Bradbear, 2009; Ilomo *et al.*, 2011).

However, the high potential for beekeeping has given rise to various initiatives such as introduction of manufactured equipment like the protective gears, frame hives and later the top bar hives (Tsutsumi and Oishi, 2010; UNDP, 2012). These initiatives are aimed at improving the efficiency and productivity of traditional methods (URT, 2001; Bradbear, 2009; Chile, 2010). Modern bee hives and their associated technologies made the processes of bee management and honey extraction easier and more efficient (Ajani *et al.*, 2013; Webster and Burgess, 2013), but modern beekeeping got slowly adopted by traditional beekeepers (URT, 2001; Verma and Attri, 2008; Liwenga and Masao, 2009).

2.2 Contribution of Beekeeping to Household Food and Income

Beekeeping is one of the most important income-generating activities in the rural communities especially in dry land areas where it forms alternative sources of livelihood for many subsistence farmers (Mickels-Kokwe, 2006; Debissa, 2007; Ebojei *et al.*, 2008; CIFOR, 2008; Bradbear, 2009; Berhane, 2010; Ayansola, 2012; Ajao and Oladimeji, 2013; Gemeda, 2014). It is an integral part of the smallholder farming systems that contribute to poverty alleviation through income generation, providing food and improved nutrition (Bradbear, 2009; Liwenga and Masao, 2009; Yohannes *et al.*, 2009; Ayansola, 2012; Ajao and Oladimeji, 2013; Musumhi, 2013), medicine and foreign exchange earnings through sustainable production of bee products (Lalika and Machangu, 2005; Mwakatobe and Machumu, 2008; CODIT, 2009; Lietaer, 2009; Berhane, 2010; Gallmann and Thomas, 2012; URT, 2012; Ajao and Oladimeji, 2013; Tesfa *et al.*, 2013; Tirado *et al.*, 2013; Gemeda, 2014). As pointed out by Pokhrel (2004), 78.35% of the total income of beekeepers in Nepal was from beekeeping and the rest from agriculture (Mary and Majule, 2009; FAO, 2012; URT, 2011; Bwalya, 2013). In Amhara region, Ethiopia beekeepers reported to earn up to 3 000 Birr (about US$ 353) annually from honey selling only which contribute the largest portion of their annual incomes (BOA, 2003; Kerealem *et al.*, 2009; Bradbear, 2009).

2.3 Factors Influencing the Development of Beekeeping Industry and Measures Required for its Upscaling

2.3.1 Enhancing factors

In Tanzania beekeeping provides a good example of one activity which has a strong local tradition (Elisa and Roth, 2008; Bradbear, 2009; Masara, 2010; Shenkute *et al.*,

2012; Ajao and Oladimeji, 2013; Tesfa *et al.*, 2013), where there is a local market and which is environmentally beneficial (URT, 1998, 2001; UNCTAD, 2006; Abebe *et al.*, 2008; Matanmi *et al.*, 2008; Bradbear, 2009; Hein, 2009; Kajobe *et al.*, 2009; Gurung *et al.*, 2012; Mbah, 2012; Ajani *et al.*, 2013; Gemeda, 2014). The main opportunities for beekeeping development in Tanzania include high populations of bee colonies coupled with the vegetation types that are preferred by honeybees (Mbuya *et al.*, 1994; URT, 1998, 2001; Kihwele *et al.*, 2001; World Bank, 2008; Bradbear, 2009; Masara, 2010; Tesfa *et al.*, 2013). Moreover, the Government has put in its agenda the need to develop beekeeping as one of the strategies to reduce poverty as defined in the National Beekeeping Policy of 1998 which is implemented through the National Beekeeping programme (URT, 1998, 2001; Milledge *et al.*, 2007; Chnayalew *et al.*, 2009; URT, 2011; FAO, 2012; Msuya and Kideghesho, 2012; Tirado *et al.*, 2013).

2.3.2 Limiting factors

2.3.2.1 Lack of capital

While there are favourable climatic and socio-economic environments, low-cost needed to start a beekeeping industry and sufficient availability of honeybee resources, the participation of people is still low in many rural areas (Bradbear, 2009; Mujuni *et al.*, 2012). Lack of capital is a critical factor to most beekeepers since they cannot afford to buy improved bee hives that are appropriate for optimum honey production (Mbah, 2012; Ajao and Oladimeji, 2013). This situation allows only the few who are willing to participate in beekeeping to practice traditional beekeeping technology (Bradbear, 2009; Kerealem *et al.*, 2009; Yirga and Teferi, 2010; Mbah, 2012; Ajani *et al.*, 2013).

2.3.2.2 Shortage of manpower and extension services

Beekeeping is one of the disciplines which suffered and is still suffering from the lack of skilled manpower, appropriately skilled trainers (URT, 1998, 2001; Kerealem *et al.*, 2009, 2012) and training materials in Tanzania (URT, 1998, 2001; Kerealem, *et al.*, 2009; Fakayode *et al.*, 2010; Kinati *et al.*, 2012; Pokhrel, 2012). The majority of the beekeepers lack the knowledge of beekeeping which results into inappropriate methods of management of bee colonies, inadequate and inappropriate processing and storage facilities (URT, 2007; Bradbear, 2009; Kerealem *et al.*, 2009; Gurung *et al.*, 2012). Professional training in Tanzania is inadequate and training curricula have not been updated to meet the needs of multiple use beekeeping (URT, 1998, 2001; Kerealem, *et al.*, 2009; Fakayode *et al.*, 2010; Kinati *et al.*, 2012; Pokhrel, 2012). The only Beekeeping Training Institute (BTI) in Tabora provides basic training to farmers, technicians and experts to the level of Ordinary Diploma (URT, 1998). However, this does not meet the ever increasing demand of trained manpower in Tanzania (URT, 1998, 2001, Ngaga *et al.*, 2005; Yirga and Teferi, 2010). The relationships between beekeepers and research institutions are not yet strengthened in such a way to solve current issues facing the sector. Beekeeping extension services are not effectively reaching the beekeepers and other stakeholders involved in beekeeping (URT, 2007; Abebe *et al.*, 2008; Bradbear, 2009; Cadwallader *et al.*, 2011; Kerealem, *et al.*, 2012; Mujuni *et al.*, 2012). Due to this problem, goods and services of the beekeeping sector have remained low in terms of quality and quantity. A well-functioning beekeeping extension service (URT, 1998, 2001; Kikula *et al.*, 2003; Bhusal and Thapa, 2005; Bradbear, 2009; Chnayalew *et al.*, 2009; Masara, 2010; Mpokigwa *et al.*, 2011), is therefore, a prerequisite for the appropriate promotion of beekeeping activities in rural areas where beekeeping potential exists.

2.3.2.3 Poor infrastructure and marketing

Beekeeping is a rural based activity but some of the rural areas in Tanzania are not easily accessible due to poor infrastructure which affects both, transportation and marketing of bee products (Sustainet, 2006; Bradbear, 2009; Aikaeli, 2010; URT, 2012). As pointed out by Ngaga *et al.* (2005) and Tesfa *et al.*, (2013), development of beekeeping activities for income generation and forest management is hampered by poor transport infrastructure and marketing systems for bee products. Due to poor transport and infrastructure, bee products fail to reach the markets in time as most of the local markets are far away and are inaccessible (Sustainet, 2006; Tsutsumi and Oishi, 2010; Bradbear, 2009; Aikaeli, 2010).

2.3.2.4 Shortage of bee forage and pesticides poisoning

One of the major concerns of beekeepers is insufficient flow of nectar sources for honeybees throughout the year (URT, 2001; Kinati *et al.*, 2012). Population pressure, charcoal making, demand for farmlands (Elisa and Roth, 2008; Yirga and Teferi, 2010), illegal harvesting and mining activities (Iddi, 2002; Mickels-Kokwe, 2006; CIFOR, 2008) are among the causes for the decline of natural forests which are the main bee forage sources of nectar and pollen. Likewise, wild fires hamper the beekeeping development as the bee hives are burnt, bees are killed and the favourable environment is destroyed (CIFOR, 2008; Bradbear, 2009; Heaf; 2009; Mary and Majule, 2009). Indiscriminate application of pesticides in crop fields may destroy the whole population of honeybees (Lepetu *et al.*, 2001;. Somerville, 2007; Tsutsumi and Oishi, 2010; Tesfa *et al.*, 2013).

2.3.3 Interventions required for beekeeping improvement

Beekeeping in Tanzania is a forest-based industry that is currently threatened by forest resources depletion (Mickels-Kokwe, 2006; Abebe *et al*, 2008; CIFOR, 2008; Bradbear, 2009) which can lead to decline of bee forage plants (Vlek *et al.*, 2003; Elisa and Roth, 2008; Liwenga and Masao, 2009; Yirga and Teferi, 2010). Agroforestry interventions could help to plan for type of plants that are suitable for honeybee forage and plant them to facilitate enough forage in order to maximize production and improvement in the quality of honey in a suitable manner and conservation of the environment (Belie, 2009; Lulandala, 2012). Agroforestry could help to reduce pressure on natural forests by encouraging beekeeping on farmers' field (Swai *et al.*, 2003; Lulandala, 2012; Msuya and Kideghesho, 2012); this could even open a scope of women and youth to participate in beekeeping as agroforestry is promoted among communities (Debissa, 2007; Belie, 2009; Lulandala, 2012).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Geographical location of the study area

The study was conducted in six villages namely Hika, Kayui, Mwamagembe, Saranda and Sasilo in Manyoni District (Figure 1). Geographically, Manyoni District is located between latitudes 5^0 30' and 7^0 34'. Longitudinally the District is situated between 33^0 27' and 35^0 26' East of Greenwich. The district occupies a total area of 28,620 km^2 that is about 58% of the entire area of Singida Region. The district has a common border with Singida District in the north, to the North East, it shares a border with Kondoa District, and to the west it shares a border with Tabora and Sikonge Districts. The district borders Bahi District, to the east while, to the South West shares the border with Chunya District and to the south east it borders with Iringa District (URT. 2011).

3. 1.2. Description of the Study area

3.1.2.1 Climate

The district forms part of the semi-arid central zone of Tanzania which experiences low rainfall and short rainy seasons, which are often erratic with fairly wide spread drought in one year out of four. The district has a unimodal rainfall regime, which is concentrated in a period of six months from November to April and the long dry season from April to November. Total annual average rainfall ranges between 500mm to 700mm per annum and temperatures range between 15°C and 32°C (URT, 2011).

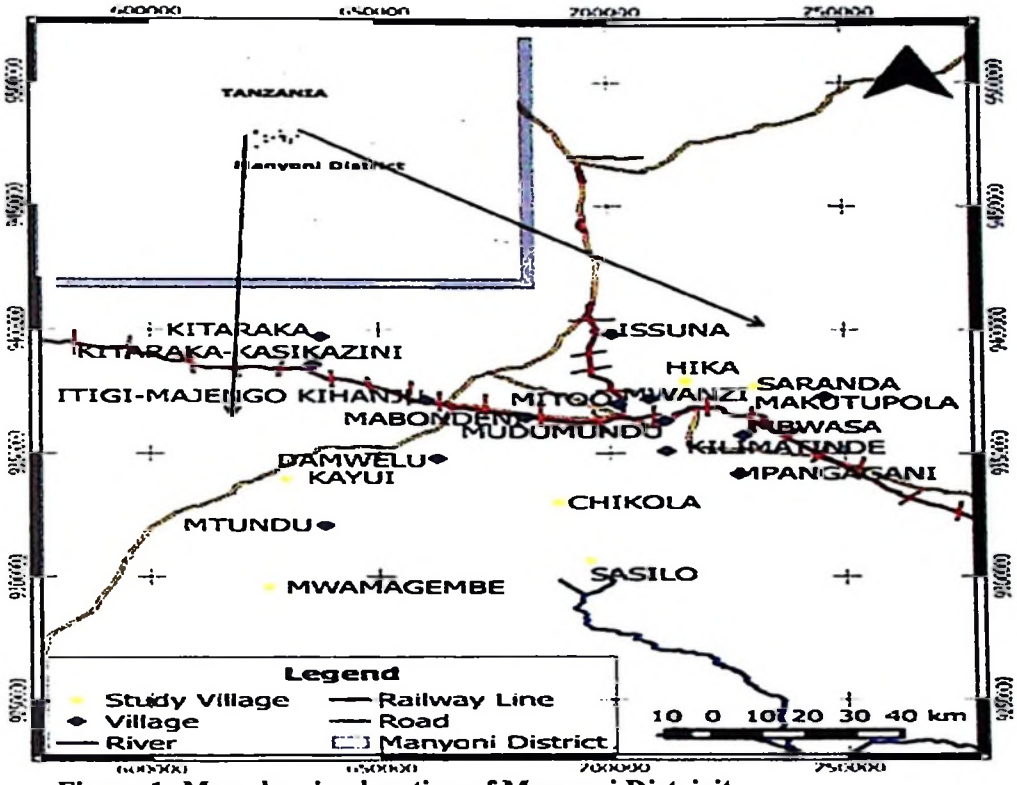

Figure 1: Map showing location of Manyoni Districit

3.1.2.2 Administration and population

The district is divided into 5 divisions, 30 wards, 99 villages and 356 subvillages. According to Population and Housing Census of 2012, the population in Manyoni District is 296 763 (URT, 2013).

3.1.2.3 Land use and vegetation

Eighty five percent, of the district's area is occupied by Forests and Game Reserves (Rungwa, Muhesi and Kizigo), 15% is the area of residence and agricultural activities. Manyoni is characterized by a mixture of grasses and shrubs including special shrubs commonly known as Itigi thickets, the larger part, which is much drier, is characterized by Miombo woodlands (URT, 2011).

3.1.2.4 Economic activities

The main economic activities in Manyoni District are farming, livestock keeping, beekeeping and trade. The major crops grown are sweet potatoes, maize, rice, cassava, legumes, sorghum and millet while cash crops are sunflower, cotton, groundnuts, onion, simsim, tobacco, yellow gram and green gram. Livestock kept include cattle, sheep, goats, chicken, ducks, guinea fowls, pigs, donkeys and rabbits (URT, 2011).

3.2 Methods

3.2.1 Sampling procedure

The district was purposively stratified into three zones based on altitude (580-900; 900-1200 and 1200-1480 meters above sea level) for low, mid and high altitude zones respectively. The essence of stratification was getting parts of the landscape that are more or less homogenous. In each zone, two wards, one village per ward and thirty (30) households per village were randomly selected for detailed study thus making a total of 180 sample households. In addition to 180 sample size of households, there were also a total of 19 key informants including 6 village leaders, 6 village elders, 6 traders of bee products, and the District Beekeeping Officer. The sampling frame was village registers and sampling units were heads of households, which were randomly selected from the village registers.

3.2.2 Data collection

3.2.2.1 Reconnaissance survey

Data collection session was preceded by a reconnaissance survey, which was conducted for the purpose of providing a general picture of the study area, ascertain sampling process and to help in improvement of the study plans and explain objectives of the study to various administrative levels.

Reconnaissance survey was also used to pretest the questionnaire to check if it was bringing the intended information.

3.2.2.2 Social survey

This was conducted using questionnaire, Focused Group Discussions (FGDs). and checklists of probe questions.

(i) Questionnaire

Semi structured questionnaires with both open and closed-ended questions was used as a tool to interview the household's head (Appendix 1).

(ii) Focused Group Discussions

Focus Group Discussions were conducted with people who are knowledgeable and have experience on beekeeping. Participants were selected based on their time convenience and were briefly interviewed to qualify for group discussion. FGD were conducted in order to complement, supplement and crosscheck information given by other methods. FGD were used to get more in-depth information and identifying constraints and interventions for development of beekeeping with the aid of household questionnaires through opening up discussions with participants.

(iii) Key informants interview

Interview with key informants were used to collect data on various issues on beekeeping. The key informants in this study included village leaders and elders, traders of bee products present in the study area and the District Beekeeping Officer. Checklists of probe questions were used to obtain information from key informants (Appendix 2).

3.2.2.3 Field survey

The survey was conducted in the study area to confirm the information obtained during interviews.

Also this survey assisted the researcher to have a general picture on the various beekeeping technologies adopted and tree species useful for beekeeping through visiting apiaries, honey processing and storage facilities. According to Katani (1999), much information can be obtained by simply observing what goes on. It is always essential to keep one's eyes on when visiting the farm and to check what you are told against what you see (Lema, 2003).

Secondary data

Secondary data were gathered through literature review from various sources of published information including government reports, electronic sources on the internet and from libraries.

3.2.3 Data analysis

Data collected were coded to facilitate data entry, where SPSS version 16.0 was used to obtain frequency distribution, percentages and cross tabulation of responses from interviewed samples. Statistical analysis and interpretation of percentage data were done by first converting them into arcsine angle values and then subjecting them to MS Excel where Two Way ANOVA using CRBD was used to determine whether there were significant differences between parameters under study. Moreover, the LSD was used to compare treatment means which were subsequently identified by letters i.e. a, b, c and d (Kothari, 2004). Detailed calculations are shown in the Appendices 3a - 16b.

CHAPTER FOUR

4.0 RESULTS

4.1 The Extent of Beekeeping Technologies in use and Levels of Production in Manyoni District

4.1.1 The extent of adoption of beekeeping in Manyoni District

The results on the extent of beekeeping in Manyoni District are presented in Table 1. It will be noted that, until the time of the study. on the average 70% of the population in Manyoni District had adopted beekeeping, the rate of adoption varies with altitude and the adoption is less evenly spread throughout the district. From high altitude more people are involved in beekeeping as compared to low altitude.

4.1.2 The trend of beekeeping adoption in Manyoni District

The results in Tables 2 and 3 present the cumulative and periodic trends of beekeeping adoption over the past 40 years. Their statistical details are provided in Appendices 3a and 3b. It will be noted that beekeeping in Manyoni District started earlier than the seventies, the adoption trends started gradually during the initial 5 years. The adoption drastically accelerated during the later 30 years and reached a maximum of 70% by 2013, this is perhaps due to greatly sensitized communities and the realised benefits.

Table 1: The extent of beekeeping adoption in various zones of Manyoni District

Ecological zones	Percent
Higher altitude zone	88a
Mid altitude zone	70b
Low altitude zone	53c
Average	**70**

The values within the same column with the different following letters do differ significantly ($p<0.05$).
LSD = 16.0

Table 2: Cumulative trend of beekeeping adoption in Manyoni District

Year	Cumulative Frequency	Means %
1973	1	0.5
1978	4	2.2
1983	8	4.4
1988	9	5.0
1993	14	7.7
1998	28	15.5
2003	53	29.4
2008	86	47.7
2013	126	70.0

Table 3: The periodic trend of beekeeping adoption in Manyoni District

Year	Frequency	Means %
1973	1	0.5e
1978	3	1.6e
1983	4	2.2e
1988	1	0.5e
1993	5	2.7de
1998	14	7.7cd
2003	25	13.8bc
2008	33	18.3ab
2013	40	22.2a
Total	126	

The values within the same column with the different following letters do differ significantly ($p<0.05$).

LSD = 8.9

4.1.2 Bee hive technologies adopted in Manyoni District

4.1.2.1 Bee hives adopted in Manyoni District

Results on the bee hive technologies adopted in Manyoni District are presented in Table 4 and Plate 1 and their statistical details are provided in Appendices 4a and 4b. It will be noted that log bee hives are more widely preferred followed by bark hives, Tanzania Transitional Hives, gourd hives, stingless bee hives and commercial bee hive in that descending order of wide use. The preference in the use of traditional bee hive technologies (log and bark and gourd hives) is possibly because they are made locally, readily available and affordable in the study area.

Stingless bee hives were recorded in zones 1 and 2 while commercial bee hives were recorded in the zones 2 and 3. Gourd hives were only recorded in zone 2 (Appendix 4a).

Table 4: Bee hive technologies adopted in Manyoni District by 2013

Bee hive technology	Means %
Log bee hive	64.4a
Bark hive	47.7ab
Tanzania Transitional Hive (TTH)	18.3c
Gourd hive	11.1c
Stingless Bee Hive	6.6c
Tanzania Commercial Hive (TCH)	1.6c

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 23.3

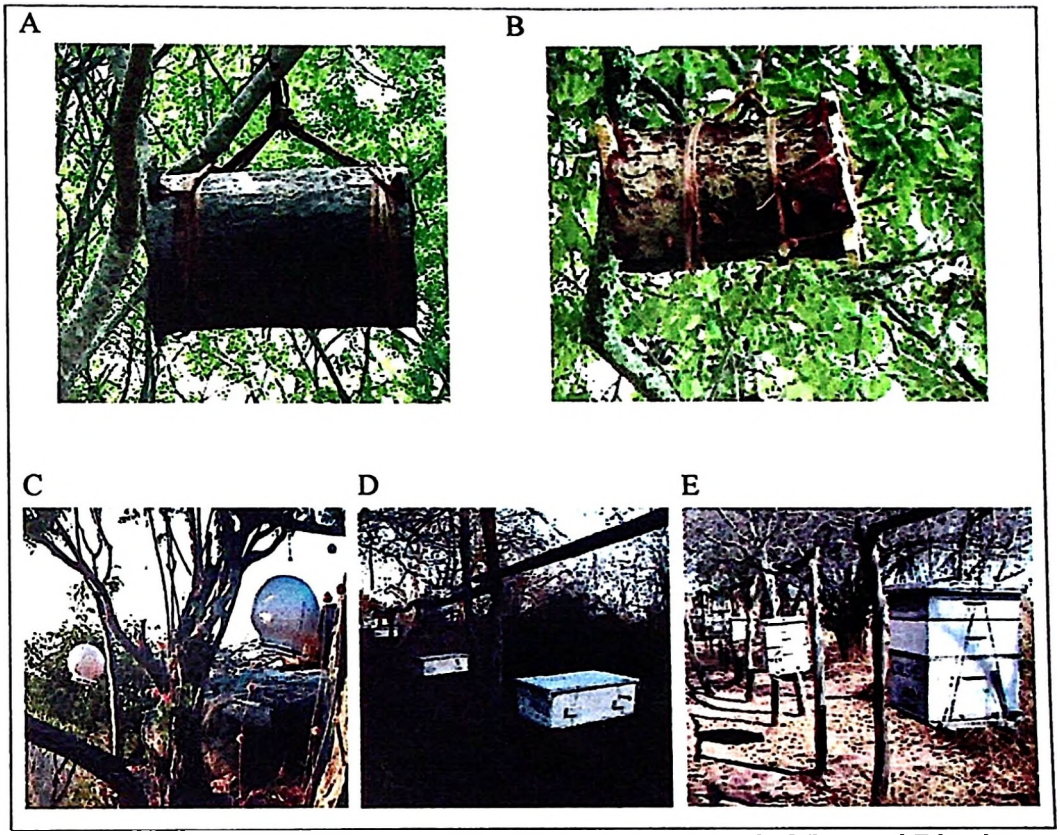

Plate 1: Various bee hives commonly used by beekeepers in Manyoni District

Key:
Plate 1A: Log bee hive
1B: Bark hive
1C: Gourd hive
1D: Tanzania transitional hive
1E: Tanzani Commercial Hive (TCH)

4.1.2.2 Tree species used for traditional bee hive construction

The results on tree species used for traditional bee hive construction in Manyoni District are presented in Table 5 with their statistical details in Appendices 5a and 5b. A total of 14 species were recorded in all ecological zones. By frequency of occurrence, the most preferred tree species for traditional bee hive construction in zone 1 were *Brachystegia spiciformis, Pterocarpus angolensis, Julbernardia globiflora, Combretum molle* and *Brachystegia boehmii* (Appendix 5a).

In zone 2 the most dominant used tree species were *Brachystegia spiciformis*, *Pterocarpus angolensis*, *Commiphora stolonifera*, *Acacia tortilis*, *Borassus aethiopum*, *Ficus sycomorus*, *Faidherbia albida* and *Syzygium cordatum* (Appendix 5a).

In zone 3 the most dominant used tree species were *Brachystegia spiciformis*, *Commiphora stolonifera*, *Terminalia sambesiaca*, *Commiphora* sp., *Combretum molle* and *Xerodoerris stuhlmanii*. *Brachystegia spiciformis* appeared to be the most significantly used tree species for traditional bee hive construction in all ecological zones with highest adoption in zone 1 (Appendix 5a).

Table 5: Tree species used for traditional bee hive construction in Manyoni District

Botanical Name	Local Name	Ethnicity	Means %
Brachystegia spiciformis	Msani/ Mtundu/ Myombo	Gogo/ Nyangwezi/ Swahili	62.7a
Pterocarpus angolensis	Mninga	Swahili	33.3b
Julbernardia globiflora	Muba	Nywamwezi/ Kimbu	27.2b
Commiphora stolonifera	Mdachi	Gogo	25.5b
Combretum molle	Mlama	Nyamwezi/ Kimbu	17.7b
Brachystegia boehmii	Mgela	Nyamwezi/ Kimbu	11.6b
Acacia tortilis	Mkungugu	Gogo	10.5b
Borassus aethiopum	Mtapa	Gogo/ Swahili	9.4b
Ficus sycomorus	Mkuyu	Swahili	8.8b
Terminalia sambesiaca	Mpululu	Nyamwezi	7.7b
Commiphora sp.	Msake	Nyaturu	7.7b
Xeroderris stuhlmannii	Mnyenye	Gogo	5.5b
Faidherbia albida	Mchese	Gogo	5.0b
Syzygium cordatum	Msua	Gogo/ Swahili	3.3c

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 29.0

4.1.3.3 Plants used for Hive baiting

The results on material used for hive baiting in Manyoni District are presented in Table 6 with their statistical details in Appendices 6a and 6b. It will be noted that, beekeepers prefer plant baits although beeswax or propolis is considered to be the best bait to attract

honeybees than other baits available. This is possibly because of lack of knowledge in beeswax processing and propolis collection. *Ocimum suave* is widely used plant species for hive baiting in all zones while *Cymbogon citratus* is the most widely used hive bait in zone 2 (Appendix 6a).

Table 6: Plants commonly used for hive baiting in Manyoni District

Botanical Name	Local Name	Ethnicity	Means %
Ocimum suave	Malumbasi/ Mazenye	Nyaturu and Nyamwezi/ Gogo	67.2a
Cymbogon citratus	Mchaichai	Swahili	10.0b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 4.3

4.1.4 Bee forage plants

The results on important bee forage plants in Manyoni District are presented in Table 7 and their statistical details are presented in Appendices 7a and 7b. A total of 29 plant species which are important sources of nectar and pollen for honeybees were recorded in all zones.

By frequency of occurrence, the most dominant bee forage plants in zone 1 were *Julbernardia globiflora*, *Brachystegia spiciformis*, *Combretum bendaranum*, *Brachystegia boehmii*, *Combretum molle*, *Cosspourea mollis*. *Terminalia sambesiaca*, *Brachystegia bussei*, *Combretum celestroides*, *Grewia bicolor*, *Combretum zeyheri*, *Euphorbia candelabrum*, *Combretum fragrans*, *Duosperma crenatum*, and *Dovyalis macrocalyx* (Appendix 7a).

The most dominant bee forage plant species in zone 2 were *Brachystegia spiciformis*, *Faidherbia albida*, *Dichrostachys cinerea*, *Azadirachta indica*, *Ceiba pentandra*, *Combretum celestroides*, *Grewia bicolor*, *Bidens pilosa*, *Acacia tortilis*, *Mangifera*

indica, *Pseudoprosopsis fischeri*, *Duosperma crenatum*, *Helianthus annuus*, *Boscia salicifolia and Dovyalis macrocalyx* (Appendix 7a).

In zone 3 the most dominant bee forage plant species were *Brachystegia spiciformis*, *Faidherbia albida*, *Combretum celestroides*, *Brachystegia boehmii*, *Eucalyptus* sp., *Dichrostachys cinerea*, *Terminalia sambesiaca*, *Bidens pilosa*, *Senna spectabilis*, *Mangifera indica*, *Pseudoprosopsis fischeri*, *Azadirachta indica*, *Adansonia digitata*, *Ceiba pentandra*, *Helianthus annuus*, *Luecaena leucocephala* and *Combretum fragrans* (Appendix 7a).

Table 7: Bee forage plants recorded in Manyoni District by 2013

Botanical Name	Local Name	Ethnicity	Means %
Brachystegia spiciformis	Msani/ Mtundu/ Myombo	Gogo/ Nyangwezi/ Swahili	60 5a
Faidherbia albida	Mgonandele	Gogo	33 3a
Combretum celestroides	Mnang'ana	Gogo/ Kimbu	30.2a
Brachystegia bohemi	Mgela	Nyamwezi/ Kimbu	27.7a
Julbernardia globiflora	Muba	Nyamwezi/ Kimbu	25 5a
Combretum bendarannm	Mlandala	Nyamwezi/ Kimbu	22.2b
Dichrostachys cinerea	Mtunduru	Swahili	21.6b
Terminalia sambesiaca	Mpululu/ Mzima	Nyamwezi	20.3b
Combretum molle	Mlama	Nyamwezi/ Kimbu	19.4b
Bidens pilosa	Mpangalale	Gogo	19.1b
Cosspourea mollis	Mlugala	Nyamwezi	18.8b
Grewia bicolor	Mkoma/ Mpele	Nyamwezi/ Kimbu	17.5b
Pseudoprosopsis fischeri	Ndalambwe	Gogo/ Nyaturu/ Swahili	17.5b
Euphorbia candelabrum	Mlangali	Kimbu	17.1b
Azadirachta indica	Mwarubaini	Swahili	16.6b
Adansonia digitata	Mbuyu	Swahili	14.6b
Ceiba pentandra	Msufi	Swahili	12 6b
Brachystegia bussei	Mkongoro/ Mtakwa	Nyamwezi	11.5b
Acacia tortilis	Mkungugu/ Mgunga	Gogo/ Nyaturu	11 2b
Mangifera indica	Muembe	Swahili	10.5b
Combretum fragrans	Mluzyamize	Nyamwezi	10.3b
Combretum zeyheri	Msana	Nyamwezi	9 8b
Eucalyptus sp.	Mkaratusi	Swahili	8 3b
Helianthus annuus	Alizeti	Swahili	7.2b
Senna spectabilis.	Msonobari	Swahili	6.1b
Duosperma crenatum	Njelula	Gogo	4.9b
Boscia salicifolia	Mtumba/ Mtuhumba	Gogo	3.3b
Dovyalis macrocalyx	Mzuyuyu	Gogo	2.7b
Luecaena leucocephala	Lucina	Swahili	1.1b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 37.6

4.1.5. Beekeeping areas (Apiaries)

The results on beekeeping areas (apiaries) in Manyoni District are presented in Table 8 and Plate 2. The statistical details are provided in Appendices 8a and 8b. It will be noted that most of the apiaries are located in forests (52.7%), farmland (47.2%) and to some extent around homesteads (5.5%). Zone 2 indicated to have more apiary sites in the farmlands (Appendix 8a).

Table 8: Beekeeping areas (Apiaries) in Manyoni District

Apiary site	Means %
Forest	52.7a
Farm land	47.2a
Homestead	5.5b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 18.8

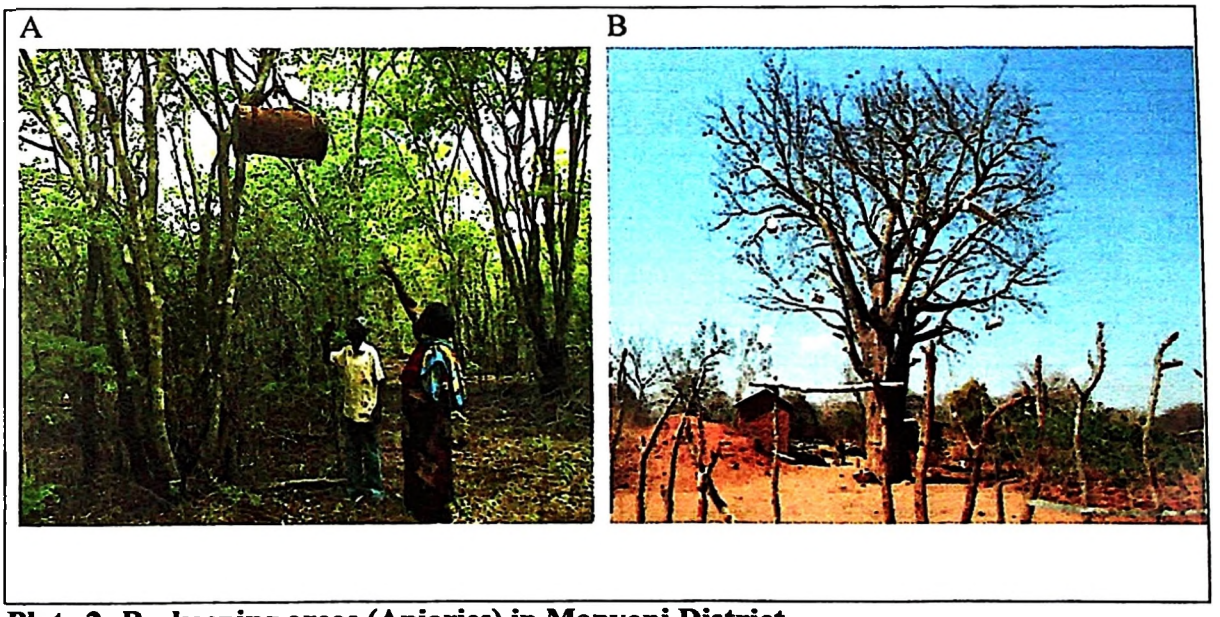

Plate 2: Beekeeping areas (Apiaries) in Manyoni District
Key:
Plate 2A: Beekeeping in the natural forest
2B: Beekeeping around homestead

4.1.6 Honey harvesting

4.1.6.1 Methods used during honey harvesting in Manyoni District

The results on methods used by beekeepers to subdue honeybees during honey harvesting in Manyoni District are presented in Tables 9 and 10, with their raw data and statistical details in Appendices 9a – 9d. It will be noted that, most of the beekeepers (79.4%) harvest honey by using fire to calm the honeybees. Only 27% were using protective clothing and 19.4% were using bee smokers during honey harvesting probably because of unavailability of the equipment and high prices. By frequency of occurrence, the most dominant tree species used to calm down honeybees during honey harvesting in zone 1 were *Pterocarpus angolensis* and *Brachystegia spiciformis*. In zone 2 the most dominantly used species were *Pterocarpus angolensis*, *Ipomoea* sp., *Grewia platyclada* and *Gutenbergia* sp. In zone 3 the most dominant species were *Pterocarpus angolensis* and *Commiphora stolonifera* (Table 10 and Appendix 9c).

Table 9: Methods preferred during honey harvesting in Manyoni District

Honey harvesting method	Means (%)
Use of fire to calm the honeybees	79.4a
Use of beekeeping protective gear	27.7b
Use of bee smoker	19.4b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)

LSD = 31.6

Table 10: Plants used to subdue honeybees during honey harvesting in Manyoni District

Botanical Name	Local Name	Ethnicity	Means %
Pterocarpus angolensis	Mninga	Swahili	48.9a
Ampelocissus africana	Bumpu	Gogo	13.9ab
Commiphora stolonifera	Mdachi	Gogo/ Nyaturu	8.9b
Euphorbia candelabrum	Mnangali	Gogo/ Kimbu	8.3b
Grewia platyclada	Mperemehe	Gogo	5.5b
Gutenbergia sp.	Uhata	Gogo	4.4b
Brachystegia spiciformis	Msani/ Mtundu/ Myombo	Gogo/ Nyangwezi/ Swahili	0.5b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)

LSD = 35.8

4.1.7 Honey processing and storage equipment

The results on honey processing and storage equipment in Manyoni District are presented in Plate 3. It will be noted that honey processing and storage is done locally by beekeepers and honey traders possibly due to unavailability of appropriate equipment, lack of skills in processing, packaging and storage of bee products.

Plate 1: Honey storage equipment in Manyoni District

4.1.8 Levels of honey production in Manyoni District

The results on honey production in Manyoni District are presented in Table 11 and their statistical details are provided in Appendices 10a and 10b. It is noted that, the mean annual honey yield per hive from commercial bee hives was highest followed by log bee hives, Tanzania Transitional Hives, bark hives, gourd hivesand stingless bee hives. Zone 1 seemed to be the most productive for each type of bee hive. This could probably be due to the high altitude and availability of bee forage in the zone.

However, zone 2 indicated to have the overall highest production among the three zones, perhaps because of the higher involvement of the community in beekeeping and the availability of commercial bee hives which indicated to have higher yield than other types of bee hives recorded amongst all zones (Appendix 10a).

Table 11: Mean annual honey production in Manyoni District as per 2013

Hive type	Means %
Tanzania Commercial Hive (TCH)	15.5a
Log bee hive	13.3ab
Tanzania Transitional Hive (TTH)	11.1b
Bark hive	10.5bc
Gourd hive	6.6d
Stingless Bee Hive	0.5e

The values within the same column with the different following letters do differ significantly ($p<0.05$).
LSD = 2.4

4.2 Contribution of Beekeeping to Household Food and Income Livelihoods in Manyoni District

4.2.1 Various sources of food security and income

The results on the various sources of household food security and income livelihood in Manyoni District are presented in Tables 12 and 13. Their data and statistical details are provided in Appendices 11a – 12b. On the average agriculture indicated to be the most significant source of household food supply in all zones followed by beekeeping and livestock keeping, trade, agroforestry, forest and employment in that descending order. On the other hand, agriculture indicated to be the most significant source of household income followed by beekeeping, livestock keeping, agroforestry, trade, forestry and employment. However, most of the households depend on more than one source of food and income.

Table 12: Sources of household food in Manyoni District

Source of household food	Means %
Agriculture	83.3a
Beekeeping	22.2b
Livestock keeping	16.6bc
Trade	12.2cd
Agroforestry	5.5de
Forestry	5.0de
Employment	4.4e

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)

LSD = 7.7

Table 13: Sources of household income in Manyoni District

Source of household income	Means %
Agriculture	94.4a
Beekeeping	61.6b
Livestock keeping	32.2c
Agroforestry	15.5d
Trade	12.2de
Forestry	7.8de
Employment	4.4e

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)

LSD = 9.1

4.2.2 Contribution of beekeeping to income livelihood and food security

Results on household income and food security are presented in Table 14 with their raw data and statistical details in Appendices 13a 13f. It will be noted that, the income generated in the study area comes from sales of crops, bee products, livestock, forest products, trade, agroforestry products and employment. Food security was met through crop cultivation and sales of crops, agroforestry products, bee products, livestock, forest products, trade and employment. On the average agriculture indicated to have the highest contribution to household income in all zones followed by beekeeping and livestock keeping, business, agroforestry and employment in that descending order.

On the other hand agriculture had higher contribution to food livelihood followed by agroforestry, beekeeping, livestock keeping, forestry, trade and employment. However, most of the households depend on more than one source of income livelihood and food.

Table 14: Contribution to income livelihood and food security in Manyoni District as per 2013

Sources of income and food security	Total income generated (Tshs)	Mean income generated	% of income generated	Mean income (Food security) (Tshs)	% of income (Food security)
Agriculture	4 006 895.0	3 242 350.0a	50.2	761 515.0a	33.2
Beekeeping	1 686 220.0	1 039 500.0b	16.1	469 600.0b	20.4
Livestock	1 234 850.0	765 250.0bc	11.8	257 200.0c	11.2
Forestry	759 170.0	501 970.0bcd	7.8	72 900.0d	3.2
Trade	572 500.0	499 600.0bcd	7.7	46 800.0d	2.0
Agroforestry	334 100.0	287 300.0cd	4.4	646 720.0a	28.1
Employment	170,000.0	126 500.0d	2.0	43 500.0d	1.9
Total	8 763 735.0	6 462 470.0	100.0	2 301 265.0	100.0
LSD =		604 271.6		119 414.8	

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)

4.3 Factors Influencing the Development of Beekeeping Industry and Measures Required for its Upscaling

4.3.1 Factors enhancing the adoption of beekeeping industry in Manyoni District

Results in Table 15 with their statistical details in Appendices 14a and 14b show the factors enhancing adoption of beekeeping industry in Manyoni District. It will be noted that awareness on beekeeping was the main enhancing factor followed by availability of beekeeping areas and consideration of beekeeping as a reliable source of income. Other factors were institutional linkages which were recorded in zones 1 and 2 while cultural norms were only recorded in zone 1 (Appendix 14a).

Table 15: Factors enhancing the adoption of beekeeping industry in Manyoni District

Influencing factors	Means %
Awareness	70.0a
Beekeeping areas	69.4a
Source of income	68.8a
Institutional linkages	10.5b
Cultural norms	0.5b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 11.0

4.3.2 Factors limiting the adoption of beekeeping industry in Manyoni District

The results on factors limiting the adoption of beekeeping industry in Manyoni District are indicated in Table 16 and Plate 4 with the statistical details provided in Appendices 15a and 15b. It will be noted that development of beekeeping was stalled by inadequate training, inadequate extension services, lack of financial capital, lack of reliable markets for bee products and long distance from homesteads to beekeeping areas. Fear of bees was a problem in zones 2 and 3 while theft of bee hives was indicated to hinder beekeeping development in zone 2 (Appendix 15a).

Table 16: Factors limiting the adoption of beekeeping industry in Manyoni District

Limiting factor	Means %
Inadequate training	69.4a
Inadequate extension services	68.8a
Lack of capital	50.7ab
Lack of reliable markets	38.3b
Long distance from homestead to apiaries	37.2b
Fear of bees	6.1c
Theft of bee hives	2.7c

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 18.2

It was also, noted (Plate 4) that beekeeping is threatened by the degradation of environment due to rampant and indiscriminate cutting of trees, clearing of forests for cultivation, tree debarking and charcoal making.

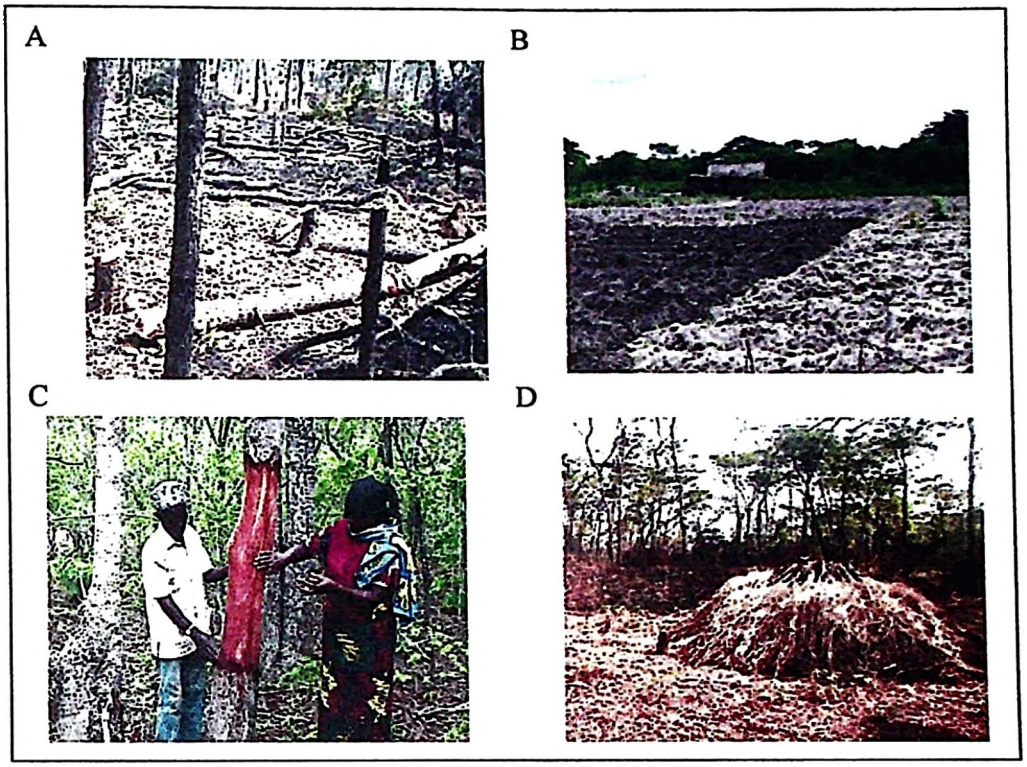

Plate 4: Forest degradation, a potential threat to beekeeping in Manyoni Distinct

Key

Plate 4A: Indiscriminate cutting of trees
4B: Clearing of forests for cultivation
4C: Tree debarking
4D: Charcoal making

4.3.3 Measures required for improvement of beekeeping in Manyoni District

Results on the measures required for improving the adoption of beekeeping and technologies in Manyoni District are presented Table 17 and details in Appendices 16a and 16b. It will be noted that development of beekeeping could be enhanced by availability of proper beekeeping equipment, improvement of extension services, improvement of training, accessibility to credit facilities, harmonisation of land tenure policies, improvement of institutional linkages, conservation of beekeeping areas, access to reliable markets and improvement of communication and transport (Appendix 16a).

Table 17: Measures required for improvement of beekeeping and technologies adoption in Manyoni District

Suggested intervention	Means %
Availability of beekeeping equipment	71.1a
Improve extension services	70.5a
Improve training	70.0a
Accessibility to credit facilities	57.2b
Harmonise land tenure policy	38.3c
Improve institutional linkages	31.1c
Conservation of beekeeping areas	17.2d
Access to reliable market	15.0d
Improve communication and transport	9.4d

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 9.9

CHAPTER FIVE

5.0 DISCUSSION

5.1 The Extent and Trend of Beekeeping Technologies in Use and Levels of Production in Manyoni District

The results on the extent of beekeeping in Manyoni District are presented in Tables 1- 3 and their statistical details are provided in Appendices 3a and 3b. The adoption of beekeeping started earlier than the 1970s and by the year 2013, 70% of the population had adopted beekeeping, implying that the extent of adoption is high. These results compare well with those reported for Sikonge District, Tabora region that was 70% (Liwenga andMasao, 2009). They are, however, relatively lower than those of 71.1% reported for Nawalparasi District in Nepal (Bhusal and Thapa, 2005) and those of 74.5% reported for Atsbi Wemberta District of Eastern Zone, Tigray Region of Ethiopia (Abebe *et al.*, 2008; Berhane, 2010).

Although the experience in Ethiopia has indicated that beekeeping was preferably more adopted in the highland than in the lowland zones (Mwakatobe, 2001; Shiferaw *et al.*, 2006), on the overall African scale, this phenomenon justifies that Tanzania is among the leading countries in beekeeping and honey production second to Ethiopia in Africa (USAID, 2012). Because, as shown by a wide variation in the within and between zones conditions, the climatic environmental factors, high altitude and adequate forage (Mbuya *et al.*, 1994; URT, 1998, 2001; Mickels-Kokwe, 2006; World Bank, 2008; Bradbear, 2009; Tesfa *et al.*, 2013) are reasons for the higher beekeeping adoption performance in Tanzania and thus calls for more reinforced efforts to increase the effectiveness, to sensitize communities on the importance of

beekeeping, to continue with capacity training, and to focus on those that are motivated to improve beekeeping practice bearing in mind that it is the rational way of resource management for ensuring sustainable resource base and the very survival of humanity (FAO, 2006; Bradbear, 2009; Hein, 2009; Hein, 2009; Lulandala, 2012; EU, 2013).

The results indicate that initially the trend of adoption of beekeeping in Manyoni District was fluctuating and gradual but picked up from the late 1990s and 2000s probably due to awareness, various campaigns, extension services, high needs of the bee products and the realised benefits of beekeeping as a viable source of income in the district. The adoption of beekeeping in the study area was a combined result of factors. Key informants revealed that, beekeeping and honey production has been a culture and deep-rooted practice for many years which is inherited from generation to generation (Kihwele *et al.*, 2001; Hussein, 2001; Elisa and Roth, 2008; Verma and Attri, 2008; Bradbear, 2009; JAICAF, 2009; Liwenga and Masao, 2009; Shenkute *et al.*, 2012). Farming was not common to people and they entirely depended on honey hunting (Kihwele *et al.*, 2001; Bradbear, 2009), wild animal hunting (Kessy, 1998) and livestock keeping for their entire livelihood. Studies showed that beekeeping, which is today practiced elsewhere, passed through different stages of development from honey hunting, traditional and improved methods of beekeeping (Belie, 2009; Bradbear, 2009; Tesfa *et al.*, 2013).

Key informants reported that the opening of Dar es Salaam-Mwanza tarmac road in 2010 has also facilitated more reliable access to the area for honey traders from elsewhere in the country preferred honey from Manyoni.

The road provides easy communication between the district and other big commercial cities in Tanzania like Dar es Salaam and Mwanza which encourage more people to come for trade of honey and beeswax (Milledge *et al.*, 2007; URT, 2011). Moreover, many people adopted beekeeping following the "*Uhuru torch rally*" commonly known as "*Mbio za Mwenge*". This has in turn led to many people adopting beekeeping and trade of bee products as a useful enterprise for sustainable livelihood. The high adoption between 1990s and 2000s was also attributed to the BDP which operated between 1998 and 2010 (FBD, 2006; Mujuni *et al.*, 2012). This reflects the significance of beekeeping in socio-economic development and environmental conservation (Bradbear, 2009; FAO, 2012; URT, 2012; Tirado *et al.*, 2013).

The biggest incentive is the income that is obtained from the sale of bee products, increased yields and the medicinal value derived from the bee products and general improvement of welfare due to raised income (Abebe *et al.*, 2008; Belie, 2009; UNDP, 2012; Gemeda, 2014) accompanied by awareness which also increased the rate of adoption of beekeeping (Bhusal and Thapa, 2005). This study, however, revealed that, stingless bees keeping accounted for almost insignificant proportion the reason being difficulties in the management practices with stingless bees as compared to stinging bees.

Results on the bee hive technologies adopted in Manyoni District are presented in Table 4 and Plate 1, their statistical details are provided in Appendices 4a and 4b. These results show that traditional bee hive technologies were widely adopted by many beekeepers possibly because they are made locally, readily available and

affordable in the study area (Elisa and Roth, 2008; Bradbear, 2009; Mujuni *et al.*, 2012; Ajani *et al.*, 2013; Gemeda, 2014). Beekeepers in Tanzania have rich indigenous knowledge of beekeeping using traditional bee hives, they are also familiar with traditional bee hives because they are easier to adopt compared to modern hives. The domination of traditional bee hive technology is a reflection of little apiary management invested, with the perception that beekeeping is a hobby, or a side-line activity (Lalika and Machangu, 2005; Bradbear, 2009; Ajao and Oladimeji, 2013).

The results showed that adoption of commercial bee hives was limited to few beekeepers as they pointed out that they were initially supported by the government and other stakeholders. Although modern hives are simple to manage with assured high honey yield, yet the technical knowledge required to construct commercial bee hive and high cost are the major drawbacks to farmers who have interest in beekeeping and this slows down the adoption rate towards modern beekeeping (Babarinde *et al.*, 2012).

It was learnt that, few beekeepers in Manyoni were keeping stingless bees for their honey, which is especially valued for medicinal properties (Bradbear, 2009; Gallmann and Thomas, 2012). In Hawaii stingless bees are kept especially for commercial purposes (Tsutsumi and Oishi, 2010) while in Zambia stingless bees honey is only collected for domestic use (CIFOR, 2008). Key informants revealed that, demand for stingless honey is high which is mainly traded as medicinal product at a price 5 times that of stinging bee honey. The high market price is somewhat mitigated by the low productivity of stingless bees.

This calls for more efforts to improve management and upscalling as the current popularity and market is higher than production. Promotion of stingless beekeeping (Meliponiculture) would be significant especially for women and youth who are not actively participating in beekeeping in fear of the stinging behaviour of the honeybees. Stingless bees can be kept at home and, therefore, offer distinct possibilities for women to get involved (FBD, 2006). Reports show that, elsewhere in Tanzania stingless bees are kept within homesteads to ensure sustainable supply of honey and pollination services (URT, 1998; 2001; Lepetu *et al.*, 2001; Bradbear, 2009).

On the overall African scale, this observation implies that Tanzania and possibly the whole of Africa relies more on traditional beekeeping. Therefore calls for more enforced efforts in promoting appropriate beekeeping technologies (Kajobe *et al.*, 2009; Ajao and Oladimeji, 2013).

The results on tree species used for traditional bee hive construction in Manyoni District are presented in Table 5 with their statistical details in Appendices 5a and 5b. The higher preference for the 14 tree species in traditional bee hive construction in Manyoni were attributed to durability and ample availability, good odour that could attract bees occupying the hives or impart unacceptable odours to honey, none absorbance of atmospheric moisture. Other features include: resistant to rotting, termite resistant, warp-proof and lightness, hence easy to lift during beekeeping operation, the trees are also excellent nectar producing species and are used for hive sitting.

This result is supported with findings by Ngaga *et al.* (2005) and Bradbear (2009) indicating that the three species most used for making local hives, were also excellent nectar species and are used for hive siting.

Studies revealed that the hives should be made from locally, well-seasoned and readily available, affordable raw materials accepted by the honeybees (URT, 2007; Bradbear, 2009). From the discusion with beekeepers and key informants, it was established that log hives made from *Pterocarpus angolensis*, *Commiphora stolonifera*, *Borassus aethiopum* and *Terminalia sambesiaca* last for over 100 years. A similar result was documented by Liwenga and Masao (2009).

The price of a log hive depends on its size as well as the wood it is made from. Traditional log hives cost from Tshs 4 000 to Tshs 7 000 per hive depending on size while the price of Tanzania Transitional Hive is Tshs 70 000 to Tshs 80 000 and Commercial bee hive cost up to Tshs 120 000. Reports show that, up to 2010, Manyoni District had 99.3% of traditional hives and only 0.2% was improved hives (URT, 2011). Despite the effort to encourage the use of commercial bee hives beekeepers still prefer on the use of traditional hives, the reason being that the commercial bee hives are very expensive and so beekeepers cannot afford to buy them.

The results on material used for hive baiting in Manyoni District are presented in Table 6, statistical details are provided in Appendices 6a and 6b. These results show that beekeepers prefer plant baits while beeswax or propolis is considered to be the best bait to attract honeybees than other baits available (URT, 2007; Bradbear, 2009;

Babarinde *et al.*, 2012; Mujuni *et al.*, 2012) is because of lack of knowledge on beeswax processing and propolis collection (Bradbear, 2009). The knowledge and use of various baits to attract honeybee colonies is universally applied in the beekeeping industry such as the use of dead rodents, cow dung, perfumes and variety of scented herbs and fruit juices in Nigeria (Ja'afar-Furo *et al.*, 2006; Babarinde *et al.*, 2012); and cassava or cattle dung commonly used as bait in Nigeria and Uganda (Hussein, 2001; Okwee-Acai *et al.*, 2010; Mujuni *et al.*, 2012). Cattle dung is dried and spread on burning charcoal placed in the hive to produce a copious smoke, which scents the hives and attracts bee swarms (Mujuni *et al.*, 2012). FGDs revealed that a mixture of stingless bees honey or elephant dung is also smeared inside empty hives to attract honeybees when stocking hives. Fresh leaves from *Ocimum suave* and *Cymbogon citratus* are rubbed onto hives, especially around the entrance, to attract bees, when dry leaves are used; they are burnt and smoked into the hive. JAICAF, (2009) recognise the use of plant species like *Ocimum kilimandscharicum* and *Plectranthus* species to scent new bee hives to attract swarms. In Himalaya beekeepers used *Juniperus* spp. needles to scrub the hives and old raw combs to attract honeybees (Verma and Attri, 2008).

Application of alternative materials to attract honeybees implies that even in the absence of beeswax, beekeepers can use other locally available baiting materials before hive siting. Baiting is the act of encouraging the honeybees to think that the hive is the best home for them thus occupying and establishing a colony (Chile, 2010). Ntenga and Mugongo (1991), suggest beekeepers to make sure the hives are occupied soon after baiting to have optimum hive occupancy so as to maximize honey yield.

The results on important bee forage plants in Manyoni District are presented in Table 7 and their statistical details are provided in Appendices 7a and 7b. The higher dominance of miombo species in the genera *Brachystegia*, *Julbernardia*, *Combretum* and *Acacia* was particularly because of its pattern of seasonal flowering and the heavy prevalence of blossoms, making them excellent for beekeeping and honey production (Mbuya *et al.*, 1994; Lepetu *et al.*, 2001World Bank, 2008; Masara, 2010; URT, 1998, 2001, 2011). Similar findings by (Mickels-Kokwe, 2006; CIFOR, 2010) showed that, the woodland and savannah areas contributes significantly to the high production potential of bee products, thus constitute the main basis of the beekeeping industry across the miombo region which covers Angola, DRC, Malawi, Mozambique, Tanzania, Zambia and Zimbabwe. *Adansonia digitata* was also a good source of nectar for honeybees especially in zones 1 and 2. Similarly, Bradbear (2009), recognise the same as important honeybee forage plant in the tropical regions. Key informants and FGDs revealed that honeybees prefer various plants including trees, shrubs and undergrowth. In most cases, bee forage plants in the study villages were of indigenous nature except for exotic fruit trees such as *Mangifera indica* and introduced trees like *Azadirachta indica*, *Luecaena leucocephala*, *Ceiba pentandra* and *Eucalyptus* species which were largely found in the homesteads. *Helianthus annuus* is widely cultivated in farmlands and was also reported as important bee forage plant (Appendix 7a).

According to key informants beekeeping plants in Manyoni District start to flower at the beginning of the rain season, i.e. November and December, most of plants flower during the rainy season i.e. from late February to April. The flowering patterns enable beekeepers to know the time to site and harvest their bee hives.

Normally beekeepers site their bee hives during the dry season when most plants are not in bloom.

Due to food shortage in the dry season, honeybees move from one place to another to seek food. It is this time when the empty hives can be occupied. Knowing the flowering pattern, beekeepers can prepare beekeeping calendar to suit their beekeeping activities, because they exactly know at what time of the year there is plentiful or scarce food for the honeybees in the area (Somerville, 2007; Musumhi, 2013).

According to Bradbear (2009); Kajobe *et al.* (2009) and Musumhi (2013), beekeeping calendar is a time-table that indicates to the beekeepers the approximate date and duration of the blossoming periods of the important honey and pollen plants in their area. Bradbear (2009) and Kajobe *et al.* (2009), suggested that beekeepers should clearly know the nectar and pollen sources so that the bee hives can be placed in areas where these sources are abundant. The flowering seasons must be recorded in order to ensure timely harvesting. This is important in the drier parts of the country, where the bees are apt to migrate upon the first sign of food shortages.

The results on beekeeping areas (apiaries) in Manyoni District are presented in Table 8 and Plate 2. The statistical details are provided in Appendices 8a and 8b. These results indicate that most of the apiaries are located in forests (52.7%), farmland (47.2%) and to some extent in homesteads (5.5%) with zone 2 having more apiaries in the farmlands (Appendix 8a).

This is also supported by the findings (Ngaga *et al.*, 2005; Mickels-Kokwe, 2006; Bradbear, 2009) confirming the idea that, beekeeping in Tanzania is forest based with most of the apiaries located in natural forests. Though beekeepers do not own the land, there is also high potential for beekeeping in the farmlands and forested areas within households where substantial bee products can be harvested from agroforestry trees as it was seen to some beekeepers.

The results on methods used by beekeepers to calm honeybees during honey harvesting in Manyoni District are presented in Tables 9 and 10, with their raw data and statistical details in Appendices 9a – 9d. These results show that, most of the beekeepers (79.4%) harvest honey by using fire to calm down the honeybees. Only 27% were using protective clothing and 19.4% were using bee smoker during honey harvesting because of unavailability of the equipments, high prices, inadequate knowledge on appropriate bee management techniques and required quality for bee products (Kerealem *et al.*, 2009; Yirga and Teferi, 2010; Mbah, 2012; Gemeda, 2014). Due to lack of protective gears, beekeepers use fire to calm down the bees when harvesting honey and the work is usually done during the night. Plant stems which can produce heavy smoke for a long period during the operation are chopped, tied together, lit and used as a bee smoker. The most dominant species used to subdue honeybees during honey harvesting were *Pterocarpus angolensis*, *Ipomoea* sp., *Commiphora stolonifera*, *Euphorbia candelabrum*, *Grewia platyclada*, *Gutenbergia* sp. and *Brachystegia spiciformis*.

Since honeybees are known for their defensive behaviour, beekeepers in various regions have devised skills of calming them (Ja'afar-Furo *et al.*, 2006) as reported for the use of smoke and water in Nigeria (Ajani *et al.*, 2013), use of smoke in Lindi,

Tanzania, Kenya and Zambia respectively (Lalika and Machangu, 2005; Mickels-Kokwe, 2006; JAICAF, 2009) and use of dry cow dung (uplae) as a smoker to harvest the comb in Himalaya (Verma and Attri, 2008). In the Himalayas, slow burning material such as old dry sacking, rotten wood, rags, or dried leaves could be smoked to calm the bees when opening a bee hive for honey harvesting (Gurung *et al.*, 2012).

However, the use of fire may have adverse impact like destroying the whole honeybee colony and reduce honey yield per hive and harvesting poor quality honey through contamination with dead honeybees, ashes and debris (Mkamba, 2006). It is thus recommended only to use little gentle puff of smoke to control the defensive behaviour of honeybees (URT, 2007; Bradbear, 2009; Gurung *et al.*, 2012). Chemical repellents are strictly prohibited and no chemicals should be included in the fuel material of the smoker (URT, 2007). Many beekeepers in the study area still practice traditional beekeeping. Those that do use improved hives do so without bee protectives and bee smoker which tends to negate the advantages of modern hives.

The results on honey processing and storage in Manyoni District are presented in Plate 3. These results indicate that after harvesting, honey processing and storage is done locally by beekeepers and honey traders. This is attributed to unavailability of appropriate equipments, lack of knowledge in processing, packaging and storage of bee products (Kugonza and Nabakabya, 2008). Very little processing is undertaken only grading and filtering of honey that are found to have too much dirt and then packed in 20 litres plastic containers ready for consumption. In order to obtain a 20 litre of strained honey beekeepers need to process about 40 litres of crude honey. Such amount of crude honey would also produce about two kg of beeswax.

In Himalaya, honey is filtered with cloth and it is kept under normal room temperature, packed in jar or bottles (Verma and Attri, 2008).

This study found that honey and beeswax were stored under varying conditions and places with different temperatures and levels of humidity. These factors are known to affect the quality of stored honey and beeswax. Excessive heat and humidity may destroy the quality of bee products (URT, 2007). This is attributed to lack of skills and equipment for processing and storing bee products to the required quality. The most commonly used container is the 20 litre cooking oil plastic bucket, which is washed and used for transporting. Due to lack of storage facilities beekeepers pack in large bulk containers (20 litre and few uses 5 litre plastic containers) and sell directly to wholesale dealers and packers.

Small storage containers were mostly those originally used for water, soda, beer and agrochemicals. Likewise, Mwakatobe and Mlingwa (2005), revealed that honey was packed in used glass bottles, which initially had been used for other items like soft drinks and alcoholic drinks. It is recommended for bee products to be stored in cool and dry storage facilities away from sun's direct heat (URT, 2007).

Studies show that, beeswax as an income generating resource is neglected and in some places its value is not appreciated (Mickels-Kokwe, 2006; Bradbear, 2009). Key informants and FGDs revealed that, few beekeepers were processing beeswax due to lack of knowledge in processing, lack of processing equipment and lack of awareness on required quality standards for bee products and commercial value of beeswax (URT, 2007; Bradbear, 2009). The result coincides well with the findings of Mickels-Kokwe (2006) and Bradbear (2009).

According to key informants, honey was the major commercial bee product in Manyoni District. The existing market for honey is directly from beekeepers to consumers for food and local brewing, honey traders were reported to have been buying honey from homes of beekeepers. This result is in agreement with findings of (Mwakatobe and Mlingwa, 2006; Liwenga and Masao, 2009). The study noted lack of direct link between the producer and the consumer that has been established for honey. There was no record of buyers coming from outside the locality, implying absence of organized markets for collection and selling bee products in the district. Most of the local markets are far away from the remote beekeeping areas and are inaccessible, thus compelling beekeepers to travel on foot or use bicycles for several hours to consuming areas. Key informants reported that, the main external markets are Arusha, Dar es Salaam, Dodoma, Geita, Mara, Mwanza, Kagera, Shinyanga, Singida and Zanzibar. This result is suported by the findings of (Mwakatobe and Mlingwa, 2006; Liwenga and Masao, 2009). However, the district has no supporting services offered to beekeepers such as availability of credit and marketing information. Yet, the coordination between extension staff and beekeepers is minimal and therefore becomes difficult for dissemination of market information between producers and consumers. Only very small quantities of beeswax are locally used in hive baiting. There is a good market and opportunity for beeswax of high quality, good colour, clean and free from any foreign matters if beekeepers in Manyoni District are made aware of its commercial value and markets identified.

FGDs with beekeepers revealed that the average farm gate price of strained honey in Manyoni District is between Tshs 4 000 and 5 000 with a mean of Tshs 4 500 per kg and that of beeswax is between Tshs 3 000 and 4 000 per kg.

The prices fluctuate widely depending on production, quality and type of honey. Crude honey is normally sold to local brew makers at a price ranging between Tshs 30 000 to 40 000 for a 20 litre plastic container.

The results on honey production in Manyoni District are presented in Table 11 and their statistical details are provided in Appendices 10a and 10b. Although slightly lower, the results almost compare well with those reported in Handeni and Zambia that were 15 kg and 10 kg of honey per traditional log hive respectively (Hussein, 2001; CIFOR, 2008). Likewise, Gemeda (2014) and CODIT (2009), found that beekeepers harvested an average of 17.2 kg and 15 kg of honey from transition hive in Sasiga and Sagure Districts, Ethiopia and Rwanda resepectively.

They are, however, comparatively lower than those of 20–25 kg reported for Eastern and Northern Ethiopia (Abebe *et al.*, 2008; Yirga and Teferi, 2010), those of 15 kg and 26 kg from traditional hive and KTBH respectively (CODIT, 2009) and of 35–40 kg (CIFOR, 2008) from a TBH reported for Rwanda and Zambia respectively. In China honey yield averages between 50–150 kg of honey per hive (Musumhi, 2013). However, production ratio of honey and beeswax of both log and bark hives is estimated at national level to be 15kg: 1kg respectively (URT, 1998; Hussein, 2001). In E thiopia, the national average of improved box hive is 20–25 kg pure honey/annum (Abebe *et al.*, 2008). Kajobe *et al.* (2009), revealed that every 10 kg of honey produced, produces 1 kg of beeswax.

According to Bradbear (2009), the ratio of honey and beeswax production using fixed comb or movable-comb hives is about 10:1.

However, in areas with more than one honey harvesting season, the annual production per colony will be higher (URT, 1998, 2001).

Key informants revealed that, hive productivity depends on size (volume) and type of the bee hive; amount of bee forage available within the vicinity of the apiary; protection of the hive against damage by fire, honey badger (*Mellivora capensis*) locally known as "Nyegere" and other bee pests (Belie, 2009; JAICAF, 2009; Kinati *et al.*, 2012) and apiary management techniques (Mickels-Kokwe, 2006; Bradbear, 2009; Okwee-Acai *et al.*, 2010). Manyoni District is among the important beekeeping areas with high honey production potential in Tanzania which have a potential of producing 8 000 tonnes per annum. Despite this high potential, it produces only 600 tonnes of honey per annum which is only 7.5% of its total potential (URT, 2001). Zone 1 seemed to be the most productive for each type of bee hive. This could probably be due to the higher altitude and availability of bee forage in the zone.

However, zone 2 indicated to have the overall highest production among the three zones, perhaps because of the higher involvement of the community in beekeeping and the availability of commercial bee hives which indicated to have higher yield than other types of bee hives recorded amongst all zones. These results concurred with those of Mickels-Kokwe, (2006) who found that honey production have been attributed to the distribution of miombo plants which provides adequate forage. On the other hand, Verma and Attri, (2008) and Babarinde *et al.*, (2012), revealed that commercial hives are simple to manage with assured high honey yield.

5.2 Contribution of Beekeeping to Household Food and Income Livelihood in Manyoni District

The results in the various sources of household food security and income livelihood in Manyoni District are presented in Tables 12 -14. Their data and statistical details are provided in Appendices 11a – 13f. These results indicate that agriculture was the most significant source of household food supply and income livelihood, this is because agriculture is the major socio-economic activity and the main source of livelihood to the communities (Mary and Majule, 2009; Liwenga and Masao, 2009; FAO, 2012; URT, 2011; Bwalya, 2013) and major source for food security because it contributes to daily diet of the family in the district, therefore, is given more priority. None of the respondents were exclusively engaged in beekeeping; instead they were doing both farming and beekeeping along with other economic activities.

This study established that, agriculture made the highest income followed by beekeeping, livestock keeping, forestry, business, agroforestry and employment. The study further revealed that agriculture had higher contribution to food security followed by agroforestry, beekeeping, livestock keeping, forestry, business and employment. The need for the adoption of enabling alternative activities which can significantly contribute to livelihoods security in rural communities where access to income is limited agrees well with the findings by researchers from elsewhere in the world recognising beekeeping as a means of diversification with valuable sources of food and income livelihood for rural communities (Debissa, 2007; Ebojei *et al.*, 2008; Bradbear, 2009; Liwenga and Masao, 2009; Berhane, 2010; Ayansola, 2012; Ajaoa nd Oladimeji, 2013; Gemeda, 2014).

This reflects acceptance of beekeeping to be instrumental in boosting household livelihoods and is complementary to both conservation efforts and strategies which aim at meeting the Millennium Development Goals in poverty reduction as well as Tanzania's Vision to the year 2025 (Mwakatobe and Machumu, 2008; CODIT, 2009; URT, 2012; Tirado *et al.*, 2013; Gemeda, 2014).

Beekeepers confessed that, part of their income obtained from beekeeping, was used for other household needs, like paying school fees, health services, transport and housing. Some money could also be invested in other economic activities including petty trading and farming. Furthermore, beekeepers acknowledged the coontribution of beekeeping to their food security pointing out that, honey plays a great role in food security in times of food shortage and throughout the year. Honey could be used as a main source to every meal, and they would sell or exchange some and get some food for their families. Similiar findings were also reported in different studies by Lepetu *et al.* (2001); BOA (2003); Lalika and Machangu (2005); Kerealem *et al.* (2009); Mwakatobe and Machumu (2008); Lietaer (2009); Yohannes *et al.* (2009); Berhane (2010); Tesfa *et al.* (2013) and Gemeda (2014) signifying the significant contribution to reduction in income poverty as well as improving food security. As it involves sustainable use of natural resources, beekeeping produces bee products without competing with other livelihood activities like agriculture and forestry (Bradbear, 2009) and offers opportunities for empowering the communities by making them self-reliant (Mickels-Kokwe, 2006; CIFOR, 2008; Ajao and Oladimeji, 2013).

It could also provide employment opportunities for majority of jobless individuals living in rural areas (Ajani *et al.*, 2013). Recent estimates by Mwakatobe and Mlingwa, (2006) show that beekeeping generates about US$ 1.7 million each year from sale of honey and beeswax and employs about 2 million rural people.

5.3 Factors Influencing the Development of Beekeeping Industry and Measures Required for its Upscaling

Results in Table 15 with their statistical details in Appendices 14a and 14b show the development of beekeeping in Manyoni District was enhanced by awareness on beekeeping, availability of beekeeping areas, consideration of beekeeping as a reliable source of income, institutional linkages and cultural norms.

Awareness raising is an important tool in motivating and mobilizing individuals to build interest and adopt the practice. This implies that awareness enhances adoption of beekeeping (Ebojei *et al.*, 2008; Tsutsumi and Oishi, 2010; Mpokigwa *et al.*, 2011; Mujuni *et al.*, 2012).

As awareness is growing amongst communities, consumers are increasingly concerned about where honey comes from and pay great attention to whether it is produced in a responsible way. Key informants reported that, the demand for what is normally called "*Asali Mbichi*" implying "*Unboiled honey*" is high; confirming that they knew honey for home consumption must be in its original form to be good for human health. Many consumers wish to avoid taking honey which is previously spoiled either by heating or adulterated. This suggests that awareness increases in communities on a certain intervention and more people are able to participate.

A report shows that, the number of beekeepers has been increasing each year from 12 500 in 2005 to 35 000 in 2010 as more people recognise the beekeeping potential to improve people's livelihood and maintain ecological stability (URT, 1998, 2001, 2011). It was also learnt that, beekeepers were supported to participate in different trade fairs such as SIDO, SabaSaba (Dar es Salaam International Trade Fair) and NaneNane (National Farmer's Day), which could have influenced an increase in output, quality and efficiency (URT, 2013). However, community involvement in beekeeping practice need to be enhanced through increasing awareness, education and empowerment towards eradicating global economic challenges (Paulo *et al.*, 2007; Ajao and Oladimeji, 2013).

The results on the availability of beekeeping areas are well supported by earlier studies (UNCTAD, 2006; Matanmi *et al.*, 2008; Bradbear, 2009; Gurung *et al.*, 2012; Gemeda, 2014) recognizing beekeeping as a sustainable land use activity because honeybees are natural part of the ecosystem and do not compete for resources with other land use activities where by very little land, marginal land and even landless farmers can generate income, supplying nutrition and support their livelihoods without having to own land which could be a major constraint to other income generating activities. Though beekeepers do not own the land, beekeeping could operate smoothly with most of the apiaries located on general land and to some extent in forest reserves and farmlands (Mbuya *et al.*, 1994; URT, 1998, 2001; Somerville, 2007; Bradbear, 2009; Tesfa *et al.*, 2013). There is also high potential for beekeeping in the farmlands and forested areas within households where substantial bee products can be harvested from agroforestry trees (Plate 2).

The impact of income generation from beekeeping in Manyoni District, agrees well with observations of Kajobe *et al.* (2009), Mbah (2012) and Ajani *et al.* (2013). These results confirm a significant role of beekeeping among rural communities as it improves household income through sales of honey and beeswax and ensures food security (Bradbear, 2009; Yohannes *et al.* 2009; Ayansola, 2012; Ajao and Oladimeji, 2013). Beekeeping offers a good way for people to create income from natural resources without damaging them (Bradbear, 2009). Report showed that beekeeping contributed 87% to Manyoni District GDP among all natural resources productions in 2010 (URT, 2011). This implies that, beekeeping increases livelihood options for poor people and is complimentary to both conservation efforts and the National Strategy for Growth and reduction of poverty (MKUKUTA).

Institutional linkages which embody issues of organizational set up and relationships or linkages among organizations were also influencing beekeeping adoption and development in Manyoni District. These findings are in line with those of Milledge *et al.* (2007), Chnayalew *et al.* (2009), URT (2011) and Msuya and Kideghesho (2012), confirming that beekeeping has a strong link with other sectors especially on the issues of land and resource use in Forest and Game Reserves, Game Controlled Areas, general land and agricultural land. If not well considered some activities like timber harvesting (Iddi, 2002; CIFOR, 2008), game hunting, slash and land clearing for agriculture (Elisa and Roth, 2008; Liwenga and Masao, 2009; Yirga and Teferi, 2010) especially for tobacco growing and use of pesticides (Tsutsumi and Oishi, 2010; Tesfa *et al.*, 2013) can have adverse impacts on beekeeping. This confirms the idea of recognizing the cross-sectoral linkages between the beekeeping and other

sectors and a need to device comprehensive approaches to ensure sustainable beekeeping management (URT, 1998, 2001; Bradbear, 2009).

The results on beekeeping and cultural norms in Manyoni District are well supported by the observations by Elisa and Roth (2008), Bradbear (2009), Ajao and Oladimeji (2013) and Tesfa *et al.* (2013) indicating honey to have been considered by many cultures as a valuable natural resource that is used as an important part of some traditional rituals (Bradbear, 2009; Tesfa *et al.*, 2013). This might be due to the integration of household's contextual factors such as cultural norms and practices to livelihood needs in their locally based management plans and by laws (Masara, 2010). Key informants revealed that bee products could be used in various ways including ceremonies, rituals, bride price, circumcision ceremonies and use during food shortages. A similar result was documented by Mwakatobe and Machumu (2008) and JAICAF (2009). In Zambia, honey could be regarded as a local currency amongst farmers where it is used for the payment of services like field cultivation and is of sufficient value to be traded for cattle in Zambezi District of Zambia and in Babati District in Tanzania (Ntenga and Mugongo, 1991; Fischer *et al.*, 1993; Verma and Attri, 2008). These confirm that, beekeepers have an integral and intimate link with the natural resources and ecosystems surrounding them.

Their knowledge base, cultural traditions and practices relating to beekeeping resources has a critical role in conserving natural resources for a variety of purposes, including economic as well as spiritual and aesthetics (JAICAF, 2009; Gurung *et al.*, 2012). In many countries of Africa and Asia, trees holding wild nests of bees are regarded as valuable, and beekeeper families often have traditional ownership of such trees.

People who clear trees if they are being used to support bee hives leave small clusters of natural vegetation alone, and firewood and charcoal cutters may avoid areas where bee hives have been sited because they are afraid of bee stings (Bradbear, 2009).

The results in Table 16 with their statistical details in Appendices 15a and 15b indicate that, the development of beekeeping in Manyoni District was hindered by inadequate training, inadequate extension services, lack of capital, distance from homesteads to apiaries, lack of capital, fear of bees, lack of reliable market and theft of bee hives. The results on inadequate training are well supported by the observation by Yirga and Teferi (2010) Kerealem *et al.* (2009, 2012) indicating that lack of skills on appropriate beekeeping technologies was a critical factor that contributed to poor yield and quality of bee products (Mujuni *et al.*, 2012). This was attributed, mainly, to inadequate mastery of techniques and skills and their application in beekeeping processes. For example the issue of high water content in honey is very much related to when harvesting is done during the season. With a high water content (more than 20%), honey may be fermented making it unsuitable for nutritional and commercial purposes, unless it is boiled to make local brew (Ngaga *et al.*, 2005; URT, 2007). Beekeepers rely on indigenous knowledge and have had limited training and information on improved beekeeping techniques.

They reported inadequacy of information and knowledge on required product quality. Beekeepers and trainers often lack appropriate training materials (Kerealem, *et al.*, 2009; Fakayode *et al.*, 2010; Pokhrel, 2012). Beekeepers must be persuaded and provided with necessary skills to practice beekeeping with emphasis on appropriate beekeeping technologies (Bradbear, 2009; Gurung *et al.*, 2012).

Bhusal and Thapa, (2005) observed that training had enhanced adoption of beekeeping with greater harvesting; peasants could generate income, solve unemployment problem and help alleviate poverty.

The development of beekeeping has been hindered by inadequate extension services; coordination between extension staff and beekeepers is minimal and, therefore, becomes difficult for information dissemination. This could have resulted due to inadequacy in personnel, finance, office equipment and transport facilities (Aikaeli, 2010). Beekeeping extension services were not effectively reaching the beekeepers, processors of bee products, manufacturers of beekeeping equipment and bee products dealers (URT, 2007; Abebe *et al.*, 2008; Bradbear, 2009; Cadwallader *et al.*, 2011; Kerealem, *et al.*, 2012). Mujuni *et al.*, (2012) pointed out that the effectiveness of beekeeping adoption depended on availability of extension services and skilled personnel who are able to identify needs and requests of services and access to information on beekeeping.

Since beekeeping is mainly forest-based to most beekeepers, distance and limited access are important factors that influence the productivity of honey in the study area. Beekeepers travel long distances on foot (up to 60 km deep into the forest) from homesteads to apiaries.

This observation is also supported by the various other findinngs (URT, 2001; Kikula *et al.*, 2003; Bradbear, 2009; Ilomo *et al.*, 2011), indicating that distance was a limiting factor to practicing beekeeping as more effort and time go into walking the long distances between apiaries and homesteads.

This is an important obstacle for female beekeepers and the youth to involve in beekeeping thus contributing to low total production, increasing unemployment, and poverty (Vlek *et al.*, 2003). Some beekeepers use bicycles to cover the distances from homesteads to apiaries as the land closer to the homesteads is unavailable for beekeeping.

Likewise, a study by Ngaga *et al.* (2005), showed that, beekeepers use an average of 4.5 hours to reach the apiaries in Chunya District. In Zambia the distance between the homesteads and the hives may be up to 40 km (Mickels-Kokwe, 2006). Aikaeli (2010), recognises that much time spent to transport goods by road to the market is an obstacle to most producers. In Tabora, honey is produced from remote beekeeping areas about 150 km south west and 80 km south east of Tabora (URT, 2013).

Fear of bee stings has also stalled the adoption of beekeeping, the finding which is similar to those variously reported (JAICAF, 2009; Mujuni *et al.*, 2012). This is due to the defensive behaviour of honeybees and lack of appropriate protective gears. People tend to fear bee stings thus denying beekeeping. In this regard, beekeeping is not yet attractive especially to the youth, women and to some urban people mainly because stinging is feared (JAICAF, 2009; Fakayode *et al.*, 2010). The defensive behavior of honeybees, however, has a positive effect to conservation of forest resources as reported by Ngaga *et al.* (2005), that few people pass in areas where bee hives are located for fear of being stung by bees, consequently giving more room for grass and other plants to grow.

Collison (2004), suggested that, people who react strongly to bee stings should avoid contacts with bees.

To avoid possibilities of people being stung by bees, beekeepers should site their bee hives away from human settlements (URT, 2007; Bradbear, 2009). Lack of capital was a critical obstacle to beekeeping development, especially in acquisition of appropriate technologies. This result is synonymous with those reported elsewhere (Kerealem *et al.*, 2009; Yirga and Teferi, 2010; Mbah, 2012; Ajani *et al.*; 2013).

This is mainly caused by lack of knowledge on sources of credit and/or difficulties of loan/credit conditions. Despite the various sources of credit available in the country, poor training for example in entrepreneurship, contributes to this, by failing to create awareness of the sources of credit to producers. On the other hand weak local institutions such as cooperatives or associations lead to problems of credit accessibility by both producers and traders (Mwakatobe and Mlingwa, 2006; Liwenga and Masao, 2009). Lack of financial capital has influence on the level and adequacy of production, processing and storage facilities of the honey which, in turn, impact on the quality and quantity of honey.

Moreover, the findings of lack of reliable market hindering the smooth development of beekeeping had also, been reported variously elsewhere (Fakayode *et al.*, 2010; Kinati *et al.*, 2012; Ajani *et al.*, 2013). This is because of problems in market accessibility, lack of joint efforts in marketing; lack of market information and low entrepreneurship skills, lack of transportation facilities from remote beekeeping areas to consuming areas and lack of training in market survey and entrepreneurship as well as inability to establish business connections among beekeepers, traders and exporters in the domestic and international markets. This is one of the problems contributing to low income realized by beekeepers.

The result on theft of bee hives and honey is also supported by various other findings (Ebojei *et al.*, 2008; JAICAF, 2009; Masara, 2010; Mbah, 2012), that theft of hives and vandalism reported to cause much losses of bee products in terms of quantity and value. This is said to be causing a lot of frustration to old and new beekeepers in the study area.

The problem of theft and vandalism in South Africa has forced beekeepers to place apiaries in remote and often secluded areas where badgers commonly occur. It was thus mentioned as among the potential factors that could decrease productivity of beekeepers. Likewise, Heaf (2009), reported that vandalism and theft reduced an operation's economic sustainability. It was further reported that at least two beekeepers closed their businesses due to persistent large-scale theft (Begg, 2001). Thefts of bee hives, conflicts between the beekeepers and their neighbours and poor management of apiaries were also hampering beekeeping development in Uganda (Kajobe *et al.*, 2009).

The study revealed that, beekeeping is threatened by degradation of environment due to rampant forest fires and indiscriminate cutting of trees, intensive clearing of forests for crop cultivation and tree debarking (Plate 4). This result is also supported by numerous other findings (Elisa and Roth, 2008; Yirga and Teferi, 2010), indicating the limited supply of honey due to reduced availability of bee forage. Similarly, forest clearing for wood harvesting for charcoal is a problem in the major beekeeping districts in Zambia, which is also the major supplier of charcoal (Mickels-Kokwe, 2006).

Charcoal burning is also rampant in the current study villages due to effective demand and proximity to Manyoni town making charcoal production profitable for households. This is a potential means of rapid loss of natural bee forage due to deforestation (CIFOR, 2008; Bradbear, 2009). Moreover, forest degradation, agricultural expansion and wood- fuel harvesting set limits to the long-term beekeeping potential in more than half of the areas considered favourable for beekeeping (Mickels-Kokwe, 2006).

The results on measures required for improving beekeeping in Manyoni District are presented in Table 17 and details in Appendices 16a and 16b. Measures that were suggested in order to improve beekeeping development and technology adoption included availability of proper beekeeping equipment, improvement of extension services, improvement of training, accessibility to credit facilities, harmonisation of land tenure policies, improvement of institutional linkages, conservation of beekeeping areas, access to reliable markets and improvement of communication and transport.

The results on availability of appropriate beekeeping equipment are well supported by the various observations (Bradbear, 2009; Tsutsumi and Oishi, 2010; UNDP, 2012; Ajani *et al.*, 2013), suggesting the use of appropriate tools and technologies at harvesting and processing to attain optimum quality of bee products. Increased availability and access to appropriate tools and equipment, packing and storage materials followed on by training on its use could help on the development of beekeeping in Manyoni.

Beekeepers still use traditional hives despite the high level of awareness about the potential of using improved equipment.

This is mainly due to unavailability and high prices which put them out of reach by many beekeepers. This may be the biggest obstacle to sustainable honey production in the study area. It is therefore, important to improve beekeeping through training on appropriate technologies that beekeepers accept, provide improved bee hives and encourage them to purchase the same.

Similar findings were reported by Engh (2011) UNDP (2012) and Ajao and Oladimeji (2013). Improved bee hives and agroforestry are likely to open up beekeeping to new groups of people, especially women since they can simply manage the honeybees close to their homesteads (Bradbear, 2009; Engh, 2011). Efforts are therefore needed to train carpenters on how to make improved hives as they have several advantages including: increased honey yield potential, management simplicity, avoiding risks of climbing trees, less exposure to honey thieves and avoiding unsustainable cutting of trees for hive construction (Chnayalew *et al.*, 2009; Fakayode *et al.*, 2010).

Availability and accessibility/ affordability of protective gears are also very necessary for beekeeping; the most important items for protective clothing are a bee veil and an overall to cover the face and the body. The other important requirement is a bee smoker; a device for generating cool smoke, used to subdue honeybees. Various studies reported the importance of beekeeping protective gear (Tsutsumi and Oishi, 2010; Gurung *et al.*, 2012; Webster and Burgess, 2013) for sustainable beekeeping development.

Appropriate processing facilities are very important for beekeepers and processors in order to remove all impurities to attain quality products. Honey should be poured on the sides of containers (for containers less than 20 litres or slanted wooden slab for large containers) in order to reduce the amount of air bubbles. Boiling or heating of honey during processing should not be practiced at all (URT, 2007; Kugonza and Nabakabya, 2008). Honey must be strained immediately after it has been harvested while still warm and less viscous and before granulation occurs.

Harvesting techniques depend on the type of hives owned by the beekeeper. Beekeepers with traditional hives harvest by cutting across and removing the central comb thus sometimes harvesting raw honey or honey mixed with larvae. Beekeepers with commercial hives can carry the super box to the centrifuge machine for honey extraction which makes it possible to extract honey without destroying the honeycombs thus allowing the bees to make more honey (CODIT, 2009; Gurung *et al.*, 2012). However, the use of commercial bee hives necessitates the need for centrifugal honey extractor, which is costing up to Tshs 1 500 000 per hive. A similar result was reported earlier by other researchers (Mickels-Kokwe, 2006; Kajobe *et al.*, 2009), indicating that beekeepers in Uganda were used to the Langstroth hive which costs 2 500 000 UGX.

Proper storage is essential in the preservation of quality bee products for beekeepers, processors and traders to efficiently manage the gap between the supply and demand for bee products at any given time. In order to improve product quality, there is a need to increase the availability and access to proper storage facilities as well as training of beekeepers and traders in improved storage techniques. Traders and investors interested in buying bee products from beekeepers and beekeeper groups in

the study area should be encouraged to supply hygienic storage containers to producers and train them how to produce high quality honey and beeswax.

Provision of more knowledge will involve training of beekeepers/ farmers through a multimedia approach like beekeepers apiary visits and tours to successful beekeepers and demonstration centres (Abebe *et al*, 2008; Shenkute *et al.*, 2012), radio and TV programmes, community video shows, electronic and print media, as have been emphasised by various scientists to be instrumental for successful information dissemination (Chnayalew *et al.*, 2009; Masara, 2010; Mpokigwa *et al.*, 2011; Mujuni *et al.*, 2012; Ajani *et al.*, 2013).

Moreover, development of extension services must consider the social economic contexts of the farmers/ beekeepers basing on the needs of the areas where the practices are introduced. Beekeepers must be involved in setting beekeeping research agenda and developing new beekeeping technologies and in providing valuable feedback to research, policy makers and development of practitioners (Bradbear, 2009; Kerealem *et al.*, 2012). Key informants suggested capacity building and strategic training programmes should essentially focus on topics of colony management and production of honey and beeswax, stingless beekeeping (Meliponiculture), beekeeping intergration in the agroforestry practices, honey quality standards and using value chain and market management to increase the benefits accruing to beekeepers. Efforts should be put into empowering the farmers with knowledge and skills, ensuring availability of improved technologies and increasing the beekeepers access to credit facilities (Mujuni *et al.*, 2012). Education increases the access to information and the understanding of the technology and facilitates its application (Abebe *et al.*, 2008).

Harmonization of beekeeping extension messages through integrated planning and cross- sectoral coordination mainly at local levels will ensure effective management and utilization of beekeeping resources for sustainable development. Capacity for effective extension services delivery has to be developed in the context of gender and overall socio-economic development targeted for different ecological zones (URT, 1998, 2001).

The main objective is to reduce contradictory messages and reduce duplication of initiatives that inundate the rural communities thus putting unnecessary demands on people's time (Kikula *et al.*, 2003). Improved extension services can significantly enhance adoption of improved technology adoption as beekeepers are eager to receive innovations towards making beekeeping a more lucrative enterprise. Bhusal and Thapa (2005) and Mpokigwa *et al.* (2011), observed that farmers who received extension services were more motivated to participate in beekeeping. Extension creates light to the reality of life and making sure that appropriate technologies for beekeepers are developed and disseminated for use in a particular context thus more people are likely to undertake beekeeping as a simple and attractive economic venture. Extension services in any sector are important incentives for farmers to adopt new innovations (Mpokigwa *et al.*, 2011). This suggests that, increased extension services in Manyoni District will tend to increase people's awareness on the importance of beekeeping enterprise as an environmentally friendly and economically viable alternative livelihood strategy which also enhances forest management (Bradbear, 2009). An increased innovation extension influences the willingness of local people to participate in beekeeping activities.

A supportive land tenure and policy must be developed which require combined negotiations involving participation from various natural resources related policies and legal instruments and traditional practices supporting beekeeping due to their cross-sectoral nature (Milledge *et al.*, 2007; Chnayalew *et al.*, 2009; Msuya and Kideghesho, 2012). Since beekeeping contributes to livelihood strategies and environmental sustainability, all beekeeping-related issues which need the attention of other sectors need to be harmonized.

This includes consideration and integration of beekeeping activities during land use planning, encouraging development of Beekeeping-Agroforestry systems, developing a strategy that would safeguard interests of farmers, beekeepers and honeybee colonies when applying agrochemicals and developing sector specific guidelines for EIA. Areas of envisaged collaboration include integrated planning, policy formulation and extension services (URT, 1998, 2001).

Beekeeping sub-sector involves different stakeholders including government, communities (beekeepers), research and training institutions, CBOs, CCOs, NGOs, private sector and donor communities. Effective collaboration and gender balance participation of stakeholders having varying interests and roles require formal institutional arrangements and mechanisms at different levels of beekeeping management (Chnayalew *et al.*, 2009).

Access to credit is very important because it is required to finance purchase of proper beekeeping equipment hence adoption of best technologies which are relatively more expensive than traditional ones.

Credit is therefore a catalyst for the development of beekeeping as it provides additional financial resources that are needed for optimum production and ultimately profitability of the sector (Fakayode *et al.*, 2010; Kerealem *et al.*, 2012). Commercial banks, SACCOS and Credit and Savings Associations now exist in many districts. These could provide capital for small inputs for small scale beekeepers, traders and processers of bee products. The private sector should be encouraged to invest in facilitation and financing of beekeeping activities to individuals, beekeeping groups and associations (Abebe *et al.*, 2008; Ebojei, *et al.*, 2008).

Fakayode *et al.*, (2010) recognise the importance of credit facilities and affordable rate of interest, subsidy on equipment for commercial beekeeping. Likewise, Abebe *et al.*, (2008); Bradbear, (2009); Berhane, (2010); Mujuni *et al.*, (2012) suggested for beekeeping stakeholders to have access to credit or grants for successful beekeeping as it plays a significant role in enhancing its promotion.

Accessibility to markets was constrained by poor linkages, either physical or communication among beekeepers and bee product traders. This result is also supported by (Abebe *et al.*, 2008; Tsutsumi and Oishi, 2010; Adeola *et al.*, 2011; Tesfa *et al.*, 2013). Improvements in the reliability of the transport systems and facilities as well as information and linkages to markets would greatly improve bee product marketing. Information about availability of stocks, buyers, prices and sellers is vital in effective marketing systems.

Improved market information and communication systems and skills would improve marketing of bee products.

This could be achieved through deliberate collection and analysis of market data and information at village, district and national levels and the development of effective dissemination systems to deliver the information to stakeholders.

Weak organization and management of existing beekeepers groups and inadequate market orientation contribute significantly to the apparent poor marketing of bee products (Mwakatobe and Mlingwa, 2006; Liwenga and Masao, 2009). Groups are not able to promote new markets for their members. There is need therefore, to strengthen the capacity of group leaders and members on group organization, management and marketing negotiation skills.

This is likely to develop stronger groups with increasing focus on marketing and value adding on bee products and lead to increased incomes of its members.

Entrepreneurship training will improve beekeepers skills and ability to bargain and develop business relationship and linkages with processors and traders and increase participation of beekeepers groups and traders in marketing training activities (Chnayalew *et al.*, 2009; URT, 2006, 2010; Gurung *et al.*, 2012). This will improve common understanding among beekeepers and traders. Beekeepers groups should be oriented towards marketing, development and implementation of marketing strategies.

Lack of telecommunication services results in a lack of market information (Sustainet, 2006; Bradbear, 2009; Aikaeli, 2010). Some areas in the study villages have no access to telecommunication services, this situation forces beekeepers after harvest to go searching for buyers and vice versa which makes it difficult for each side to easily access the others due to communication barriers.

Efforts are, therofore, needed to provide telecommunication services so as to increase adoption and boost development of the beekeeping industry in Manyoni District. Effective communication enhances understanding and acts as an incentive for technology adoption (Mpokigwa *et al.*, 2011) and promotes dialogue between stakeholders, which is the basic prerequisite for community involvement in beekeeping (Danicom, 2002).

Transport improvement implies enhancing the condition of roads and introduction of reliable vehicles to transport bee products from remote beekeeping areas and collection points.

Product spoilage as well as loss in product quality and market value will be minimized. In the study area, roads were only passable seasonally which restricts the transportation of equipment and bee products especially in the rainy season. There is need to invest in improving the roads in the district. Beekeepers and traders cited lack of transport infrastructure as a severe constraint towards beekeeping development which makes market access a problem. Without public transport it is difficult for beekeepers to access the markets of bee products (Sustainet, 2006; Aikaeli, 2010; URT, 2012).

Manyoni District falls within the semi-arid areas of Tanzania where there are frequent food shortages due to uncertainty of rainfall and reduced availability of all-year round water supplies (Mary and Majule, 2009). The area is, however, well established in beekeeping practices which are highly dependent on water availability and flowering plants for honeybees to gather nectar and pollen as food in order to be able to make honey (Vlek *et al.*, 2003; Mickels-Kokwe, 2006; Lulandala, 2012).

Drought can be a constraint in beekeeping as it may affect the feed sources (bee forage and water) and the high temperatures may lead to honeybee colonies absconding to areas where resources are available for their survival (Abebe *et al.*, 2008).

The continually escalating human population, dwindling forest estates and deteriorating environmental conditions, however, will in the future require increased promotion and, therefore, adoption of systems which integrate the various human need resource components to create integrated more diverse, productive, profitable, health and sustainable land use system (Swai *et al.*, 2003; Debissa, 2007; Belie, 2009; Lulandala, 2012; Msuya and Kideghesho, 2012).

This suggests the need for adoption of agroforestry as an important option for diversifying the livelihoods of the Manyoni community who are in the food insecurity zone because of recurrent drought over times. This productive and conservation system will ensure water supply, conservation of beekeeping areas for enhanced sustainability of productivity of the beekeeping industry (Debissa, 2007; Belie, 2009; Lulandala, 2012). According to Lulandala (2012), Agroforestry consists of resource use practices and technologies in which woody perennials are deliberately combined on the same resources management unit with herbaceous crops and animals or aquatic life forms or insects (e.g. honeybees and stingless bees) either in some forms of spatial arrangement or temporal sequence where there are both ecological and economic interactions among the different components. There is need, therefore, to encourage adoption of agroforestry practices as a means of promoting and sustaining beekeeping development in Manyoni District.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the results and subsequent discussions, the study concludes:

i. Beekeeping adoption in Manyoni District started earlier than the 1970s. The adoption was very low and varied at different times but drastically increased in the 1990s and 2000s due to increased community awareness and obviously shown benefits. Currently, 70% of the communities have adopted beekeeping. Only few were keeping stingless bees due to lack of knowledge.

ii. Most of the beekeeping activities were based on traditional practices using log and bark hives mainly because of low costs, accessibility to raw materials and lack of effective education on other improved technologies. Beekeepers are slowly shifting to improved hives.

iii. A total of 14 tree species are preferred by Manyoni District communities for traditional bee hive construction.

iv. Baits of plant origin (*Ocimum suave* and *Cymbogon citratus*) are more widely used for hive baiting to attract honeybees than other baits available because of lack of knowledge in beeswax processing and propolis collection.

v. A total of 12 plant species which are important sources of nectar and pollen for honeybees were recorded. Most of the bee forage plants are of indigenous nature except for exotic fruit trees such as *Mangifera indica* and introduced

trees like *Azadirachta indica*, *Leucaena leucocephala*, *Ceiba pentandra* and *Eucalyptus* species. *Helianthus annuus* are widely cultivated in farmlands.

vi. Most of the apiaries are located in natural forests, farmlands and to some extent in homesteads.

vii. Beekeepers harvest honey by using fire to calm down the honeybees using particular plant species. The use of protective clothing and bee smokers is limited.

viii. Honey processing and storage is locally done by beekeepers due to due to unavailability of appropriate equipment, lack of skills in processing, packaging and storage of bee products.

ix. The mean annual honey yield per hive from commercial bee hives was highest followed by log bee hives, Tanzania transitional hives, bark hives, gourd hives and stingless bee hives. Few beekeepers were processing beeswax due to lack of knowledge in processing, processing equipment and lack of awareness on its commercial value.

x. Beekeeping and honey production have significant contribution to household income and food security of the local people. However, beekeeping was found only as a side-line activity to increase the mean annual income of beekeepers with agriculture being the main activity.

xi. Beekeeping development in Manyoni District was enhanced by community awareness, availability of beekeeping areas, and consideration of beekeeping as a reliable source of income, institutional linkages and cultural norms.

xii. Inadequate training and extension services, lack of capital, distance from homesteads to apiaries, fear of bees, lack of reliable market and theft of bee hives were the factors limiting the adoption of beekeeping in Manyoni District.

6.2 Recommendations

Based on the results, preceding discussion and conclusions, the study recommends the following:

6.2.1 Recommendations for immediate application

(i) Training and extension services are needed so as to improve the beekeepers knowledge on appropriate beekeeping technologies, honeybee management, processing, storage of bee products, maintenance of required quality standards of the bee products (honey and beeswax) and stingless beekeeping (Meliponiculture). Implement an exchange programme where beekeepers can learn by seeing what others are doing.

(ii) Availability of proper beekeeping equipment, accessibility to credit facilities and reliable markets, harmonisation of land tenure policies, improvement of institutional linkages, and improvement of communication and transport are crucial for enhanced sustainability of beekeeping.

(iii) Improve the beekeeping research and create linkages with extension systems to sufficiently address the challenges and constraints of the beekeeping subsector and enhance technologies generation and transfer.

(iv) There is need to promote integrated beekeeping into agroforestry practices for enhanced beekeeping, improvement of food and income diversification, employment and the overall socio-economic development.

(v) Agroforestry practices provide for enhanced availability of critically required bee forage and water supply for honeybees. Adoption of agroforestry, therefore, needs to be rigorously promoted as a means of accelerating and sustaining beekeeping development.

(vi) Development of efficient and effective marketing systems for the bee products and facilitation of access of the beekeepers to credit facilities will improve the level of beekeeping in the district.

(vii) There is need to train carpenters and others artisans of the various beekeeping equipment in order to enhance equipment affordability and promote local manufacture of buckets and strainers.

6.2.2 Recommendations for further research

(i) Integration of beekeeping into agroforestry practices need further research to establish the best nectar and pollen producing bee forage plants for enhanced yield of bee products and agricultural crops.

(ii) Carrying out research on the stingless beekeeping (Meliponiculture) in order to establish the best conditions for enhanced management and technologies for increase yield per hive.

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APPENDICES

Appendix 1: Household questionnaire

A. General information

1. (i) Date of interview.....
   (i) Questionnaire number.....
   (ii) Division.....
   (iii) Ward.....
   (iv) Village .....
   (v) Name of interviewer .....

B. Background information

2. Name of household head or respondent .....

3. Gender (*Tick the relevant right choice*)
   (i) Male
   (ii) Female ☐

4. Age of the respondent (*Years*) .....

5. Education level of the respondent
   (i) No formal education
   (ii) Primary education ☐
   (iii) Secondary educations (form four or form six)
   (iv) Other (*Specify*) .....

6. Household size (number) .....
7. What is your occupation *(Please fill in the space provided below)*
   .....
8. For how long have you been in this area *(Years)*?
   .....

C. The extent of beekeeping, technologies in use and levels of production

9. Are you involved in beekeeping?
   (i) Yes ☐

   (ii) No
10. If No why? Give reason (s)
    (i) .....
    (ii) .....
    (iii).....
    (iv).....
11. If YES for how long have you been practicing beekeeping? (*Years*).. .....

12. Where do you keep your bee hives? *Explain*

.....

13. What type of honeybees do you keep?

(i) Stinging honeybees
(ii) (ii) Stingless bees
(iii) (iii) Both

14. What type of bee hives do you use?

Type of bee hive		**Number**
Traditional bee hive	Log hive	
	Bark hive	
	Gourd hive	
	Other (Specify)	
Improved hives (modern hives)	Tanzania Transitional Hive (TTH)	
	Tanzania Commercial Hive (TCH)	
Stingless bee hive	Stingless Bee Hive	

Reasons for using such type of bee hive

.....

15. Which tree species are used for traditional bee hive construction?

(i) .....
(ii) .....
(iii).....
(iv).....
(v) .....
(vi).....

16. Which plants are important sources of forage for honeybees?

(i) .....
(ii) .....
(iii).....
(iv).....
(v) .....

17. Which plants are commonly used for hive baiting

.....

18. Which plants are used to subdue honeybees during harvesting

.....

19. Do you wear bee protective gears during honey harvesting process?

(i) Yes
(ii) No

20. Do you use bee smoker during honeyharvesting?

(i) Yes
(ii) No

If No, why? *Explain*

.....

21. Do you experience any challenges regarding beekeeping?

(i) YES
(ii) NO

If yes explain/mention the problems:

.....

D. Contribution to household food and income livelihood in Manyoni

22. What are the sources of household food and income on the household (Tick all which apply)

Sources of household food	**Tick**	**Sources of household income**	**Tick**
Beekeeping		Beekeeping	
Agriculture		Agriculture	
Livestock production		Livestock production	
Forestry		Forestry	
Agroforestry		Agroforestry	
Trade		Trade	
Employment		Employment	

23. Specify amount of income generated on each of the sources on the household food and income

Sources of household and income	Quantity (kg, liter, bundle, pieces, bags)	Price	Actual amount collected per year		Total cost
			Own use (Food)	Trade	
Honey					
Beeswax					
Honeybees					
Bee hives					
Maize					
Sunflower					
Beans					
Rice					
Groundnuts					
Tobacco					

Sesame					
Tomato					
Onion					
Sorghum					
Cowpea					
Cassava					
Cattle					
Goat					
Poultry					
Fruits					
Firewood					
Charcoal					
Timber					
Poles					
Retail shop					
Local brew					
Milling machine					
Employment					

24. After harvesting, where and how do you preserve bee products? (What packaging materials are you using to store your bee products?)

.....

25. Who/ where is your common/ main market? *Mention*

.....

E. Factors influencing beekeeping development

26. What do you think is the most factor which influences development of beekeeping industry in your area? (Tick all which apply)

Factor	Tick
Beekeeping areas	
Source of income	
Awareness	
Institutional linkages	
Cultural norms	

27. Factors limiting the adoption of beekeeping in Manyoni District
What do you think is the most factor which limits the development of beekeeping industry in your area? (Tick all which apply)

Factors	Tick
In adequate training	
Inadequate extension services	
Lack of capital	
Distance from homestead to apiaries	
Fear of bees	
Lack of reliable markets	
Theft of bee hives	

28. Measures required for up-scaling of beekeeping industry in Manyoni District What are your suggestions to improve beekeeping practices in the area? (Tick all which apply)

Factors	**Tick**
Improve extension services	
Harmonise land tenure policy	
Improve institutional linkage	
Improve training	
Availability of beekeeping equipment	
Accessibility to credit	
Improve communication and transport	
Accessibility to markets	
Conservation of beekeeping areas	

Appendix 2: Checklist for Key informants

1. Population and socio-economic profile
2. What is the status of beekeeping in this area?
3. Types of hives, extent of use, location (forests, farmlands and homestead.)
4. What are the major activities undertaken to promote beekeeping in this area
5. What extension approaches do you think would be appropriate in helping to promote beekeekiping in this area?
6. What are the flowering pattern for bee forage plants?
7. How many times for honey harvesting per year from different type of hives?
8. What/ where are the common markets for honey and beeswax?
9. What constraints do you face in implementing beekeeping extension activities
10. What constraints do farmers face in adopting beekeeping in this area.
11. What is your perceptions regarding future interventions to improve the industry?

THANK YOU FOR YOUR TIME

Appendix 2a: The trend of beekeeping adoption in Manyoni District

Year	Ecological zones (%)			Freq.	Percent	Means (%)	Cum. Freq.	Percent (Cum)	Means (Cum)
	Zone 1	Zone 2	Zone 3						
1973	0	1	0	1	1.6	0.5c	1	1.6	0.5
1978	2	1	0	3	5.0	1.6c	4	6.6	2.2
1983	3	0	1	4	6.6	2.2c	8	13.3	4.4
1988	1	0	0	1	1.6	0.5c	9	15.0	5.0
1993	2	2	1	5	8.3	2.7dc	14	23.3	7.7
1998	7	5	2	14	23.3	7.7cd	28	46.6	15.5
2003	13	8	4	25	41.6	13.8bc	53	88.3	29.4
2008	11	12	10	33	55.0	18.3ab	86	143.3	47.7
2013	13	13	14	40	66.6	22.2a	126	210.0	70.0
Total	**52**	**42**	**32**	**126**	**210.0**	**70.0**	**329**	**548.3**	**182.7**

The values within the same column with the different following letters do differ significantly ($p<0.05$).
LSD = 8.9

Appendix 3b: ANOVA for the trend of beekeeping adoption in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	3584.258	8	448.0322	16.6045	2.18E-06	2.591096
Columns	29.6079	2	14.80395	0.548649	0.588221	3.633723
Error	431.7212	16	26.98257			
Total	4045.587	26				

Appendix 4a: Bee hive technologies adopted in Manyoni District by 2013

Bee hive technology	Ecological zones (%)				Means
	Zone 1	Zone 2	Zone 3	Total	
Log hive	85.0	65.0	43.3	193.3	64.4a
Bark hive	71.6	48.3	23.3	143.2	47.7ab
Tanzania Transitional Hive	23.3	26.6	5.0	54.9	18.3c
Gourd hive	0	33.3	0	33.3	11.1c
Stingless Bee Hive	13.3	6.6	0	19.9	6.6c
Tanzania Commercial Hive	0	3.3	1.6	4.9	1.6c

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 23.3

Appendix 4b: ANOVA for bee hive technologies adopted in Manyoni District by 2013

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	5682.071	5	1136.414274	10.13863	0.001142	3.325835
Columns	959.7803	2	479.8901639	4.281388	0.045372	4.102821
Error	1120.875	10	112.0875284			
Total	7762.727	17				

Appendix 5a: Tree species used for traditional bee hive construction in Manyoni District

Botanical Name	Common Name	Ecological zones (%)			Total	Means
		Zone 1	Zone 2	Zone 3		
Brachystegia spiciformis	Mtundu/ Myombo	83 3	61 6	43 3	188 2	62 7a
Pterocarpus angolensis	Mninga	43 3	56 6	0	99 9	33 3b
Julbernardia globiflora	Muba	81 6	0	0	81 6	27 2b
Commiphora stolonifera	Mdachi	0	51 6	25 0	76.6	25 5b
Combretum molle	Mlama	33.3	0	20 0	53 3	17.7b
Brachystegia boehmii	Mgela	35 0	0	0	35.0	11 6b
Acacia tortilis	Mkungugu	0	31 6	0	31 6	10 5b
Borassus aethiopum	Mtapa	0	28 3	0	28 3	9 4b
Ficus sycomorus	Mkuyu	0	26 6	0	26 6	8 8b
Terminalia sambesiaca	Mpululu	0	0	23 3	23 3	7 7b
Commiphora sp.	Msake	0	0	23 3	23 3	7 7b
Xeroderris stuhlmannii	Mnyenye	0	0	16 6	16 6	5 5b
Faidherbia albida	Mchese	0	15 0	0	15 0	5 0b
Syzygium cordatum	Msua	0	10 0	0	10 0	3 3c

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 29.0

Appendix 5b: ANOVA for trees used for traditional bee hive construction in Manyoni District

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows	6287	13	483.5795	1.155335	0.362196	2.119166
Columns	403.5	2	201.754	0.482017	0.622946	3.369016
Error	10883	26	418.5623			
Total	17573	41				

Appendix 6a: Plants commonly used for hive baiting in Manyoni District

Botanical Name	Local Name	Ecological zones (%)			Total	Mean
		Zone 1	Zone 2	Zone 3		
Ocimum suave	Malumbasi/ Mazenye	86.7	61.7	53.3	201.7	67.2a
Cymbogon citratus	Mchaichai	0.0	30.0	0.0	30.0	10.0b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 4.3

Appendix 6b: ANOVA for plants commonly used for hive baiting in Manyoni District

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows	2995.300772	1	2995.301	9.508151	0.091039	18.5128205
Columns	365.0072606	2	182.5036	0.579332	0.633179	19
Error	630.0490371	2	315.0245			
Total	3990.357069	5				

Appendix 7a: Bee forage plants recorded in Manyoni District by 2013

Botanical Name	Local Name	Ecological zones (%)			Total	Means
		Zone 1	Zone 2	Zone 3		
Brachystegia spiciformis	Mtundu/ Myombo	73 3	60	48 3	181 6	60.5a
Faidherbia albida	Mgonandele	0	60	40	100	33 3a
Combretum celestroides	Mnang'ana	25	39	26 6	86.6	30 2a
Brachystegia bohemi	Mgela	58 3	0	25	83 3.	27 7a
Julbernardia globiflora	Muba	76 6	0	0	76 6	25 5a
Combretum bendaranum	Mlandala	66 6	0	0	66 6	22 2b
Dichrostachys cinerea	Mtunduru	0	45	20	65	21 6b
Terminalia sambesiaca	Mpululu/ Mzima	39	0	22	53 3	20 3b
Combretum molle	Mlama	58 3	0	0	58 3	19 4b
Bidens pilosa	Mpangalale	0	38 3	19	43 3	19 1b
Cosspourea mollis	Mlugala	56 6	0	0	56 6	18 8b
Grewia bicolor	Mkoma/ Mpele	23 3	29 4	0	48 3	17 5b
Pseudoprosopsis fischeri	Ndalambwe	0	30	22 6	24 9	17 5b
Euphorbia candelabrum	Mlangali	32 3	19	0	21 6	17 1b
Azadirachta indica	Mwarubaini	0	38 3	11.6	49 9	16 6b
Adansonia digitata	Mbuyu	0	26	18	10	14.6b
Ceiba pentandra	Msufi	0	28	10	48 3	12 6b
Brachystegia bussei	Mkongoro/ Mtakwa	31 6	0	0	31.6	11.5b
Acacia tortilis	Mkungugu	0	33 6	0	21 6	11·2b
Mangifera indica	Muembe	0	18 3	13 3	31.6	10 5b
Combretum fragrans	Mluzyamize	18 3	0	12 6	19 9 .	10 3b
Combretum zeyheri	Msana	29 6	0	0	21 6	9 8b
Eucalyptus sp.	Mkaratusi	0	0	25	25	8 3b
Helianthus annuus	Alizeti	0	11 6	10	21.6	7 2b
Senna spectabilis	Msonobari	0	0	18.3	18 3	6 1b
Duosperma crenatum	Njelula	1 6	13 3	0	14.9	4.9b
Boscia salicifolia	Mtumba/ Mtuhumba	0	10	0	10	3.3b
Dovyalis macrocalyx	Mzuyuyu	6 6	1 6	0	3 2	2.7b
Luecaena leucocephala	Lucina	0	0	3 3	3 3 ·	1 1b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 37.6

Appendix 7b: ANOVA for bee forage plants recorded in Manyoni District by 2013

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	8259.829	28	294.9939	0.835901	0.692169	1.677507
Columns	333.829	2	166.9145	0.472973	0.625614	3.161861
Error	19762.69	56	352.9051			
Total	28356.35	86				

Appendix 8a: Beekeeping areas (Apiaries) in Manyoni District

Apiary site	Ecological zone (%)			Total	Mean
	Zone 1	Zone 2	Zone 3		
Forest	70	50	38.3	158.3	52.7a
Farm land	48.3	61.6	31.6	141.5	47.2a
Homestead	3.3	11.6	1.6	16.5	5.5b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 18.8

Appendix 8b: ANOVA for beekeeping areas (Apiaries) in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2110.889	2	1055.445	27.56007	0.004578	6.944272
Columns	262.4198	2	131.2099	3.426189	0.135853	6.944272
Error	153.1846	4	38.29616			
Total	2526.493	8				

Appendix 9a: Methods used during honey harvesting in Manyoni District

Honey harvesting method	Ecological zone (%)			Total	Means
	Zone 1	Zone 2	Zone 3		
Use of fire to calm the honeybees	88.3	96.6	53.3	238.2	79.4a
Use of beekeeping protective gear	40.0	35.0	8.3	83.3	27.7b
Use of bee smoker	28.3	25.0	8.3	61.6	19.4b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 31.6

Appendix 9b: ANOVA for methods used during honey harvesting in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2752.960554	2	1376.48	50.95822	0.001426	6.9442719
Columns	888.6041748	2	444.3021	16.44836	0.011753	6.9442719
Error	108.0477468	4	27.01194			
Total	3749.612476	8				

Appendix 9c: Plants used to subdue honeybees during honey harvesting in Manyoni District

Botanical Name	Local Name	Ecological zones (%)			Total	Mean
		Zone 1	Zone 2	Zone 3		
Pterocarpus angolensis	Mninga	86.6	33.3	26.6	146.5	48.9a
Ampelocissus africana	Bumpu	0	41.7	0	41.7	13.9ab
Commiphora stolonifera	Mdachi	0	0	26.6	26.6	8.9b
Euphorbia candelabrum	Mnangali	0	25.0	0	25	8.3b
Grewia platyclada	Mperemehe	0	16.6	0	16.6	5.5b
Gutenbergia sp.	Uhata	0	13.3	0	13.3	4.4b
Brachystegia spiciformis	Mtundu/ Myombo	1.6	0	0	1.6	0.5b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 35.8

Appendix 9d: ANOVA for plants used to subdue honeybees during honey harvesting in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	3613.64268	6	602.2738	2.224815415	0.112358	2.99612
Columns	651.196211	2	325.5981	1.20276809	0.334126	3.88529
Error	3248.48763	12	270.7073			
Total	7513.32653	20				

Appendix 10a: Mean annual honey production in Manyoni District as per 2013

Hive type	Ecological zones (%)			Total	Means
	Zone 1	Zone 2	Zone 3		
Tanzania Commercial Hive	0	26.6	20	46.6	15.5a
Log Hive	16.6	13.3	10	39.9	13.3ab
Tanzania Transitional Hive	18.3	15	0	33.3	11.1b
Bark hive	13.3	6.6	11.6	31.5	10.5bc
Gourd hive	0	20	0	20	6.6d
Stingless Bee Hive	1.6	0	0	1.6	0.5e

The values within the same column with the different following letters do differ significantly ($p<0.05$).
LSD = 2.4

Appendix 10b: ANOVA for mean annual honey production in Manyoni District in 2013

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	798.5218	5	159.704	1.271966	0.3478486	3.3258
Columns	241.3844	2	120.692	0.961254	0.4151087	4.1028
Error	1255.570	10	125.557			
Total	2295.476	17				

Appendix 11a: Sources of household food in Manyoni District

Source of household food	Ecological zones (%)			Total	Means
	Zone 1	Zone 2	Zone 3		
Agriculture	91.6	76.6	81.6	249.8	83.3a
Beekeeping	26.6	21.6	18.3	66.5	22.2b
Livestock keeping	20	16.6	13.3	49.9	16.6bc
Trade	13.3	18.3	5	36.6	12.2cd
Agroforestry	6.6	3.3	6.6	16.5	5.5de
Forestry	6.6	5	3.3	14.9	5.0de
Employment	3.3	5	5	13.3	4.4e

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 7.7

Appendix11b: ANOVA for sources of household food in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	6584.55	6	1097.425	87.31524	3.396E-09	2.99612
Columns	66.01207	2	33.00604	2.6260836	0.1132467	3.885294
Error	150.8225	12	12.56854			
Total	6801.385	20				

Appendix 12a: Sources of household income in Manyoni District

Source of household income	Ecological zones (%)			Total	Means%
	Zone 1	Zone 2	Zone 3		
Agriculture	96.6	95	91.6	283.2	94.4a
Beekeeping	80	58.3	46.6	184.9	61.6b
Livestock keeping	40	33.3	23.3	96.6	32.2c
Agroforestry	15	20	11.6	46.6	15.5d
Trade	13.3	18.3	5	36.6	12.2de
Forestry	11.6	6.6	5	23.2	7.8de
Employment	3.3	5	5	13.3	4.4e

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 9.1

Appendix 12b: ANOVA for sources of household income in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	9785.705	6	1630.951	93.169059	2.326E-09	2.99612
Columns	214.2922	2	107.1461	6.1207867	0.0147137	3.885294
Error	210.0634	12	17.50528			
Total	10210.06	20				

Appendix 13a: Household income generated from various sources in Manyoni District as per 2013

Sources of household income	Ecological zones (%)			Total income (Tshs)	Mean income (Tshs)	% of income generated
	Zone 1	Zone 2	Zone 3			
Agriculture	2 858 865.8	3 226 831.7	3 641 352.5	9 727 050.0	3 242 350.0a	50.2
Beekeeping	1 092 250.0	1 281 250.0	745 000.0	3 118 500.0	1 039 500.0b	16.1
Livestock keeping	683 867.0	861 965.0	749 918.0	2 295 750.0	765 250.0bc	11.8
Forestry	726 200.0	448 650.0	331 060.0	1 505 910.0	501 970.0bcd	7.8
Trade	378 455.0	1 004 355.0	115 990.0	1 498 800.0	499 600.0bcd	7.7
Agroforestry	243 900.0	163 760.0	454 240.0	861 900.0	287 300.0cd	4.4
Employment	121 940.0	135 600.0	121 960.0	379 500.0	126 500.0d	2.0
Total	**6 105 477.8**	**7 122 411.7**	**6 159 520.5**	**19 387 410.0**	**6 462 470.0**	**100.0**

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 604 271.6

Appendix13b: ANOVA for household income generated from various sources in Manyoni District as per 2013

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows	2.0436E+13	6	3.40601E+12	44.28928679	1.68924E-07	2.99612
Columns	93793178573	2	46896589286	0.609809584	0.559466145	3.885294
Error	9.22844E+11	12	76903660564			
Total	2.14527E+13	20				

Appendix 13c: Various sources and quantities of household income in Manyoni District as per 2013

Sources/ Product		Average quantity sold (Kg)	Average price (Tshs)	Total income (Tshs)	Average income (Tshs)	% of income generated
Agriculture	Maize	2 148	695.0	1 492 860.0		
	Sunflower	493	600.0	295 800.0		
	Beans	187	1 400.0	261 800.0		
	Rice	214	960.0	205 440.0		
	Groundnuts	98	1 495.0	146 510.0		
	Tobacco	143	1 900.0	271 700.0		
	Sesame	137	1 625.0	222 625.0		
	Tomato**	8	8 000.0	64 000.0		
	Onion**	12	9 400.0	112 800.0		
	Sorghum	133	455.0	60 515.0		
	Cowpea	95	1 140.0	108 300.0		
	Sub total			**3 242 350.0**	294 759.1	50.2
Beekeeping	Honey	190	4 100.00	779 000.00		
	Bees wax	20	3 950.00	79 000.00		
	Stingless bees*	4	39 000.00	156 000.00		
	Bee hives	6	4 250.00	25 500.00		
	Sub total			**1 039 500.00**	259 875.0	16.1
Livestock keeping	Cattle	4	130 000.0	520 000.0		
	Goat	6	30 000.0	180 000.0		
	Chicken	9	7 250.0	65 250.0		
	Sub total			**765 250.0**	255 083.3	11.8
Agroforestry	Honey	36	4 000.0	144 000.0		
	Stingless bees*	2	32 000.0	64 000.0		
	Cassava**	3	6 000.0	18 000.0		
	Charcoal*****	6	5 750.0	34 500.0		
	Firewood***	4	700.0	2 800.0		
	Baobab fruits**	6	4 000.0	24 000.0		
	Sub total			**287 300.0**	47 883.3	4.4
Forest	Firewood***	22	735.0	16 170.0		
	Charcoal*****	10.5	6 000.0	63 000.0		
	Timber****	56	7 550.0	422 800.0		
	Sub total			**501 970.0**	167 323.3	7.8
Trade	Retail shop	12 months	19 550.0	234 600.0		
	Local brew	8 months	12 500.0	100 000.0		
	Milling machine	10 months	16 500.0	165 000.0		
	Sub total			**499 600.0**	166 533.3	7.7
Employment	Casual labour	-	70,000.0	70 000.0		
	Masonry	-	56,500.0	56 500.0		
	Sub total			**126 500.0**	63,250.0	2.0
	Total			**6 462 470.0**		

*Honeybee colonies (Live bees)
** 20 Lt Bucket
*** Bundle
**** Pieces
***** Bags

Appendix 13d: Household income generated for purchase of food in Manyoni District

Sources of household food	Ecological zone (%)			Total income (Tshs)	Mean income (Tshs)	% of income (Food security)
	Zone 1	Zone 2	Zone 3			
Agriculture	734 850 0	775 235.0	783 550 0	2 293 635 0	764 545 0a	33 2
Agroforestry	524 445 0	693 490 0	722 225 0	1 940 160 0	469 600 0b	28 1
Beekeeping	511 750.0	465 800 0	431 250 0	1 408 800 0	257 200 0c	20 4
Livestock keeping	323 140.0	224 235.0	224 225 0	771 600 0	72 900 0d	11 2
Forestry	109 432.0	54 728 0	54540 0	218 700 0	46 800 0d	3 2
Trade	51 915 0	44 758 0	43 727.0	140 400 0	646 720 0a	2 0
Employment	44 900.0	42 850.0	42 750 0	130 500 0	13 500 0d	1 9
Total	**2 300 432.0**	**2 301 096.0**	**2 302 267.0**	**6 903 795.0**	**2 301 265.0**	**100.0**

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 119 414.8

Appendix 13e: ANOVA for household income generated for purchase of food in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.62806E+12	6	2.71344E+11	90.33227808	2.78575E-9	2.99612038
Columns	0.000244141	2	0.00012207	4.06381E-14	1	3.88529383
Error	36046060000	12	3003838333			
Total	1.66411E+12	20				

Appendix 13f: Various sources and quantities of household food supply per year in Manyoni District in 2013

Sources/ Product		Average quantity sold (Kg)	Average price (Tshs)	Average income (Tshs)
Agriculture	Maize	516	695.0	358 620.0
	Beans	31	1 400.0	43 400.0
	Rice	85	980.0	83 300.0
	Sorghum	37	465.0	17 205.0
	Groundnuts	28	1 400.0	39 200.0
	Cassava**	14	6 500.0	91 000.0
	Sunflower	42	600.0	25 200.0
	Tomato*	3	8 000.0	24 000.0
	Cowpea	33	1 140.0	37 620.0
	Onion*	5	9 000.0	45 000.0
	Sub total			**764 545.0**
Beekeeping	Honey	103	4 000.0	412.000.0
	Beeswax	18	3 200.0	57 600.0
	Sub total			**469 600.0**
Livestock	Goat	5	30 000.0	150 000.0
	Chicken	12	8 000.0	96 000.0
	Egg	70	160.0	11 200.0
	Sub total			**257 200.0**
Agroforestry	Maize	43	675.0	29 025.0
	Sorghum	54	455.0	24 570.0
	Cassava**	12	4 750.0	54 625.0
	Honey	82	4 000.0	326 000.0
	Poles****	17	12 500.0	212 500.0
	Sub total			**646 720.0**
Forest	Firewood***	6	650.0	3 900.0
	Charcoal**	12	6 000.0	69 000.0
	Sub total			**72 900.0**
Trade	Petty trading	12	3 900.0	46 800.0
	Sub total			**46 800.0**
Employment	Casual labour	-	43.500.0	43 500.0
	Sub total			**43 500.0**
	Total			**2 301 265.0**

* 20 Lt Bucket
** Bags
*** Bundle
**** Pieces

Appendix 14a: Factors enhancing the adoption of beekeeping industry in Manyoni District

Influencing factors	Ecological zones (%)			Total	Means
	Zone 1	Zone 2	Zone 3		
Awareness	88.1	73.3	48.5	209.9	70.0a
Beekeeping areas	56.7	67.2	84.3	208.2	69.4a
Source of income	79.4	68.6	58.5	206.5	68.8a
Institutional linkages	18.3	13.3	0	31.6	10.5b
Cultural norms	1.6	0	0	1.6	0.5b

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 11.0

Appendix 14b: ANOVA for factors enhancing the adoption of beekeeping industry in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	8606.771263	4	2151.693	93.78606	9.345E-07	3.837853
Columns	1011.396065	2	505.698	22.04191	0.0005566	4.45897
Error	183.5405325	8	22.94257			
Total	9801.70786	14				

Appendix 15a: Factors limiting the adoption of beekeeping industry in Manyoni District

Limiting factor	Ecological zones (%)			Total	Means
	Zone 1	Zone 2	Zone 3		
In adequate training	77.0	49.3	82.0	208.3	69.4a
Inadequate extension services	76.6	45.0	85.0	206.6	68.8a
Lack of capital	41.6	49.0	61.6	152.2	50.7ab
Lack of reliable markets	28.3	46.6	40.0	114.9	38.3b
Distance from homestead to apiaries	65.0	20.0	26.6	111.6	37.2b
Fear of bees	0	6.6	11.6	18.2	6.1c
Theft of bee hives	0	8.3	0	8.3	2.7c

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 18.2

Appendix 15b: ANOVA for factors limiting the adoption of beekeeping industry in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	7463.4854	6	1243.914	10.44366	0.000359	2.99612
Columns	118.6883	2	59.34415	0.498242	0.61963	3.885294
Error	1429.286	12	119.1072			
Total	9011.4597	20				

Appendix 16a: Measures required for improvement of beekeeping and technologies adoption in Manyoni District

Suggested intervention	Ecological zones (%)			Total	Means
	Zone 1	Zone 2	Zone 3		
Availability of bee keeping equipment	90.0	70.0	53.3	213.3	71.1a
Improve extension services	68.2	55.1	88.3	211.6	70.5a
Improve trajning	80.6	73.0	56.3	209.9	70.0a
Accessibility to credit facilities	71.0	52.3	48.3	171.6	57.2b
Harmonise land tenure policy	58.0	43.6	13.3	114.9	38.3c
Improve institutional linkages	43.3	38.3	11.6	93.2	31.1c
Conservation of bee keeping areas	28.3	20.0	3.3	51.6	17.2d
Access to reliable market	23.3	11.6	10.0	44.9	15.0d
Improve communication and transport	28.3	0	0	28.3	9.4d

Means in the same column that are followed by the different letters do differ significantly ($p<0.05$)
LSD = 9.9

Appendix 16b: ANOVA for measures required for improvement of beekeeping and technologies adoption in Manyoni District

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	7632.603	8	954.0754	29.02905	4.11875E-8	2.591096
Columns	2032.856	2	1016.428	30.92621	3.1826E-06	3.633723
Error	525.8596	16	32.86623			
Total	10191.32	26				