ADOPTION OF MODERN BEEKEEPING TECHNOLOGIES AMONG RURAL HOUSEHOLDS IN SELECTED LOCAL GOVERNMENT AREAS OF BENUE STATE, NIGERIA

BY

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MTech/SAAT/2019/9335

DEPARTMENT OF AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA, NIGER STATE

JULY, 2023

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A THESIS SUBMITTED TO THE POST GRADUATE SCHOOL FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN AGRICULTURAL EXTENSION AND RURAL SOCIOLOGY

JULY, 2023

DECLARATION

I hereby declare that the thesis titled: **"Adoption of modern beekeeping technologies among rural households in selected local government areas of Benue State, Nigeria"** is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledged.

ABDULLAHI, Bashiru ---------------------------

MTech/SAAT/2019/9335 SIGNATURE & DATE

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA, NIGERIA

CERTIFICATION

The thesis titled: **"Adoption of Modern Beekeeping Technologies among Rural Households in Selected Local Government Areas of Benue State, Nigeria"** by: ABDULLAHI, Bashiru (MTech/SAAT/2019/9335) meets the regulations governing the award of the degree of M.TECH of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project is dedicated to the Almighty Allah for his mercies over my life and academics and to my late mum and great-grandma, Mrs. Abdullahi Kariyute and Mrs. Asuku Aliimoh, may Allah grant them eternal rest. Also, this project is dedicated to my father, friends, relatives, and my able supervisors. Thank you all for your unwavering love, support, and inspiration.

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ABSTRACT

Nigeria is not among the top five (5) honey producers in Africa despite her rich vegetation that can support beekeeping. Thus, this study was conducted to examine adoption of improved beekeeping technologies among rural households in selected Local Government Areas of Benue State. Specifically the study aimed to describe the socio-economic characteristics of bee farmers; determine the level and rate of adoption of modern beekeeping technologies; assess the extent of utilization of bee products; determine the factors affecting the adoptions of modern beekeeping technologies; and examine the challenges associated with modern beekeeping technologies adoption in the study area. Three stage sampling techniques were used to select 212 beekeepers; Data were collected from primary source using semi-structured questionnaire complemented with interview schedule. Data collected were analyzed using both descriptive statistics such as (means, percentages and frequency distribution) and inferential statistics such as (survival analysis and Cox proportional hazard rate). The findings indicated that the majority (76.0%) of the respondents were between the age ranges of 41–60 years, with a mean age of 50 years. About79% had tertiary education, while 93.9% were married, with a mean household size and beekeeping experience of 6 people and 10 years, respectively. Social media (88.2%), family and friends (61.3%), radio (60.8%), and beekeepers groups (59.0%) were found to be the major sources of information. The result of level of adoption showed that bee suits had mean of ($\overline{X}$=2.7), baiting ($\overline{X}$=2.6), and Kenya top bars ($\overline{X}$=2.6) had higher adoption rate with beekeepers reaching the decision within the first-three years of beekeeping practices. Whereas water provision ($\overline{X}$=2.4), hive inspection ($\overline{X}$=2.3), and swarm catcher ($\overline{X}$=2.1) had a moderate adoption rate reaching the decision within first-five years. Honey is most utilized bee product; bee wax was occasionally utilized while propolis, bee venom, bee pollen and royal jelly were never utilized in the study areas. The result of the factors influencing adoption of improved beekeeping technologies indicates that extension contact (0.7515) had direct relationship with bee suit and water provision adoption. Membership of cooperative (1.1219) and beekeeping workshop (1.7458) had direct influence on baiting adoption. Household size (0.7903) and extension contact (0.5082) had inverse relationship with adoption of Kenya top bars. Lastly, indiscriminate bush burning (97.2%), theft (91.5%), lack of beekeeping skills (76.9) and high of cost beekeeping materials (75.0%) were the major challenges associated with beekeeping in the study area. The study concludes the rate adoption of modern beekeeping technologies and extent of bee product utilization was low. Therefore, the study recommended that State Ministry of Agriculture, Governmental and Non-Governmental Organizations as well as other relevant stakeholders and beekeeping cooperatives should organize workshop and training for beekeepers in the study areas in order to facilitate high utilization of other bee product, as beekeepers in the study area had low utilization of bee products.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Agriculture is the mainstay of the Nigerian economy with regards to employment and is linked with other sectors of the economy. It contributed 23.78% to the Gross Domestic Product (GDP) in the second quarter of 2021 (Nigeria Bureau of Statistic (NBS), 2021). It is one of the most important index for measuring and comparing the economic progress of a nation. Approximately about 70% of Nigeria's active population engaged in agricultural production at a subsistence level (Eboh, 2008; Adebayo and Olagunju, 2015).

Despite the large involvement of Nigerians in agriculture, Nigerian agriculture was unable to produce enough food to meet the needs of its burgeoning population, which is expected to grow at a 2.54% annual rate (NBS, 2021). However, efficient and effective utilization of agricultural resources, the sector could compete favourably with other sectors of the economy and possibly displace petroleum oil which has adversely affected the agricultural sector since its discovery (Workney, 2011). Since independence, successive government has attempted to revitalize the agricultural sector through policies, program and interventions aimed at agricultural transformation, enhancing productivity, stimulating economy growth as well as reducing poverty in rural areas. Despite all these efforts, majority of Nigerian farmers still practice subsistence agriculture because they are resource poor, not educated, lack access to capital and conservative in nature (Eboh, 2008; Adebayo and Olagunju, 2015). Therefore, to reduce poverty and enhance livelihood in rural areas, it is essential to focus on high potential areas of agricultural sector that could be more productive as well as diversifying the source of income. Beekeeping is one of the agricultural sub-sectors where such potential exists (Egwu, 2014).

According to Lowore *et al.* (2010), bee farming requires little resources (little startup capital, less fertile land can be utilized within little time and space). This could be integrated into livelihood diversification strategies of smallholder farming households in order to provide an additional source of income and to spread risk. Beekeeping accounted for approximately a million metric tons of honey annually, with an exchange market value of over a billion dollars (Food and Agriculture Organization Statistics (FAOSTAT), 2009). The most essential service rendered by honeybees to mankind is ecosystem services (pollination) for the successful production of many crops (Artz *et al.,* 2011).

Bees' by-products including honey are good sources of revenue, a means of poverty reduction, sustainable forest resource management and major source of livelihood diversification among farmers. When compared with other agricultural sub-sectors such as crop farming, livestock and fish farming, beekeeping has a low capital investment that can be undertaken by most people. There is no competition for the use of resources from other agricultural sub-sector in beekeeping, which favours natural vegetation conservation (Japan Association for International Collaboration of Agriculture and Forestry (JAICAF), 2009; Isaacs and Kirk, 2010). Honey and other bee products could generate $10 billion in annual revenue from local and international trade, according to the Nigeria Export Promotion Council, which was developed by the United States Agency for International Development (USAID) in 2019. Domestic consumption of honey and other bee products in Nigeria is currently 380,000 metric tons. The overall honey produced in Nigeria is grossly insufficient and poorly documented; this can partly meet the country domestic consumption and industrial needs from the public based farms dominated by small scale beekeepers. Data from FAOSTAT (2015) revealed that Nigeria is not among the top five (5) honey producers in Africa despite her rich vegetation that can support beekeeping. Ajao and Oladimeji (2013) opined that beekeeping in Nigeria is a seasonal activity that predominantly remains rudimentary and unexploited, but has the potential of increasing Nigeria export base. It could provide food, nutritional and livelihood security to the rural work force on an ecologically sustainable basis.

Apart from honey and other by-products such as beeswax, propolis, bee venom, bee pollen and royal jelly which are highly priced globally most especially in non-producing countries, it was reported that 35 – 73% of the world's cultivated crops are been pollinated by different breed of bees indicating that most of the plant species rely on bee insects for pollination (Klein *et al.*, 2007; Harshwardhan *et al.*, 2012). Beekeepers can give pollination services, beehive rentals to farmers and orchardists in addition to selling honey and other bee products (Admin, 2011).

Adoption decision is not an overnight activity; rather, it is a mental process that an individual farmer goes through when making rational decisions about adopting new technology. New innovations must meet specific economic, cultural, institutional, technical, and social requirements in order to facilitate their adoption. Therefore, new technology should be more economically viable and accessible to farmers than the existing choices. Moreover, it should be technically feasible to small farm holders and culturally acceptable (Ehui *et al*., 2004; Amanuel, 2018).

1.2 Statement of the Research Problem

Despite the enormous benefit attributed to honeybee such as rural income diversification, improving health, reducing poverty and unemployment as well as increasing crop production, Nigerian beekeepers have numerous challenges in terms of production efficiency, storage capacity, post-harvest handling, and packaging, all of which render their products unsuitable for export. In most cases, beekeeping has remained conservative and unrewarding due to the methods used. As a result, the yield of honey and other bee products has consistently remained stable over the years. It rarely exceeds 45 kilograms per year per modern hive and hardly exceeds 7 kilograms per year per traditional hive (Dereje *et al.*, 2020).

Most small scale bee farmers are only interested in honey which is one out of possible six (6) major bee products. This could be attributed to inadequate awareness, negligence or inadequate processing skills. After pressing the honey from the comb, the comb is thrown away which could have been converted into bee wax. Also, the crude methods of harvesting destroy the propolis used by bee to seal their opening in the hive. Unfortunately, large scale beekeepers that are into processing, could not processed clean wax to meet international standard which could be attributed to shortage of trained manpower and appropriate technical assistance for bee farming, as well as shortage of appropriate technical knowledge, inadequate financial resources, inadequate suitable market information, inappropriate processing technology for product diversification and poor management practices which reduced honeybee productivity. The effect of adoption has not been felt as many beekeepers still produce at subsistence level. Poor level of awareness among the rural farmers, unacceptability and poor handling among others could be the problems associated with the adoption of modern beekeeping technologies in the study area. Therefore, adoption of modern bee farming technologies and improved management practices is a way forward towards increasing honey yield, other bee products and enhancing crop productivity through bee pollination. Previous studies (Bunde and Kibet 2013; Adgaba *et al.*, 2014; Gebiso, 2015; Asmiro *et al*, 2017; Jebesa, 2017) on beekeeping adoption have focused on the level of adoption and the categories of adopters and primarily focused on the economic and nutritional benefits of bee products (wax, propolis, bee venom, bee pollen, and royal jelly), with little documented evidence of beekeepers' utilization of these products. The identified gaps in the literatures necessitate the conduct of this research. Based on the foregoing, the researcher formulated the following research questions:

i. what are the socio-economic characteristics of bee farmers in the study area?
ii. what are the level and rate of adoption of modern beekeeping technologies in the study area?
iii. what are the extent of utilization of bee products?
iv. what are the factors affecting the adoptions of modern beekeeping technologies?
v. what are the challenges associated with adoption of modern beekeeping technologies in the study area?.

1.3 Aim and Objectives of the Study

The broad objective of the study is to ascertain adoption of modern beekeeping technology in the study areas. The specific objectives are to:

i. describe the socio-economic characteristics of bee farmers;
ii. determine the level and rate of adoption of modern beekeeping technologies in the study area;
iii. assess the extent of utilization of bee products;

iv. determine the factors affecting the adoptions of modern beekeeping technologies;
v. examine the challenges associated with adoption of modern beekeeping technologies in the study area.

1.4 Hypothesis of the Study

$H0_1$: Selected socio-economic characteristics (age, marital status, household size, education, area devoted for beekeeping and beekeeping experience) have no significant influence on adoption rate of modern beekeeping technologies

1.5 Justification for the Study

In order to minimize food insecurity in Nigeria, agricultural production must be intensified through the use of contemporary technologies. Adoption and appropriate usage of such technologies in beekeeping are essential for increased honey quality and quantity. There are number of factors that influence whether a technology is adopted positively or negatively. To gain a better understanding of the major factors affecting adoption of modern beekeeping technologies in the study areas, policymakers, researchers, and organizations involved in beekeeping development programs must first identify factors that positively or negatively influence adoption of modern beekeeping technologies. This will aid them in developing effective methods to improve adoption processes. Also, the findings from this study will serve as a guide to identify the areas that require intervention in order to enhance adoption of modern bee technologies that is concerned and might establish strategic underpinnings in planning for rural development and poverty reduction. The findings emanating from this study assess the level of adoption of modern bee keeping and utilization of other bee by-product thus, various strategies of improving the adoption of modern beekeeping was recommended. Lastly, the findings will improve the body of literature for further studies.

CHAPTER TWO

2. 0 LITERATURE REVIEW

2.1 Global Overview of Apiculture

Apiculture is one of the most widely practiced sub-livestock economic activities in the world. The total number of bee hives in the globe was projected to be 81,027,786 in 2013. (FAOSTAT, 2015). The number of hives varies by region, with Asia having the most; moreover, the types of hives range from traditional to modern. Honey production is expected to reach 1.6 million tons per year globally (Adedipe *et al.,* 2014; FAOSTAT, 2015). The nations that produce the most honey in Europe include Romania, Spain, Hungary, Germany, Italy, Greece, France, and Poland; these countries are located in Southern Europe, which is a member of the European Union. The European Union as a whole is the world's second-largest honey producer, behind China. There are around 16 million beehives owned by 600,000 beekeepers in the European Union (FAOSTAT, 2015; Hogeland, 2016).

Honey production in Romania is the highest in Europe, with 20,000 and 35,000 metric tons produced in 2014 and 2015, respectively. In Asia, the major honey producers are China, India, Iran, and South Korea. China, in particular, is the world's leading producer of honey. Every year, they produce an incredible 300,000 metric tons of honey on average. In 2013, she produced 466,000 metric tons of honey (Workney, 2011; FAOSTAT, 2015). Africa is also recognized for its honey production, with the following countries producing and exporting the most honey; Ethiopia, Tanzania, Angola, Central African Republic and Kenya. Ethiopia is Africa's biggest honey producer. Beekeeping has a long history in

Ethiopia, accounting for 1.3 percent of the country's agricultural GDP. Honeybees are kept by one out of every ten families (Demisew, 2016).

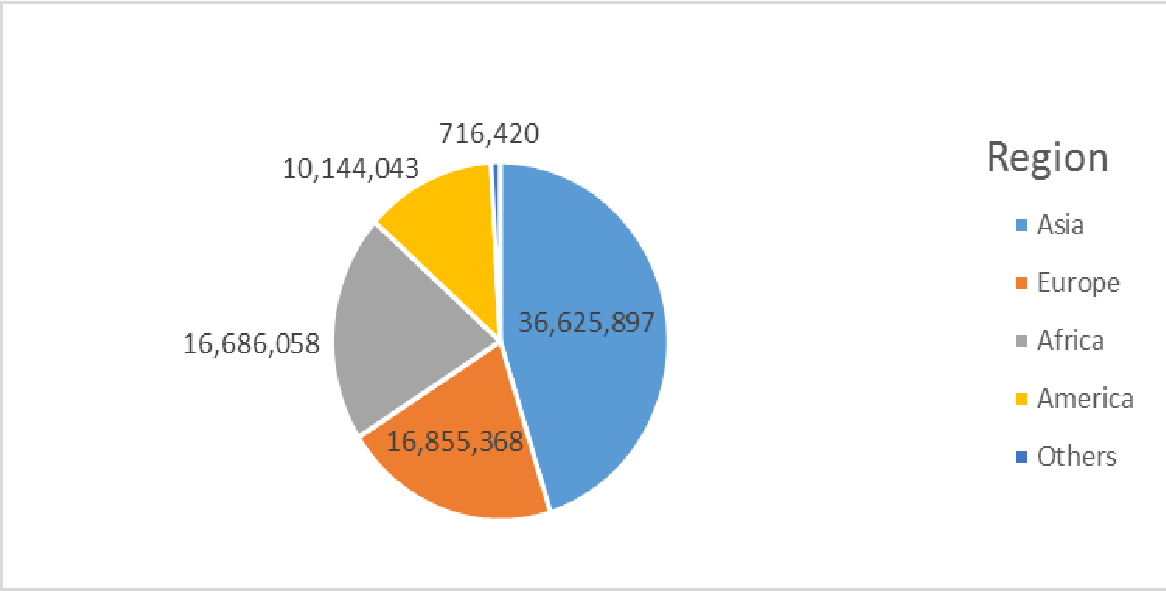

Figure 2.1: Bee hives per region
Source: FAOSTAT, (2015)

2.2 Bee Production in Nigeria

Between 1000 and 1500 AD Arab travelers in West Africa, which included the present day Northern region of Nigeria were involved in trade. One of the precious items of trade recorded was the use of honey for alcoholic drink called (Mead), invariably, the existence of honey in the region acknowledged the presence of bee hives, from where honey was produced (Azaiki, 2013; Ogbari and Ama, 2014). The unearthing ultimately developed into bee farming in Nigeria. Gradually, the act of beekeeping extended to many parts of the country where farmers adopted various methods.

Traditional beekeeping in Zaria depicts that bee hives were placed on trees, whilst plaited grasses were used in the Ngamo area. Honey combs are harvested after dark, after a full moon, or before a new moon appear. The Kanuri people of Nigeria's North Eastern region use calabashes on trees as bee hives (Ogbari and Ama, 2014), although, the natural nesting habitats for bees include cavities in large trees, ant hills, rocks, beneath bridges, ceilings, and discarded containers. Similarly, they can also be found in the grooves of trees in the wild. Hardwood or half-quarter steel drums with wooden top bars are used in traditional bee hives. Modern hives were introduced to Ibadan on farms in Ayepe, Osun state, Ilesha, and Dogon Dawa in the north by the International Institute for Tropical Agriculture (IITA).

The traditional honey harvesting practice in Nigeria is a crude method which involves allowing bees to breed in the wild and burning their hives to disperse the bees, which often resulted to killing the bees in the process. This aged long practice reduces bee population and it sustainability as economic venture for income/livelihood for rural dwellers. Thus, beekeeping in trees is practiced by men, by climbing the trees through the use of ladder and ropes. Pots are kept on the ground as hives in beekeeping in several sections of Nigeria's southern and central states. Palm-wine is used to attract bees to traditional hives in Eastern Nigeria. Clay or mud hives are used to raise bees in Southern Bauchi (Ogbari and Ama, 2014).

According to Tabinda *et al*. (2013) Beekeeping refers to the preservation of honey bee colonies to get pure honey and helps in pollination. The researcher added that the maintenance of honey bee colonies, commonly in hives is carried out by man. Tarunika (2014) opined that beekeeping provides a suitable source of income for farmers without land since it is migratory in nature, even the landless farmers can take up this profession and did not compete with crop production or animal husbandry for any input.

The bee farmers needed few hours in a week to look after his bee colonies; making it ideal as a part time activity (Samson, 2016). Beekeeping is inextricably linked with agricultural and rural development. At the home level, it provides nutritional, economic, and ecological security to rural populations; it is an additional source of income generating activities (Naushad, 2018). Bees gather pollen from flowers and feed on nectar, which is then transformed into honey using various enzymes. Gums and resins are also obtained from plant secretions or wounded plant parts and utilized for sealing and empty cell nests making (Lamessa, 2007; Ogbari and Ama, 2014). In addition, the productivity of crops is enhanced by bee through pollination which invariably ensures food security. It is estimated that approximately 80% of crop pollination occurs with the help bees therefore, boosting the quality of fruits, vegetables, and seed crop output. Beekeeping has been highlighted as a sustainable agricultural practice that could alleviate poverty and sustain rural employment in Nigeria, and it has been identified as a helpful means of boosting livelihoods (Messely, 2007; Samson, 2016). Beekeeping requires very little initial capital, little effort, and may be easily undertaken by men and women, youth and individuals with impairments. It allows different members of the community to make use of available resources to support their livelihoods.

The best and most suitable times for beekeeping and production are October to November and the spring seasons, but honey can be produced all year round by planting special species of bee flora plants and moving colonies to different natural floral belts across the country. In a developing country like Nigeria, beekeeping is rarely a person's sole source of income and livelihood, but it is important as a source of supplementary income, food, and employment (Petem *et al.*, 1998; Samson, 2016).

Other bee products like bee wax used in candle making, propolis used in apitherapy for its anti- viral and bacterial properties. Pollen on the other hand has found its way to some health food outlets because of it rich protein while other products like royal jelly which is secreted by the glands of young workers bees improves general wellbeing and brain function, meanwhile bee venom is used to heal various conditions and illness. All these bee products are demanded globally. Achieving a sustainable bee productivity, improved management practices and environmental techniques and technologies needs to be adopted (Gebiso, 2015).

2.3 Bee Products and Bee Technologies

Pollination services provided by bees help to preserve biological equilibrium in nature, allowing many animal and plant species, including humans, to thrive. They also provide bee products, which are a completely natural food source. People have used them since the ancient period, and they are an especially good source of sustenance in today's increasingly fast-paced world. Aside from honey, which is by far the most popular bee product, bees also offer us with Propolis, Pollen, Royal jelly, Wax, bee bread and Venom (Asmiro *et al.*, 2017).

2.3.1 Honey

Nectar from flowers is collected by honey bees. Nectar is a sweet liquid whose composition varies depending on the plant species in which the nectar is collected. The forager bees brought nectar back to the hive in their honey stomachs and gave it to the house bees. They thicken the nectar before pouring it into the comb's cells, where it ripens into honey before being sealed up with a wax coating. Pollen is collected by honey bees from flower stamens. While the bee is sipping nectar, pollen clings to its hairs. Using a comb on its forelegs, the bee extracts pollen from its hairs and adds saliva to help roll it into balls. On its hind legs, the bee flies to the beehive with these pollen basket loads. These loads, along with a small amount of honey and saliva, are pushed into honeycomb cells by house bees using their heads. The bees then ripen the mixture into bee bread by processing them (Bunde and Kibet, 2013).

Meaza (2010) posits that the taste, colour and aroma of honey are determined by the type of plants from which nectars are collected by bees. Sunflowers, for example, produce a golden yellow honey; clover produces a sweet, white honey; and agave species produce a bitter honey that is beloved in various cultures, according to the study. Dark honey has a strong flavour and often contains a lot of minerals; pale honey has a milder flavour. Dark and light honey has different levels of appeal in different countries. Because honey darkens during storage or when cooked, its color can also reflect its quality. However, some honeys that are totally fresh and unheated might be dark in colour. Glucose is a major constituent of honey. When the glucose crystallizes, the honey becomes solid and is known as granulated honey (Brodschneider and Crailsheim, 2010).

2.3.2 Bees wax

Young bees, approximately 2 to 3 weeks old, produce the best bee wax. They prepare the bee wax after feeding royal jelly to the young brood and right before they leave the hive to forage. Bee wax is obtained from beneath the abdomens of worker bees. It is utilized by bees to construct hive structures. The wax is utilized to make comb cells for the bees' young. It's also utilized to seal hive cracks and construct honey storage cells. Furthermore, bee wax protects the brood from infection by acting as a cushion. Beeswax is used in a variety of ways by humans. It has always been and will continue to be the most useful bee product on the market (Brodschneider and Crailsheim, 2010; Meaza, 2010; Daniel, 2013). Its origins can be traced back to the early days history, when it was utilized to pay taxes. During its early history, it was even regarded as legal tender in Europe. In the past, artists used bees wax to create models.

Priests used it to embalm dead, while woodworkers used it to hold wood pieces together. Other uses of bees wax include: Producing waterproof walls in the ancient Roman Empire, writing tablets, reinforcing sewing threats, food preservatives, and moisture-proof casing. Many of these uses are still applicable today couple with industrial use for making candles, cosmetics, polishes, food applications, and pharmaceutical product with many applications (Brodschneider and Crailsheim, 2010).

2.3.3 Royal jelly

The worker bee secretes royal jelly from its head glands, which is a white paste-like fluid. The jelly is utilized to feed the colony's larvae. Royal jelly is made up of 67 percent water, 12.5 percent crude protein, 11% simple sugars, and 5% fatty acids vitamin C + enzymes + minerals (Harshwardhan *et al.*, 2012). When the nurse bees are 5 to 15 days old, they produce this essential substance, which is fed to the larvae for the first three days of their lives. The larvae chosen as the queen are then fed a diet consisting solely of royal jelly. Following that, a series of chemical events occur, converting the queen into a massive, fertile bee with a long life expectancy who would live on royal jelly for the remainder of its existence. When the queen is four days old, the royal jelly is normally extracted. It's taken from the queen cells, where it's dumped in massive numbers. In reality, the queen floats through the jelly. The jelly is extensively utilized because of its numerous advantages. To begin with, it promotes the formation of neurological cells, which aids in the treatment of

Alzheimer's and Parkinson's disorders. It's also used to treat wounds, decrease cholesterol, fight inflammation, and prevent tumors from being vascularized (Brodschneider and Crailsheim, 2010).

2.3.4 Propolis

Another significant honeybee product is propolis. Bees collect resins from flowers, trees, and other man-made sources, which they subsequently use to manufacture propolis. Its composition is usually dependent on the season, the location, and the resin sources available. In most cases, however, it's made up of 1/5 resins and vegetable balsams, 1/3 wax, 1/10 essential oils, and 1/5 pollen. Depending on the plants, it will have a different chemical makeup. Propolis is used by bees to seal hive cracks as well as to keep fungus and bacteria out. When propolis dries, it hardens and becomes impenetrable. It protects the bees from extremes temperature, such as cold and heat. According to previous studies, bees use the substance to seal large animals like rats and other invaders when they die within the hive. This makes the dead carcass innocuous to the hive's residents (Nwaihu *et al.*, 2015).

Propolis contains antibacterial, antiseptic, and detoxifying effects. It's used to treat wounds caused by ulcers, inflammation, and even burns. The term "Russian penicillin" has been given to it. Propolis prevents bacterial development in cuts, burns, and wounds when used as an antiseptic ointment or wash. It's also a fantastic sore throat treatment. Chemical composition will differ based on the sources employed, and no two products will have the same therapeutic characteristics.

2.3.5 Bee pollen

The anthers of flowering plants are used to make pollen for bees. Sugars, proteins, lipids, and amino acids make up this substance. Bees generally acquire pollen while foraging from one blossom to the next. They serve as pollinators in the process. Pollen is packed, mixed with nectar and honey, and then stored as granules when they return to the hive. This forms what is referred to as bee bread. It is the main source of protein for the bees and helps in the production of royal jelly and bee wax (Meaza, 2010).

The benefits of bee pollen have been reported in a variety of non-scientific sources. Endocrine disorders, chronic issues, male sterility, the common cold, ulcers, acne, and high blood pressure are among them. Some of the proven medical benefits of pollen include its role in eliminating prostate problems and allergies. It is used to treat prostate cancer and edema. It can also be used to treat high fevers and pollen sensitivity. Pollen is a dietary supplement. It is, however, impossible to extract precise chemical components from pollen from various places (Brodschneider and Crailsheim, 2010).

2.3.6 Bee venom

Bees are also known for their sting, which most people are familiar with. Bees, however, require a compelling motive to sting. When you come across bees in the wild, they will only sting if their lives are in danger, but when you come across a beehive, it's a different story. Guard bees faithfully undertake their duty of guarding the entrance to their hive, which not only houses larvae but also abundant honey and pollen supplies (Qaiser *et al.*, 2013). As a result, we should never approach apiaries or stand in front of hives. It is totally natural to have a reaction after being stung by a bee. However, if we have an allergic reaction, we should seek medical help. Bee venom is used in medicine to desensitize persons who are allergic to bee venom. Bee venom is also utilized to cure a variety of ailments and illnesses all around the world, but only under medical supervision. Bee venom has recently gained popularity in the cosmetics business. Because it's considered to be a natural Botox alternative, it's added to lotions and serums (Meaza, 2010).

2.3.7 Supplementary feeding

Supplementary feeding is simply honey, sugar syrup, beet sugar syrup, or maize syrup given to bees to make up for nutritional deficiencies (Wright *et al*., 2018). Beekeepers also feed their bees in the spring to provide extra resources, increase brood rearing, and boost nutrition in the fall. Bees, unfortunately, are at the mercy of their surroundings. Beekeepers also feed their bees in the spring to provide extra resources, increase brood rearing, and boost nutrition in the fall. The colony may face disaster if the weather is extreme (hot or cold). They can't gather enough pollen and nectar to keep their numbers up during unusually wet springs. They may starve over the winter if there isn't enough good feed close to the hive. The following are the reasons for supplementary bee feeding according to Wright *et al.* (2018):

i. To help your colony develop when there are shortages of pollen and nectar
ii. To optimize colony growth for nectar flows
iii. To optimize colony group for pollination
iv. To build up colonies for seasonal divisions
v. To sustain colony growth and development during weather fluctuations
vi. To build up colonies after pesticide or disease loss
vii. To provide food for better overwintering

When natural pollen is not accessible or of sufficient quality, beekeepers often utilize artificial diets to replenish the protein, fat, vitamins, and minerals lost (Somerville, 2005; Mortensen *et al*., 2019), when these diets don't contain any natural pollen, they're termed pollen substitutes, and when they do, they're called pollen supplements (Mortensen *et al*., 2019).Beekeepers have the option of purchasing commercially available diets or creating their own (Mortensen *et al*., 2019).

In many of their early studies, they employed various soy flours and brewer's yeast as diet basis in many of their early research. In pollen substitutes today, these are still a common, inexpensive, and easily accessible source of protein. Pea protein, potato protein, maize gluten, egg products, milk products, and blood meal are among the numerous other substances included in pollen substitutes (Brodschneider and Crailsheim, 2010; Saffari *et al*., 2010; Mortensen *et al*., 2019). Pollen replacement research from the beginning paved the way for present feeding techniques. Beekeepers today utilize a variety of different diets and feeding methods. Pollen substitutes are often placed in patty form just above the brood nest by beekeepers. They can also put them in dry powder feeders outside of the hives (Saffari *et al*., 2010). Pollen substitutes in liquid form are less typically fed in feeders linked to the hive body by beekeepers (DeGrandi-Hoffman *et al*., 2008).

2.3.8 Modern hives

Beekeeping has been practiced by humans for over 9,000 years. Egyptians first raised bees in Nile River mud-made clay containers. They even transport the beehives downriver to pollinate a variety of crops. Other societies, such as the Celtic and South American, kept bees in hollow logs with skeps. The disadvantage of these types of beehives is that they must be busted open to get the honey, which kills the bees. Fortunately, by the 18th century, wooden boxes had become fashionable, and countless colonies had been saved. Beekeeping did not become more efficient until the 1850s, when Reverend Lorenzo Lorraine Langstroth built his hive. Until the 1960s, Langstroth hives were the standard. Several designs gained popularity at the time, eventually leading to the top bar style used by Bee pods today. The top bar hive was created in a way that is as unique as the human-bee connection.

One of the first reported top bar hives was a Greek technique that used terra cotta pots. Bees can enter and escape through two holes on the bottom of the pot, while a wooden lid covers the top. Beekeepers lift the lid to extract the comb and honey without harming the colony. Kenya and Tanzania, on the other hand, were the source of today's design inspiration. Despite the fact that both models are named after African regions, subtle differences in how bees are managed exist. The Kenyan hive design is ideal for natural beekeepers since it makes inspections and honey harvesting as painless as possible. The Kenyan hive has a sloping box and stands on four legs. The lid is hinged and opens only on one side. It was built in this fashion to keep bees calm during inspections and honey collection.

2.3.9 Hives inspection

Bee keepers had varying degrees of experience in beehive management (follow-up, checking for predators, cleaning the environment, providing additional feeding, watering, and honey harvesting). Welay and Tekleberhan (2017) argue that regular inspection of hives and apiaries is necessary to protect honeybee colonies from numerous natural disasters and threats (pests, infections, and chemical poisoning). In different sections of the country, beekeepers undertake external hive inspection to varying degrees. The majority of beekeepers in Ethiopia visit their hives on a daily basis, while some visit them every 2 to 5 days (Getachew, 2018). Internal hive inspection is nearly never conducted by most farmers due to the difficulty of conventional hives for internal inspection (fixed combs attached to the body of traditional beehive). Internal hive inspection is confined to those honeybee colonies positioned in the backyard and under the eaves of the house (Birhanu, 2016).

2.3.10 Water provision

Bees, like all animals, require food, water, and a safe place to live. Most insects obtain all of their water from their food: consider a caterpillar that eats mostly water-rich plant leaves. However, because the pollen and nectar that make up a bee's diet are low in moisture, bees require a water supply. Honey bees will begin hunting for water as well as pollen and nectar when the temperature warms and foraging activity increases. Honey bees are quick learners and will return to a water source on a frequent basis once they have discovered one. Foragers will perform the waggle dance to direct hive mates to water sources, much as they will for flowers. To get bees to utilize the water you want them to, attractive water sources should be supply early in the year so they learn to use them

2.4 Concept of Adoption

Adoption, according to Rogers (1962), is the mental process through which a person proceeds from first hearing about a new innovation to final adoption. Rogers and Shoemaker (1971) define adoption as "a decision to make full use of new ideas as the best course of action available. Feder *et al*. (1985) defined adoption as a farmer's willingness to use a new innovation after learning about the potential of the innovation. The researchers classified individual and aggregate adoption of new technology. According to the authors, individual adoption refers to a farmer's decision to incorporate a new technology into his or her production methods, Aggregate adoption, on the other hand, refers to the process of disseminating a new technology over a region or population. A farmer's decision to accept new technology is based on a thorough examination of a wide range of technical, social, and economic issues. The study added that, whether an innovation is adopted or rejected is a personal choice.

In view of Dasgupta (1989), individuals' continuing usage of a suggested practices or behavior over a reasonable long period is referred to as adoption. At the farm level, the adoption of technology in agriculture is not uniform. It's a complicated procedure that's influenced by a variety of elements. The farmers’ socio-psychological system and their degree of readiness and exposure to improved practices and ideas i.e. changes like the awareness and attitude of farmers towards improved agricultural technologies and the institutional factors which act as incentives/disincentives to agricultural practices and the farmers’ resource endowment like the land holding size and labor are some of the factors of considerable importance in bringing about the technological change in agriculture (Ray 2001; Workney, 2011).

Ray (2001) viewed adoption as a variable that represented the behavioral changes that farmers go through while accepting new ideas and technologies in agriculture. Many socio-economic factors influence the adoption of new technology in agriculture, according to the researcher, which occurs as a result of behavioral changes such as desirable changes in knowledge, understanding, and ability to apply technological information, changes in feeling behavior such as changes in interest, attitudes, aspirations and values as well as changes in overt abilities and skills. In general, technology adoption is influenced by the following five factors; compatibility or riskiness, advantage or profitability, complexity, observability or availability and triability/divisibility, or initial capital costs (Gebiso, 2015).

2.5 Socio-economic Factors Affecting the Adoptions of Modern Beekeeping

The mere introduction of new technology to small-scale farmers does not guarantee its widespread adoption and subsequent diffusion. The decision of a farmer to adopt any new innovation is influenced by different factors such as socio-economic, institutional, Psychological, demographic and physical characteristics of the farmers'. Micah (2013) studied the socioeconomic factors that influence beekeeping in Switzerland. The findings revealed that more than half of the respondents were married, the majorities were over 55 years old, and the majority of whom used Swazi top-bar hives. The studies also demonstrated that the farmer's experience and colony size had an impact on honey production. The researchers suggested that colony sizes be increased and that langstroth beehives be employed because of their high yield.

Benedict *et al.* (2016) assessed the Socio-economic characteristics of beekeepers in Kenya. The results revealed that 69 percent were males, 77 percent were within the age range of 18-55 years, and 64% attained at least primary level of education. In addition, the study depicts that 77% of the respondents were agro-pastoralists. It further showed that cost, availability, management regime, productivity level and quality of hive determined choice of beekeeping technology which included. The researcher recommended, the extension training should be provided to beekeepers to equip them with the necessary skills on bee management.

Bunde and Kibet (2015) also investigated the socio-economic variables affecting modern beekeeping technology adoption in Kenya's Baringo County. According to the studies, the majority of respondents (70.1%) do not practice beekeeping. The major challenges to beekeeping were lack of beekeeping materials, inadequate extension contact and finance. Gender, age, family size, and education were also found to be significant in the logistic regression model. The study recommended that farmers should be trained in contemporary beekeeping procedures to boost their yields as part of poverty-reduction measures. Previous research has discovered substantial evidence that socioeconomic factors influence the adoption of contemporary bee hives (Yehuala *et al.*, 2013; Adgaba *et al.*, 2014; Jebesa, 2017).

2.5.1 Age of the respondents

Age is an important socioeconomic factor which influences subsistence farmers' adoption decisions. The assumption is that older and experienced farmers will have more skill and knowledge of farming which enhance their ability to comprehend and make better farming decisions, including the adoption of technology. Though, young household heads may be more innovative and less risk averse which can make them likely to adopt new innovation (Agne, 2017). According to Mujuni *et al.* (2012), the majorities (65%) of the beekeepers in Uganda were above 50 years of age, Farinde *et al.* (2005) reported that 73.8 percent of beekeepers were within the age of 30 years and above. Bumbaire added that, majority (78%) of young beekeepers are under the age of 30. Because of the exodus of youngsters to urban centers in quest of white-collar jobs. Matanmi (2008) opined that farming in Uganda's rural areas is dominated by elderly farmers. Similarly, Asmiro *et al.* (2017) opined that the average age of households' was 48 years.

Gebiso (2015) opined that the increase in technology adoption with age could be due to resources in the hands of older farmers as compared to young farmers with little capital, although This contradicted the findings of Blanca *et al.* (2018), who concluded that young farmers with a small number of family members who have worked in agriculture for multiple generations and who have positive attitudes toward innovation adopt innovations faster than older farmers. This was substantiated by a study by Oladimeji *et al.* (2017), which found that modern bee farmers were younger, had more formal education, but had a smaller family size, resulting in better decisions and adoption rates. Muya (2014) discovered that when beekeepers' ages increased, the adoption index declined. Adgaba *et al.* (2014) added that adoption rates decreased with increase in age of the beekeepers because they become more conservative with decrease in strength to carryout rigorous activities of agriculture. Bunde and Kibert (2015) also concluded that the average age of adopters was lower than that of non-adopters, and that the two were negatively associated.

2.5.2 Family size of the respondents

The family size plays an important role in determining what occurs on the farm. It provides the human factor in farming through labour and management inputs. The relationship between family size and adoption will depend on the balance of the effects. Family demands may motivate the adoption of improved agricultural practices as a means to meet the demands. Therefore, farmers with a large family composition may have a considerable influence on technology adoption decisions in order to meet their family's needs. As a result, it was assumed that households with a large family would be more likely to accept technology (Workneh, 2011). This is similar to Bunde and Kibet (2015), who opined that family size has a positive influence on the adoption of modern technologies. Although, larger household sizes may increase the physiological needs of households, the return from the farm may be used to meet the needs of the family with little or no saving to pay for the adoption of new innovations. As a result, this study assumes that family size has both positive and negative effects on the adoption of new innovations.

2.5.3 Sex of the respondents

Matanmi (2008) reported that 90% of bee hunters and 80% of modern beekeepers were male. This can be attributed to the conventional method of hanging hives too high which makes it impossible for women to operate them thus reducing women's participation. The majority of traditional and modern beekeepers in Nigeria, according to Olademiji (2017), were men. In Uganda, the majority of beekeepers were men, with only 5% of them being female. Furthermore, Ugandan rural women work 16-18 hours a day, thus involving them in beekeeping increases their workload (Mujuni, *et al*., 2012; Olademiji, 2017).

2.5.4 Level of education of the respondents

Farmers' ability to obtain and process information linked to new innovation is said to be aided by their level of education in adopting such enhanced agricultural technologies. According to Oladimeji *et al.* (2017), formal education has a direct influence on the adoption of technology. Workneh (2011) added that educational level contributed positively to adoption of new technology. Education would increase the understanding of the technology and anticipated to increase adoption (Wokneh, 2011). In a similar study, Kerealem (2005) reported that farmers with formal education are more likely to be exposed to the external environment and information which helps them to get acquainted with availability of technology and subsequently the decision to adopt the technology.

According to Mujuni *et al.* (2012) reported by Olademiji (2017) beekeepers in Bushenyi district had completed formal education, with the largest percentage (42.5%) having completed secondary school and 17.5 percent having completed tertiary education. This demonstrates that educated respondent keep bees in the study area, which may encourage them to use new technologies because education makes it easier for farmers to adopt new innovations. (Onemolease, 2005; Mujuni *et al.*, 2012). Egwu (2014) added that most respondent (39%) in Delta State do not attend any formal education while the Majority (70%) attended one forms of formal education or the other. Micah (2013) found that all beekeepers in Manzini had one forms of formal education which is expected to increase their ability to obtain and analyse information that can help them make rational decision as regards adoption of modern technologies.

2.4.5 Years of beekeeping experience of the respondents

One important variable in explaining adoption behaviuor of farmers is the years of experience in farming. The number of years a farmer spent in farming will increase the experiential base and this should assist in making adoption decisions. Years of farming practice, according to Bunde and Keibet (2015), improve the decision to use technology. Longer years of farming experience, according to Wongelu (2014), signify acquired agricultural knowledge and skill, which has a favorable association with adoption level. Farmers' willingness to adopt new technologies increased as their years of expertise in the business grew (Muya, 2014). According to the findings, experienced farmers were more inclined to attempt new and difficult agriculture technologies. Visiting other beekeepers' apiaries or demonstration locations might assist a beekeeper have a better understanding of beekeeping. Visits from farmers to farmers to share their experiences also help to establish a good attitude toward an invention or new technology (Million and Belay, 2010) The experience of the bee farmers is expected to influence the adoption and use of modern beekeeping technologies for increase productivity and ensuring food security..

2.5.6 Frequency of contact with extension agents and attendance in extension events

Extension agents educate farmers about new technology and better farming methods. Extension initiatives aid in the diffusion of new technology by boosting the supply of information about current agricultural practices (Amanuel, 2018). The extension staff must keep a close eye on the use and adoption of improved box hive technologies. Many studies have shown that farmers who have access to extension services are more likely to embrace improved agricultural technologies (Amanuel, 2018).

Attendance in extension activities such as demonstrations, training, and field days is also important for improving farmers' experience, capacity, and confidence in the benefits of better agricultural technologies. Training is critical for increasing beneficiary productivity while also raising awareness of the technology. According to Rahman (2007), who was quoted by Workney (2011), training may have instilled technical competency, increased exposure to the subject matter, and persuaded farmers to use upgraded technology in their farms. One of the most important predictors of acceptance was beekeeper participation in demonstrations and training of modern beehives (Gebiso, 2015).

The acquisition of technical skills and knowledge about beekeeping through training was likely to influence farmers' adoption decisions positively (Welay and Tekleberhan, 2017). Farmers who had been taught in modern apiculture obtained understanding regarding the usage and techniques of implementing the new technology which is capable of improving their chances of adoption (Yehuala *et al.*, 2013). The researcher added that, training increased farmers' awareness and confidence in the technology, resulting in increased productivity. According to Jebesa (2017), beekeepers skill development through training aided in the adoption of modern box hives. Participation in on-farm demonstrations and attendance at training influenced farmers' adoption decisions (Amanuel 2018). Participation in extension events was found to have a favorable and substantial link with adoption in other research (Amannuel, 2018).

2.5.7 Availability of honeybees' equipment

The cost of introducing contemporary hives and working tools to the rural community is out of reach for most farmers, and even for those who can afford them, they are not readily available (Tessega, 2009). Small holders should have access to new technology and all other relevant inputs at the correct time and location, in the right amount and quality to enhance their productivity (Ehui *et al.,* 2004). To manage the hive with honey bee colony, beekeepers must wear protective clothing (overall suit, bee veil, and gloves) and use equipment such as a smoker. The availability of the above materials has an impact on the technology's acceptance and subsequent adoption (Wongelu, 2014).

2.5.8 Cooperative membership

Cooperative membership could positively influence adoption decisions of a farmer. Ogunbameru *et al.* (2008) argued that participation in cooperative have the potential of creating confidence between farmers and financial institutions thus allowing farmers to have access to farm credit from such institutions using their collective grains in a community warehouse as collateral. In other words, if farmers are grouped into societies/associations, access to credit facilities would be facilitated. The membership of association/cooperatives could influences adoption of new technologies Cooperatives are useful instrument in effecting rural change. It has been a useful pathway of channeling funds to smallholder farmers by formal credit institutions and a tool for food security (Oluwatayo *et al.*, 2008). Thus, cooperative membership is expected to be positively related to the adoption of sustainable food crops production strategies among women farmers.

2.5.9 Cultural factors

Beekeeping and the adoption of related technologies have also been influenced by cultural considerations (Raina *et al*., 2009; Mujuni *et al*., 2012). This is primarily owing to the fact that apiculture has traditionally been regarded as a male-dominated activity (Ogaba and Akongo, 2001; Shackleton *et al.,* 2011). According to additional research, women are increasingly becoming involved in apiculture for the financial benefits (Raina *et al.*, 2009; Macoloo *et al.*, 2013). According to a study conducted by Simeon and Victor. (2019), more women in Coastal Kenya were able to take up beekeeping as a result of group formation.

Women, on the other hand, suffer numerous cultural barriers that prevent them from fully participating in beekeeping. For example, Qaiser *et al.* (2013) found that women beekeeping organizations in Pakistan's Chakwal District experienced a number of issues due to their inability to perform some apiary management activities such as honey harvesting. Because of perceived risks such as falling out of trees and bee stings, beekeeping is viewed as an undesirable alternative for women in Kenya (Gok, 2013). Men continue to adhere to the norm that women should stay away from men's activities (Ogaba and Akongo, 2001), demonstrating that gender roles in African cultures are still respected.

2.5.10 Economic factors

One of the most important indicators of a household's wealth is livestock ownership. The sector is a significant source of income for farmers, allowing them to invest the dividends on adoption of agricultural technologies. It has varied effects on different people in different regions when it comes to adopting improved technologies. It has a beneficial impact on household adoption of agricultural technologies in the majority of cases (Wangelu, 2014). Many adoption studies have found that keeping livestock has a favorable impact on adoption (Taha, 2007; Gidey and Mekonen, 2010).

Farmers' adoption behavior is influenced by land-related characteristics, as land holding is an important unit where agricultural operations take place. Many adoption studies found that the size of a farm was positively associated to the adoption of new technologies (Annuel, 2018). Farmers' adoption behavior is influenced by land-related characteristics, as land is an important variable for agricultural operations. Many adoption studies found that the size of a farm was positively associated to the adoption of new technologies (Annuel, 2018).

Another factor is the ability to obtain credit from a financial institution in order to purchase agricultural technologies. Farmers who have access to financing sources will be able to purchase contemporary beekeeping equipment more easily than those who do not. Farmer participation in off-farm/non-farm occupations will alleviate financial limitations that prevent them from purchasing inputs like modern beehive equipment. As a result, credit has a beneficial and considerable impact on the adoption of current beehive technology (Sisay *et al.,* 2013). Wangelu (2014) added that households having access to financing were more likely to embrace new agricultural technologies. Workney (2011) investigated the financial benefits of bee hives and the factors that influence their adoption in a number of Ethiopian districts. The study found that credit, knowledge, household head's, education level, perception, and visits to demonstrations all had a positive and significant impact on bee hive adoption. The researcher recommended linking honey producers to stable and reliable markets and following a participatory value chain based approach; promoting private entrepreneurs to provide additional services for value addition; promoting farmer-to-farmer knowledge sharing; and encouraging farmer groups create a learning environment are some initiatives that could go a long way in the sustainable development of this important economic sub-sector.

Oladimeji *et al.* (2017) examined the adoption of improved technologies and management practices among bee farmers in North Central and North Western Nigeria towards sustainable development goals. According to the findings, modern bee farmers were younger, had more formal education, but had a smaller household size, which resulted in better judgments and adoption rates, increased output per hive and invariably increased net margin. It further revealed that the decision to adopt and level of adoption of improved techniques and practices had slight variations and where it does, not either by the same coefficients, direction, magnitude or structure. The researchers recommended that honey bee farmers' and relevant government agencies should collaborate to ensure gradual adoption of improved management practices and environmentally adaptable techniques capable of increasing the output and make efficient use of the abundant apicultural resources.

Bunde and Kibet (2015) investigated the socioeconomic factors that influence the adoption of modern beekeeping technology in Kenya's Baringo County. The majority of respondents do not practice better beekeeping, according to the research. The study added that, the main challenges of beekeeping include lack of Bee keeping materials, extension support and lack of capital. It was also revealed from the logistic regression model that gender, age, family size, and education were significant. The contemporary beekeeping industry makes a major contribution to household income. According to the researchers, the ministry of livestock development and fisheries, as well as other development agencies working in the area, should promote modern beekeeping by providing beekeeping materials such as smokers and protective gear, as well as training farmers on modern beekeeping practices to help them increase their yields.

Blanca *et al.* (2018) used a survival analysis approach to investigate the factors that influence the adoption of improved maize seeds in Southern Mexico. The study revealed that majority of farmers who adopted improved maize seeds made their selection during a 10-year time frame. The study added that the 1994 NAFTA Mexican agriculture policy reform had detrimental effects on the adoption rate of improved maize seeds. Appropriate extension information systems, according to the study, will allow farmers to acquire more information on the value of embracing innovation as well as assist them in marketing their products. Williams (2014) also delved into the factors influencing Delta State farmers' adoption of agricultural innovation. Poor extension services from change agents, climatic, fund/incentives, fear of loss, and cost of innovation are the most important factors that hinder the adoption of agricultural innovation by farmers in Delta State; In addition, factors such as superiority, profitability, simplicity, and compatibility of an innovation promote its adoption.

Lastly, Adedipe *et al.* (2014) assesed the factors that influence the adoption of improved maize varieties in Kano, Katsina, and Maradi, West Africa. The study indicated that affordability, understanding of how to use technology, and appropriate packaging's of technology were the most important factors of adoption, followed by gender, total farm size, and extension agent visits. Households with heads who were older and more educated were likewise more likely to acquire technology.

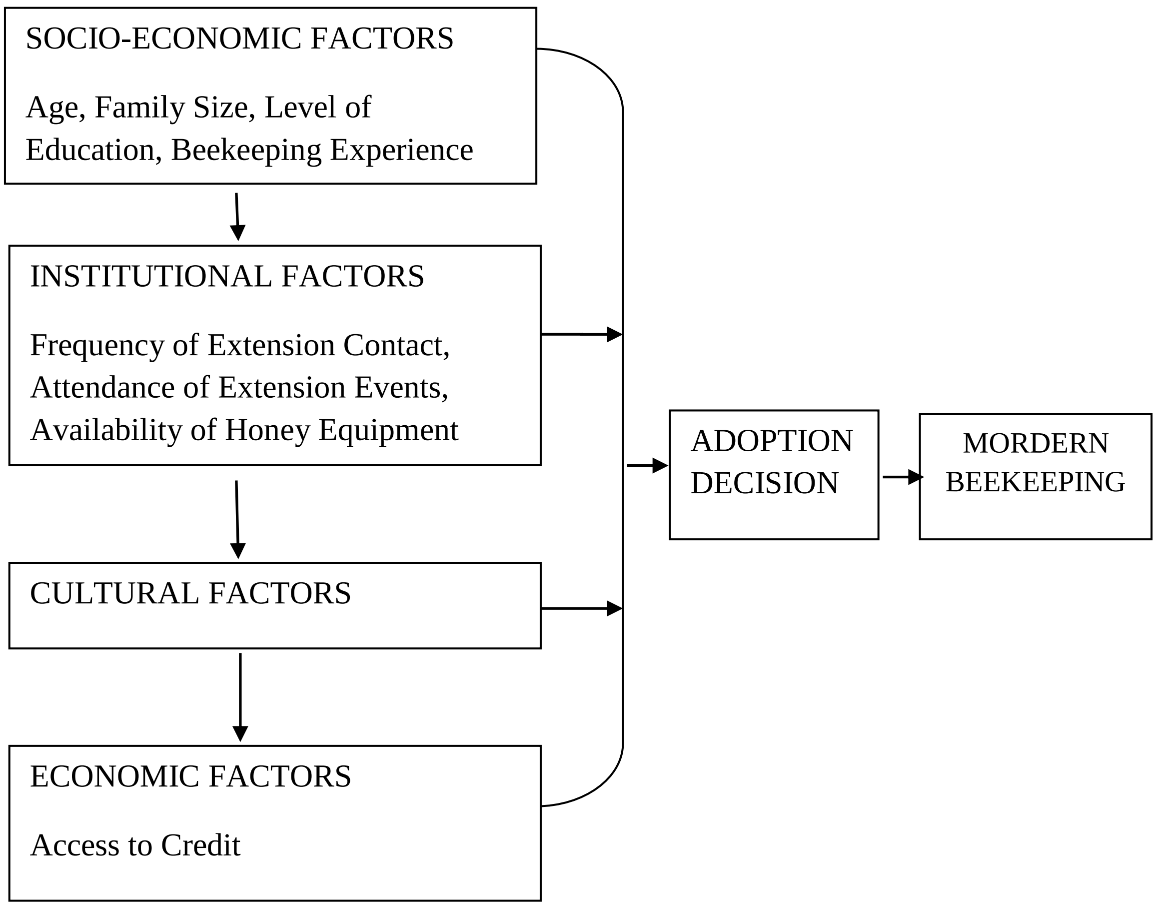

Figure 2.2: Determinant of adoption of improved beekeeping

Source: Authors design (2021)

2.6 Challenges of Beekeeping

Malede *et al*. (2015) opined that a lack of bee forage, rainfall, agro-chemical poisoning, pests and predators, absconding, and a lack of honey storage facilities are the biggest obstacles to beekeeping unrealized potential in Gondar. Qaiser *et al.* (2013) opined that the major challenges to beekeeping were unwillingness of the beekeepers to learn and upgrade, lack of security for bees colonies from theft & bush burning, no government supports and bad policy on agriculture and inadequate exposure to modern equipment and technology. Benedict *et al.* (2016) found that recurrent drought, attack by pests and predators, low prices, insecurity and inadequate extension services were the major challenges of beekeeping in Kitui Kenya.

Bunde and Kibet (2013) added that lack of Bee keeping materials, extension serves, and lack of capital were the major constraints associated with beekeeping in Kenya. Labe (2017) reported that the major challenges of beekeeping in Nigeria were ignorance and fear of bee sting, bush burning, application of pesticides and insecticides, inadequate technical skills, absconding of bees lack of modern beekeeping equipment associated with its high cost, pest and predators. Nwaihu *et al.* (2015) opined that lack of finance and non-colonization of hives was the major constraint militating against the beekeeping in Imo state.

2.7 Theoretical Framework

2.7.1 Survival model

Medical research was the first to make use of survival analysis and duration models. In the survival analysis literature, death or failure is regarded a "event" in the context of modeling time to event data. Although survival analysis was first employed to investigate death as a specific event in medical research (Narendranathan and Stewart, 1993; Blanca *et al.,* 2018) and demographical studies (Carroll, 2006), since the 1970s similar statistical techniques have become increasingly applied in economics and social sciences. Because of its unique characteristics, survival data requires a different statistical analysis than quantitative data.

Aside from the issue that survival data is not normally distributed, it frequently contains censored subjects with insufficient information. The censoring and abnormality distribution of survival data necessitates the use of certain methodological and statistical techniques. Subjects may be censored on the right or left. In the statistical analysis, censored subjects must be included. However, a significant number of censored respondents may influence the accuracy of statistical tests, according to (Blanca *et al.,* 2018).

The survival analysis can be used in socioeconomic research to analyze complicated phenomena like unemployment, employment, inflation, bank loan supply and demand, product life expectancy, producer and consumer, adoption rate, and so on. Inferring incident about event rates as a function of time is done via survival analysis. The Kaplan–Meier estimator and Cox proportional hazards regression are the two main approaches for estimating the true underlying survival curve. The Kaplan–Meier estimator is straightforward and allows for stratification factors, however it does not allow for covariates (Blanca *et al.,* 2018).

The Cox model does give a framework for generating inferences about covariates, and some versions require proportional risks, but when utilized and interpreted appropriately, all variants are highly flexible. For consistent unbiased estimates, independent censoring is required, either directly in the Kaplan–Meier estimator or provided covariates in the Cox model. As long as we have available representative risk sets at each time point to allow us to model and estimate event rates, survival analysis can handle correct censoring, staggered entry, recurrent occurrences, conflicting risks, and much more. Statistical approaches for survival analysis are still a hot topic in academia, the collaboration and communication among statisticians and their colleagues will be immense benefit for readers.

Survival analysis, as compared to traditional models such as probit, tobit, and logit, is similar to Tobit, which is used for heterogeneous populations with incomplete observations (censored) (Beyene and Kassie, 2015). Though the Tobit model requires that the dependent variable has a normal distribution, the survival analysis allows for models that do not require any assumptions about the underlying baseline distribution of the time-to-event data, which often violates the normality criterion. It also allows for the inclusion of external fixed and time-dependent parameters, as well as the provision of the adoption date and the factors that impact this decision.

The Duration Analysis (DA) can examine changes in explanatory factors over time and between farms, addressing both the decision and diffusion of improved beekeeping technologies adoption. The DA allows cross-sectional and time-variant data to be combined in a dynamic framework (McWilliams and Zilberman, 1999; Blanca *et al.,* 2018). The Survival Analysis was first used in economic by Lancaster (1992), who studied the duration of unemployment. In the agricultural industry, survival analysis has been used in various studies, including Sanchez *et al.* (2011) adoption of conservation tillage and Blanca *el al*. (2018) improved maize seed adoption, improve conservative practice adoption by Knowler (2017), sustainable technology adoption by Hazell (2008) and organic agriculture adoption by Hogeland (2016).

The researcher focused at why farmers adopted improved beekeeping practices, as well as the timing of their adoption and the time-varying exogenous factors that influenced their decision. Because of the data and sample characteristics, the Duration Analysis was chosen because of its ability to meaningfully address the major study objectives (heterogeneous population, censored time variable with violated assumption of normal distribution and the presence of relevant exogenous variable related to agricultural policy reforms that may affect the time of adoption). This statistical method provides a methodology and tools that enable for more flexible investigation of the time-event relationship.

Let T be a nonnegative random variable that indicates the length of spell (the adoption of improved beekeeping technologies). In addition, consider (t) as a manifestation of (T) where each subjects observed duration are a set of data $t_1 < t_2 < \cdots t_n$. Let $f(t)$be a continuous Probability Distribution Function (PDF) of T. The duration variable's probability distribution can be specified by the Cumulative Density Function (CDF).

$$F(t) \int_0^t f(s)ds = pr\ (T \leq t) \tag{2.1}$$

Equation (1) is the probability of T to be smaller than a value t. Nevertheless, researchers are interested in the probability that Thas a length of at least t. This probability is given by the survival function as:

$$S(t) = P(T > t) = \ 1 - F(t) \tag{2.2}$$

The probability that the duration of adoption occurs in an infinitesimal time period Δtafter time (given that the non-adoption decision has lasted up to $t$is:

$$P\left(t \leq T < t\frac{\Delta t}{T} > t\right) \tag{2.3}$$

In a further step, the hazard function $\Delta t$is defined as the probability that a farmer adopts the improved beekeeping at time t (i.e., $T = t$), given he has not adopted it before t.

$$h(t) = \lim_{\Delta \to 0} \frac{P\left(t \leq T < t + \frac{\Delta t}{T} > t\right)}{\Delta t} = \frac{f(t)}{S(t)} \quad (2.4)$$

The hazard function can be further mathematically expressed as follows,

$$h(t) = \frac{f(t)}{S(t)} = \frac{dF(t)/dt}{S(t)} = \frac{-\, dlnS(t)}{d(t)} \quad (2.5)$$

In addition to the length of the duration time of adoption, a set of explanatory variables may affect the distribution of the duration. This means that the $\Delta(t)$should be re-specified and re-defined as follows

$$h(t, x, \theta, \beta) = \lim_{\Delta \to 0} \frac{\Pr(t \leq T < t + \frac{\Delta}{T} \geq t}{\Delta} \quad (2.6)$$

Where:

β is a vector of unknown parameters of x;

x is the vector of explanatory variables which may include time-invariant and time-varying variables; and

θ is a vector of parameters that characterize the distribution function of the hazard rate.

After the explanatory factors are included, the hazard function $h(t, x, \theta, \beta)$ May be divided into two parts. The first element is a component of the hazard that is dependent on the characteristics of the subject $g(x, \beta)$. The baseline hazard function is the second $h_0(t)$ which is equal to the hazard when all covariates are zero. Notably, the latter is unaffected by personal qualities; this component depicts how the hazard rate changes over time. In this context, the shape (distribution function) of the hazard function has important implications for duration dynamics. In this research, the non-parametric method of the Kaplan-Meier (KM) estimator will used to explore the covariate effects and the potential distribution to be used if the parametric approach was applied. The KM estimator produced an empirical approximation of survival and hazard, which is similar to an exploratory data analysis; denoting the distinct failure times of individuals as $t_1 < t_2 < \cdots\ t_n$.

In this study, the semi-parametric Cox proportional hazards model will used to estimate the survival data and explain the effect of explanatory variables on hazard rates. This model will be used because of its better fit, robustness and no assumptions of any previous distribution and shape of the hazard function. Under the Cox proportional hazards model, the duration of each farmer is assumed to follow its own hazard function $hi(t)$ which can be expressed as:

$hi(t) = h(t; xi) = h0\ (t)\ \exp(xi\ \beta) = h0(t)\exp(\beta_1 x_{i1} + \cdots + \ \beta_1 x_{i1}$

thus, $\log hi\ (t) = \propto (t) + \ \beta_1 x_{i1} + \ \ldots + \ \beta_k x_{ik}$

where; $\propto (t)\ =\ \log h_0\ (t)$and $\beta$are the proportional effects of x on the probability of improved beekeeping adoption.

2.7.2 Theory of adoption

Agricultural technologies include both physical objects such as seeds or fertilizer, as well as new farming methods. The technology may not be new as such, but novel to the farmer. A new technology (or innovation) is defined by Rogers (2003) as "an idea, practice, or thing that is viewed as novel by an individual or other unit of adoption."

2.7.3 Theory of reasoned action

Fishbeinn and Azjen's Theory of Reasoned Action was first developed in 1975 for sociological and psychological study, but it has recently become a foundation to investigate individuals' usage behavior (Davis *et al*., 1992). Any human behavior is predicted and explained in this model by three primary cognitive components: attitudes (a person's favorable or unfavorable feelings toward a behaviour), social norms (social influence), and intentions (a person's decision to do or not perform a behaviour). This type of human behavior should be volitional, systematic, and logical. In addition, three boundary factors are identified to test and assess the TRA: volitional control, intention stability across time, and measurement of intention in terms of target, time, context, action, and specificity.

Furthermore, several approaches are established to strengthen the robustness between corresponding purpose and attitude, such as generality, target, action, context, and time horizon. The key disadvantages of TRA, on the other hand, are the failure to address the role of habit, cognitive deliberation, misunderstanding through a survey (attitudes, subjective norms, and respondents' intentions), and moral issues. Furthermore, the voluntariness of TRA usage is a critical issue for its validation.

2.7.4 Theory of planned behaviour

To extend the TRA model, a new variable called perceived behavioural control (PBC) was added. PBC is primarily defined by the availability of resources, opportunities, and skills, as well as the perceived importance of those resources, chances, and skills in achieving desired objectives (White, 2015). Although both TPB and TRA believe that a person's behavioural intention (BI) influences their behavior, TPB applies the PBC to behaviors that are not under their volitional control. PBC is used to provide not only realistic limitations, but also a self-efficacy type component. Furthermore, PBC has a direct impact on actual behavior as well as an indirect impact via behavioral intentions. As a result, according to the TPB model, three key aspects influence BI: perceived behavioural control, subjective norm, and behavioural attitude. The TPB model, however, has two major flaws

(Taherdoost, 2012). First, if a computer system is not accessible, one's sentiments toward information technology will be mostly irrelevant. Second, the new TPB might be considered as a more appropriate theoretical framework that is influenced by the degree of individual voluntariness in deciding whether or not to employ information technology in the workplace.

2.7.5 Theory of interpersonal behaviour

This model primarily clarifies the intricacies of human behaviour as they are influenced by social and emotional aspects. As a result, in order to improve prediction power, this model includes not only all aspects of TRA and TPB, but also habits, facilitating situations, and impacts. Roles, norms, and self-concept are all part of the social factors notion, which is related to the subjective norms construct in TRA (Fishbein and Ajzen, 1975). In summary, an individual in TIB is neither wholly deliberate nor fully automatic, nor fully autonomous nor entirely social. TRA varies from TIB in that TRA seeks to account for the greatest amount of variance with the fewest variables, whereas TIB seeks to account for the greatest amount of variance overall, because even a tiny amount of variance can be socially significant if the behavior in issue is vital.

Emotions, social variables (similar to subjective norms in TRA) and habits are highlighted as the major factors in forming an intention in this paradigm. To argue the behavior, TIB has three layers. Personal features and previous experiences shape personal ideas, attitudes, and social circumstances that influence behavior at the first level. The second level examines how affect, cognition, and social variables, as well as personal normative views, influence behavior intentions. The ability to do a certain behavior is predicted at the third level by behavioural intents, situational conditions, and prior experience (Taherdoost and

Masrom, 2009). In comparison to TRA and TPB, the fundamental disadvantage of TIB is its complexity and lack of parsimony.

2.7.6 Technology acceptance model

This model is based on the TRA model. TAM model is eliminated user's subject norms and intriguing due to the TRA model's ambiguous theoretical and psychometric status. Users' motivation is explained by three factors: perceived usefulness, perceived ease of use, and attitude toward to use, according to TAM. As a result, TAM would include not just BI, but also two key beliefs: perceived usefulness and simplicity of use, which have a significant impact on the user's attitude. These can be classified as unfavorable and favorable attitudes toward the system. External variables (user training, system features, user engagement in design, and the nature of the implementation process) are sometimes taken into account in the TAM model (Thompson, 1991). In the subject of technological acceptance, TAM is perhaps one of the most often mentioned models. It has gained a lot of empirical support throughout the years. TAM is limited in its application outside of the workplace since it ignores the social influence on technology adoption. Furthermore, some external variables must be included to TAM in order to produce a more consistent prediction of system use. The capacity of TAM to apply in a consumer situation where the adoption and use of information technology is not only to perform tasks but also to meet emotional needs may be limited because intrinsic motives are not addressed in TAM.

2.7.7 Diffusion of innovations theory

The DOI model looks into a variety of innovations by introducing four factors (time, communication channels, and innovation) that determine how a new idea spreads. DOI has been used not only at the corporate and individual levels, but also as a theoretical platform for worldwide adoption discussions. Three crucial parts are combined in the DOI model: adopter characteristics, innovation characteristics, and the innovation decision process.

The idea of 'diffusion of innovation,' according to Rogers (1995), was developed to lay the groundwork for doing research on innovation acceptance and adoption. Rogers developed the 'diffusion of innovation' theory for the acceptance of inventions by individuals and organizations based on information from over 508 diffusion studies, the process by which an innovation is conveyed through certain channels over time among members of a social system, according to the theory (Rogers, 1995). Basically, it’s the process of the members of a social system communicated an innovation through certain channels over time known as diffusion. The Rogers’ (1995) diffusion of innovation theory explained that the innovation and adoption happened after going through several stages including understanding, persuasion, decision, implementation, and confirmation that led to the development of Rogers (1995) S-shaped adoption curve of innovators, early adopters, early majority, late majority and laggards.

People's willingness to adapt and use new technology in their personal and professional lives is referred to as technology readiness (TR) (Perlusz, 2004). Adventurers, pioneers, skeptics, paranoids, and laggards were the five technology readiness sectors identified by Perlusz (2004) based on their technology readiness score and technological readiness. This is similar to S-shaped adoption curve of innovators, early adopters, early majority, late majority, and laggards proposed by Rogers (1995). The dissemination of innovation or technological readiness is crucial for organization implementation success because it is a market focus. According to Kuo *et al*. (2015) Task-technology Fit (TTF) emphasizes individual effect. Increased efficiency, effectiveness, or qualities are all examples of individual impact. A strong fit between task and technology, according to Kuo *et al*. (2015), enhances the chance of utilization as well as the performance impact, because the technology more closely meets the task needs and wishes of users.

The Theory of Reasonable Action (Fishbein and Ajzen, 1975), for example, is about one factor that influences a person's conduct intention and attitudes toward that behavior. "Attitude" is a person's appraisal of an object, "belief" is a relationship between an object and some attribute, and "action" is a consequence or purpose, according to Fishbien and Ajzen (1975). Attitudes are emotional and are generated by a set of beliefs about the behavior's object (e.g Credit card is convenient). A second aspect is a person's subjective norms about how their immediate group views particular behaviors (for example, my classmates use credit cards and it's a status symbol to have one). The first two factors are identical to those found in the Theory of Reasonable Action (Fishbein and Ajzen, 1975). The third aspect, known as perceived control behavior, refers to the control that individuals believe they have over their actions.

Taylor and Todd (1995) proposed the Decomposed Theory of Planned Behaviour (Decomposed TPB). Attitude, subjective norms, and perceived behavior control are the three key components influencing behavior intention and actual behavior adoption in the Decomposed TPB. Shih and Fang (2004) used the TPB and Decomposed TPB to investigate the adoption of internet banking. There has been a lot of research on the Theory of Reasoned Action (Fishbein and Ajzen, 1975), Theory of Planned Behavior and Decomposed Theory of Planned Behavior (Taylor and Todd, 1995), but they were mostly used for products that were already on the market and included a societal perspective. Adoption studies have shown that the adoption diffusion process of agricultural innovations, whether in Nigeria or elsewhere, is a function of a number of variables which can be grouped, as socio-economic, socio-psychological, socio-cultural, environmental and institutional, and innovations factors. The socio-economic, institutional, and attributes of the innovations comprise the categories of factors considered in this study. Available studies showed that knowledge of innovations and use are all influenced by socio-economic characteristic of the farmers, institutional factors, attributes of the innovations and so on. For instance, Abubakar *et al.* (2006) found such characteristics as age, education, frequency contact with extension agents and farm size to be significantly and positively related with adoption of technology, while Sule *et al.* (2007), also found participation in social organizations, credit, cost of innovation, availability and years of experience to be positively and significantly associated with adoption.

The more risk averse the farmer is, the less willing he will be to adopt, and even if he adopts, he will try to minimize the risk by devoting only a small proportion of land to the new practice. Access to information about the existence of a new practice and knowledge about how it can be optimally used, can also be an important factor in determining the differential rate of adoption (Oluwatayo *et al.,* 2008). Studies by Ayoade *et al.* (2011) showed that the perception of the farmers on attributes of innovations shows that attributes are related to rates of innovations' adoption. In the context of small-farmer peasant economy as in Nigeria, the shortage of working capital is often emphasized as a major constraint to adoption of new technology. Farmers who earn some income from non-agricultural sources may, however, have less capital constraint than those who depend mostly on agricultural production (Barret *et al*., 2005).

Agricultural production can indeed be expanded through the adoption of new innovation and sustainable practice for increased productivity. The adoption of the innovations by farmers, therefore, is expected to cause positive changes towards ensuring food security. In the study, the adoption of modern beekeeping technologies is expected to positively influence food crops production and effective way of ensuring food security.

2.8 Conceptual Framework

The conceptual frame work was based on the assertion that beekeepers adoption of modern beekeeping is influenced by socio-economic variables (gender, age, house size, level of education, beekeeping experience and area devoted for beekeeping), institutional variables (Access to credit, membership of cooperative, extension contact), sources of information, risk attitude of farmers, intervening variables (government policy, cultural and climatic factor) and characteristics of technology which interact together to influence adoption decision of beekeepers. Adoption and continuous usage is expected to bring about improve in honey yield, quality wax processing, improve income, improve standard of living and producing to meet international market standard. To assess modern beekeeping adoption, the conceptual framework highlights the interactions in the process with regards to relation between the categories of independent variables and their components. The diagrammatic representation of the framework in figure 2 can be explained as a process in which the predictive contribution of the independent variables influences the dependent variables. The adoption of improved beekeeping may also depend on numbers of intervening variables which directly or indirectly affects the adoption processes.

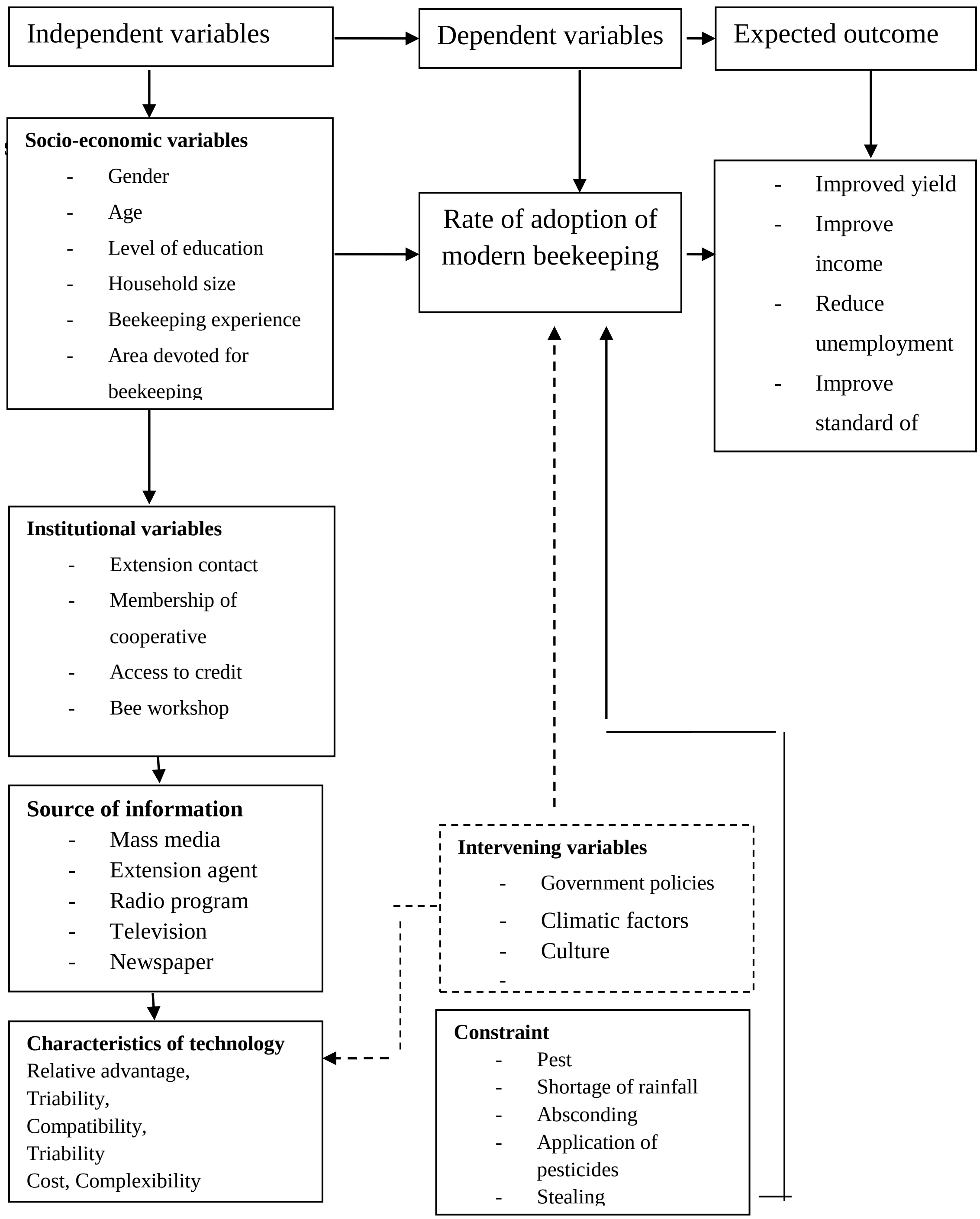

Figure 2.3: Conceptual framework on the adoption of modern beekeeping.

Source: Authors' own construct

Key: ——► Direct

- - - -► Indirect

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Study Area

The study was conducted in Benue State, Nigeria. The State is one of the six States constituting the North Central region of Nigeria with its headquarters in Makurdi. Benue State is located between Latitudes $6^0 30'$N and $8^0 10'$N and Longitudes $6^0 33'$E and 10^0E. The State is bordered by Nasarawa and Taraba States in the North and North-east respectively, Cross River, Ebonyi and Enugu States in the South and Kogi State in the West respectively. Currently, the State covers a total land area of 33,955 square km (National Investment Promotion Commission, 2019). The human population of the State is 3,950,249 people in 2006 (National Population Commission, 2006). With the state population growth rate of 3.04%, the projected population of the state is 6,474,050 people in 2020 (NBS, 2020).

The wet season begins in April and ends in November while the dry season starts in December and ends in March. The average annual rainfall in the state is 1,290 mm. Temperature is fairly regular and ranges from 25.5^0C in August to 30.0^0C in April. The soil types support sustainable production of arable crops. The major spoken languages are Tiv, Idoma and Igede. Others are Agatu, Akpa, Basa, Eloyi, Etulo, Iyive, Izi-Ezaa-Ikwo-Mgbo, Kukele, Oring, Otank and Wannu while the major occupation of the people in the State is farming. Major crops cultivated are rice, yam, cassava, groundnut, millet, soybeans, maize, citrus, mango, sorghum, sweet potato, cocoyam, oil palm, tomatoes, cowpea, cashew and okra.

The State accounts for over 70% of Nigeria’s soybean production (National Investment Promotion Commission (NIPC), 2019). Tree crops such as mangoes and oranges of various species are also produced in commercial quantity. They also rear a wide range of livestock such as pigs, goats, sheep and chicken. Many of the inhabitants also engage in trading, while a reasonable number of them are civil servants. Benue state is made up of three Agricultural zones namely; A, B and C.

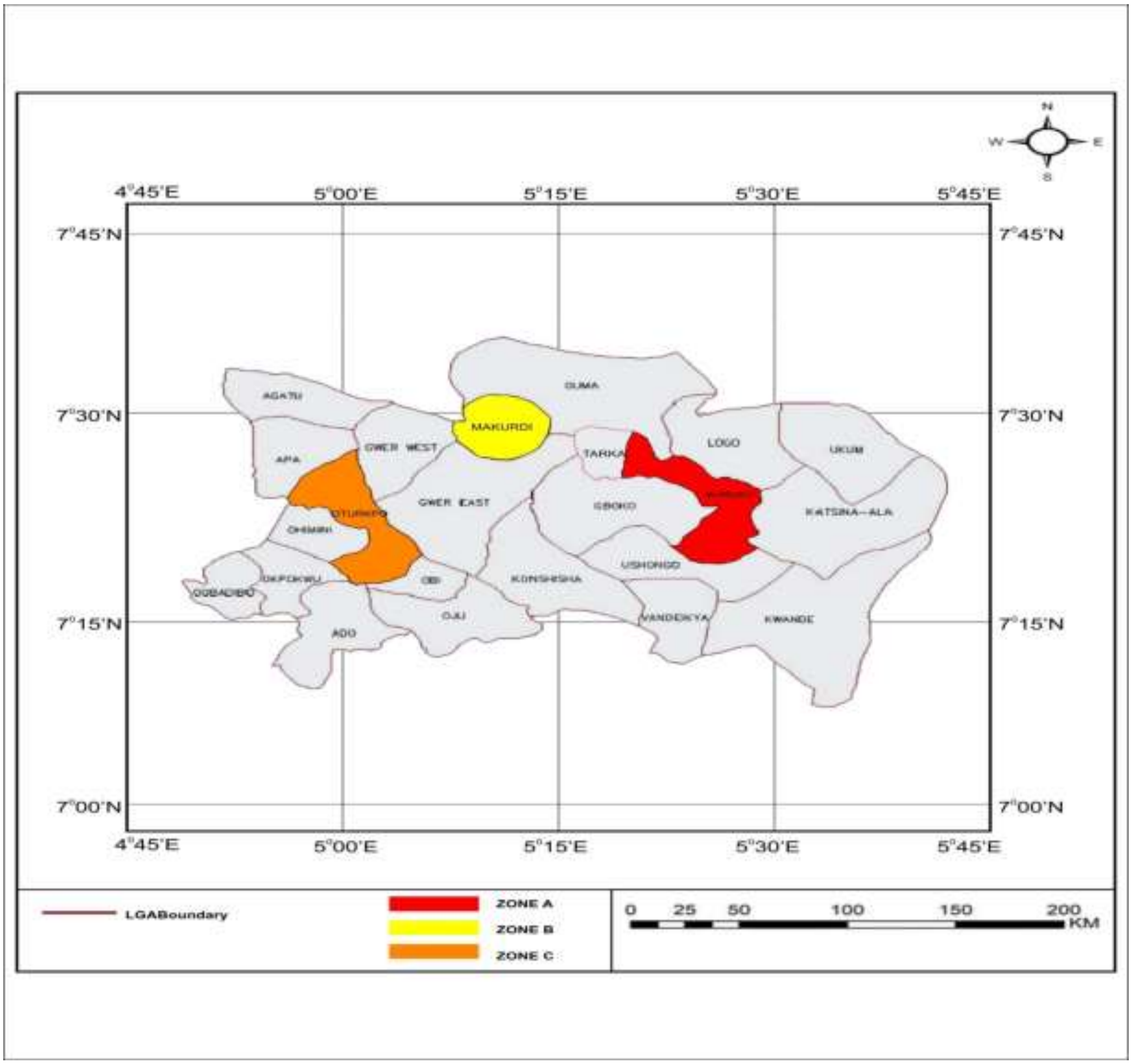

Figure 3.1 Map of Benue State Indicating the Selected Local Government Areas

3.2 Sampling Techniques and Sample Size

Three stage sampling technique was employed to select bee farmers in the study areas. The first stage was random selection of one extension block from each of the three (3) Agricultural zones in Benue State. These are Buruku Agricultural Zone (I), Markudi Agricultural Zone (II) and Otukpo Agricultural Zone (III). The second stage involves random selection of extension cells from each of the selected extension block. The final stage was the random selection of bee farmers in each of the selected cell. Upon discussion with chairman of beekeepers association Benue State, Community heads and extension agent from each Agricultural zone, the Sample frame of 512 was obtained. A total number of 225 respondents were used as sample size but only 212 questionnaires were returned. The sample size was derived using the Taro Yammane model as used by Sunday *et al.* (2015)

$$n = \frac{N}{1+N(e)^2} \qquad (3.1)$$

Where

n = Sample size required;

N = Sampling frame;

1 = constant; and

e^2 = level of precision (5%)

Table 3.1: Sampling techniques and Sample Size

Agricultural Zone	Extension blocks	Selected cells	Sample frame	Sampled size
Zone I	Buruku	Binev	56	25
		Mbaapen	79	35
		Mbaya	84	37
Zone II	Markudi	North Bank Base	64	28
		Kanshow	34	15
		Nav base	53	23
Zone III	Otukpo	Otobi	64	28
		Owetor	53	23
		Akpegede	25	11
Total	3	9	512	225

Source: Benue Bee farmers Association and ADP Benue State (2021)

3.3 Methods of Data Collection

Primary data were used for the study. A semi-structured questionnaire complemented with an interview schedule was used to collect data from bee farmers. The data obtained include the general information of the bee farmers' socio-economic characteristics such as Age, Gender, Marital status etc. Also, data on factors influencing adoption of improved bee management practices was collected as well as data on the constraint faced by bee farmers in the study areas. Data was collected with the assistance of extension agent from Buruku, Otukpo and Markudi branch of the State Agricultural Development Programme. Out of 225 questionnaires distributed only 212 were returned and analyzed.

3.4 Validity and Reliability Test for Data Collection Instrument

Validity of research instrument is the extent to which the instrument measures what to be measured by a given scale or index. It was carried out to ensure accuracy and effectiveness of the instrument for data collection. Face validity was employed in which the data collection instrument (Questionnaire) was given to the team of supervisors and experts knowledgeable in the area of extension for their inputs before going to the field to administer the questionnaire. Meanwhile test-retest reliability method of administering questionnaire over the same group of individual was adopted. The scores obtain from first and second test were subjected to Pearson Product Moment Correlation (PPMC) and a reliability co-efficient of 0.79 was obtained which indicates reliability of the instrument.

3.5 Measurement of Variables

The variables to be measured in this study include the following:

3.5.1 Dependent variable

The dependent variable for the study was the adoption of modern beekeeping technologies and the time variation in the adoption of technologies. Therefore, the last time to decide adoption of the technology was identified. In this study, the start date was set at the year in which the beekeepers responsible for the keeping of bee. Additionally, the end period was the year in which the beekeepers adopted the technology of the improved beekeeping. For those who had not adopted the technology when the study was conducted, their end year was set as a censored value. Although adoption could take place in the future, for these cases, the statistical procedure of the time variable was censored on the right with the date on which the survey was established as final data.

3.5.2 Independent variables

The following independent variables were measured as follows:

i. Age (AG): Age of respondents was measured in years.

ii. Marital status (MS): was measured as married (1), single (2), divorced (3) or widowed (4).

iii. Sex (SX)**:** Gender is the categorization into male or female which was measured as a dummy variable, one (1) is assigned to male while, zero (0) to females.

iv. Education (ED): This is respondent's acquisition of formal education which was measured as the number of years spent in formal schooling. (Yrs)

v. Beekeeping experience (BEXP): This was measured in years (Yrs).

vi. Household size (HS)**:** This was measured in number of people per household. (No)

vii. Access to credit (AC): This was measured as a dummy variable (1 if access, 0 if otherwise).

viii. Extension Contact (EC): This was measured by no of visit (No)

ix. Membership of cooperative (MC): This was measured as a dummy variable (if yes 1, 0 if otherwise)

x. Participation on Nigeria Export Promotion Council (Bee workshop, 2019) (BW): This was measured as a dummy variable (if yes 1, 0 if otherwise)

xi. Numbers of hives (NH): This was measured in numbers (No)

xii. Sources of information (SI) this was measured in 1 Extension agent, 2 bee farmers, 3 friends and relative, 4 cooperative, 5 ADP, 6 Social media

xiii. Area devoted for bee farming (AD): This was measured in hectares (ha)

xiv. Type of bee hives: (TH) was measured in 1 Clay pot, 2 Kenyan Top bar, 3 Langsroth hive, 4 wire hives and 5 log hive

xv. Baiting material (BM) was measured in 1 wax, 2 Syrups, 3 granulated sugar, 4 Lime and 5 cow dung.

xvi. Apiary visit will be measured as dummy (if yes 1, 0 if otherwise)

3.5.3 Level of adoption of modern beekeeping technologies

The objective two (2) which is to determine the level of adoption of modern bee management practices which include supplementary feed, pest and disease control, baiting of hives, hives inspection, apiary cleaning, queen breading, pollen collection, record keeping, water provision, bee pollination services and modern technology such as Kenya top bar and langstroth, bee suit, swarm catcher and queen catcher, honey extractor, thermometer, hygrometer, engages in laboratory activities, hives shading and queen excluder. To determine level of adoption, 3-points Likert rating scale of high, moderate and low adopter was used. The corresponding values of 3, 2 and 1 were added together to obtain an aggregate score of 6, which was then divided by 3 to obtain a mean score of 2.0 as the cut-off mean for categorization into High adopter (≥ 2.0) and low adopter (< 2.0).

3.5.4 Extent of utilization of bee products

To determine the extent of utilization of bee products which include wax, propolis, royal jelly, bee-pollen and bee venom, 3-point type Likert rating scale of always, occasionally and never, was used. The corresponding values of 3, 2 and 1 was added together to obtain an aggregate score of 6, which was then divided by 3 to obtain a mean score of 2.0 as the cut-off mean categorization into always utilized (≥ 2.0) and never utilized (< 2.0).

Table 3.2: Explanatory variables and the expected outcome

Variable	Type Variable Type	Expected Outcome (+/-)
Marital status	Categorical	+/-
Level of education	Continuous	+
Beekeeping experience	Continuous	+
Household size	Continuous	+/-
Level of involvement in beekeeping	Categorical	+
Extension contact	Categorical	+
Membership of cooperative	Categorical	+
Beekeeping workshop	Categorical	+
Types of baiting	Categorical	+
Types of bee hives	Categorical	+
Area for devoted bee farming	Continuous	+
Age	Continuous	-

Source: By authors; (+/-) indicates a positive or negative relationship with the dependent variable

3.6 Method of Data Analysis

Data was analyzed using descriptive statistics such as means, frequency and percentages and inferential statistics such as survival analysis and cox proportional hazard rate. Objective (I), (III) and (V) were achieved using descriptive statistics such as frequency distribution table and percentages and mean.

Objectiv (II) was achieve using survival analysis

Objective (IV) was achieve using cox proportional hazard rate

3.7 Model Specification

3.7.1 Survival analysis

This statistical method provides a methodology and tools that allow for the analysis of the time-event relationship in more flexible conditions. Let T be a non negative random variable that measures the length of a spell (the adoption of improved beekeeping). Furthermore, consider (t) as a realization of (T) where the observed durations of each subject consist of a series of data $t_1 < t_2 < \cdots t_n$. Let $f(t)$ be a continuous Probability Distribution Function (PDF) of T. The probability distribution of the duration variable can be specified by the Cumulative Density Function (CDF).

$$F(t)\int_0^t f(s)ds = pr\ (T \leq t) \tag{3.2}$$

Equation (1) is the probability of T to be smaller than a value t. Nevertheless, the researcher was interested in the probability that Thas a length of at least t. This probability is given by the survival function as:

$$S(t) = P(T > t) = 1 - F(t) \tag{3.3}$$

The probability that the duration of adoption occurs in an infinitesimal time period Δtafter time (given that the non-adoption decision has lasted up to $t$is:

$$P\left(t \leq T < t\frac{\Delta t}{T} > t\right) \tag{3.4}$$

In a further step, the hazard function $\Delta t$is defined as the probability that a farmer adopts the improved beekeeping at time t (i.e., T = t), given he has not adopted it before t.

$$h(t) = \lim_{\Delta \to 0} \frac{P\left(t \leq T < t + \frac{\Delta t}{T} > t\right)}{\Delta t} = \frac{f(t)}{S(t)} \tag{3.5}$$

The hazard function can be further mathematically expressed as follows,

$$h(t) = \frac{f(t)}{S(t)} = \frac{dF(t)/dt}{S(t)} = \frac{-\,dlnS(t)}{d(t)} \tag{3.6}$$

In addition to the length of the duration time of adoption, a set of explanatory variables may affect the distribution of the duration. This means that the $\Delta(t)$should be re-specified and re-defined as follows

$$h(t, x, \theta, \beta) = \lim_{\Delta \to 0} \frac{\Pr(t \leq T < t + \frac{\Delta}{T} \geq t}{\Delta} \tag{3.7}$$

Where:

β is a vector of unknown parameters of x;

$x$is the vector of explanatory variables which may include time-invariant and time-varying variables; and

θ is a vector of parameters that characterize the distribution function of the hazard rate.

After the inclusion of the explanatory variables, the hazard function $h(t, x, \theta, \beta)$can be split into two components. The first component is the part of the hazard that depends on the subject characteristics$g(x, \beta)$. The second one is the baseline hazard function $h_0(t)$, which is equal to the hazard when all covariates are zero. Notably, the latter one does not depend on individual characteristics; this component captures the way the hazard rate varies in duration. In this context, the shape (distribution function) of the hazard function has important implications for duration dynamics. In this research, the non-parametric method of the Kaplan-Meier (KM) estimator will used to explore the covariate effects and the potential distribution to be used if the parametric approach was applied. The KM estimator produced an empirical approximation of survival and hazard, which is similar to an exploratory data analysis; denoting the distinct failure times of individuals as $t_1 < t_2 < \cdots t_n$.

3.7.3 Cox proportional hazards model

The Cox proportional hazards model, the duration of each beekeepers is assumed to follow its own hazard function $hi(t)$which can be expressed as:

$$hi(t) = h(t; xi) = h0\ (t) \exp(xi\ \beta) = h0(t)\exp(\beta_1 x_{i1} + \cdots + \ \beta_1 x_{i1}) \qquad (3.8)$$

$$\log hi\ (t) = \ \propto (t) + \beta_1 MS + \beta_2 GD + \beta_3 ED + \beta_4 BE + \beta_5 HS + \beta_6 AC + \beta_7 EC + \beta_8 MC + \beta_9 BW + \beta_{10} NH + \beta_{11} CI + \beta_{12} SI + \beta_{13} AD + \beta_{14} TH + \beta_{15} BM + \beta_{16} AV + \beta_{17} AG + \mu \qquad (3.9)$$

Where:

$hi(t) =$ Probability that adoption will occur (Adoption 1, if otherwise 0)

t = time to event for each observation

$\propto (t)$ = baseline hazard

β = estimated coefficient

$\beta_1 - \beta_{16}$ = Coefficient of explanatory variables

MS =Marital status (Married 1, if otherwise 0)

GD = Gender (male 1, female 0),

ED = Education (Years),

BE = Beekeeping experience (Years),

HS = Household size (Numbers),

AC = Access to credit (Yes 1, 0 no),

EC =Extension contact (Number of visit)

MC = Membership of cooperative (Yes 1, 0 no)

BW = Bee workshop (Yes 1, 0 no),

CI = Cost of innovation (₦),

SI = Source of information (number),

AD =Area devoted foe beekeeping (ha)

TH = Types of hives (Number)

BM = Baiting material (Number)

AV = Apiary visit (Yes 1, 0 no)

AG = Age (years)

a = constant term and e = error term

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents and discusses the results obtained from the analyses carried out to achieve the objectives of the research.

4.1 Socio-economic Characteristics of Bee Farmers

This section presents and discusses the findings on socio-economic characteristics of the bee farmers in the study area which comprises of the age, marital status, level of education, beekeeping experience, level of involvement, primary occupation, extension contact, access to credit and membership of cooperative.

4.1.1 Age of the bee farmers

Table 4.1 shows that most (76.0%) of the bee farmers were between the age range of 41 – 60, with an average age of 50 years. This implies that in the study areas, bee farmers were dominated by middle-aged men gradually getting out of their active and productive age. This indicates low involvement of youth in beekeeping, this is because the study area had large arable lands that supported farming, thus the majority of the young and energetic youth engaged in farming while the elite with limited time for the rigorous farming activities engaged in beekeeping which is less rigorous and time consuming. This is comparable to the findings of Matanmi (2008) and Mujuni *et al*. (2012), who reported that the majority of Ugandan beekeepers were 50 years of age, which was attributed to the migration of young people to cities in quest of white-collar jobs. However, the findings disagree with Farinde *et al*. (2005), who reported that the majority of beekeepers were within the age group of 30 years and above.

4.1.2 Marital Status of the bee farmers

The result in Table 4.1 depicts that the majority (93.9%) of bee farmers were married, while 6.1% were single. This implies that married respondents dominate the study area. This is because the research area is an agrarian community whose members marry in order to increase household size, which is expected to help carry out farming activities, which can go a long way in boosting farmers' income and improving their livelihoods. However, large household sizes increase the expenditures incurred by farmers. This is similar to the study of Asmiro *et al.* (2017) who reported that most of the beekeepers in the study area were married.

4.1.3 Household Size of the bee farmers

The result in Table 4.1 reveals that most (78.8%) of bee farmers had household size within the range of 4–11 people, with an average of 6 people per household. This implies that the most of bee farmers had fairly large household sizes. This is similar to the findings of Bunde and Kibet (2015), whose study concluded that beekeepers are dominated by farmers with larger household sizes. This is expected to have influence on the adoption of new innovations. This is because farmers with a large family composition may adopt new technology in order to satisfy their family's needs through improved production; although, meeting other physiological needs of the family may interfere with their adoption decision.

Table 4.1: Distribution of beekeepers according to socio-economic characteristics

Variables	Frequency	Percentage	Mean
Age (Years)			
30 and below	1	.5	
31 – 40	24	11.3	
41 – 50	103	48.6	
51 – 60	58	27.4	50
61 and above	26	12.3	
marital status			
Single	13	6.1	
Married	199	93.9	
Household size			
3 and below	37	17.5	
4 – 7	125	59.0	6
8 – 11	42	19.8	
12 and above	8	3.8	
Level of education			
Secondary	41	19.3	
Tertiary	168	79.2	
Non-formal	3	1.4	
Beekeeping Experience			
1 – 5	63	29.7	
6 - 10	58	27.4	10
11 – 15	49	23.1	
16 – 20	42	19.8	
Involvement in beekeeping			
Part-time	205	96.7	
Full-time	7	3.3	
Primary occupation			
Farming	82	38.7	
Gathering of nuts	3	1.4	
Civil servant	93	43.9	
Artisan	3	1.4	
Beekeeping	28	13.2	
Agro-processing	3	1.4	
Access to credit facilities			
No	212	100.0	
Cooperative Membership			
Yes	176	83.0	**5**
No	36	17.0	
Area devoted for beekeeping (ha)			
0.1 - 0.5	82	38.7	
0.6 - 1.0	92	43.4	0.9
1.1 - 1.5	32	15.1	
1.6 - 2.0	6	2.8	

Source: Field Survey, 2022

4.1.4 Level of education of the bee farmers

Table 4.1 shows that the most (79.2%) of bee farmers had tertiary education, 19.3% had secondary education, and only 1.4% had no formal education. This implies that bee farmers in the study area were dominated by farmers who have the ability to obtain and process information regarding adoption of new innovation. This is similar to the findings of Mujuni *et al.* (2012) and Olademiji (2017), whose studies opined that all beekeepers in the study areas had completed formal education. However, the findings contradict the study of Egwu (2014), whose study revealed that the majority of beekeepers in Delta State do not have any formal education. The reason for this finding could be attributed to the fact that the majority of modern beekeepers in the study areas were civil servants who engaged in beekeeping as a means of diversifying their sources of income as a result of their exposure.

4.1.5 Years of beekeeping experience of the bee farmers

Table 4.1 shows that about half (50.1%) of the bee farmers in the study area had 6–15 bee farming years of experiences with an average of 10 years of experiences. This implies that experienced bee farmers dominate beekeeping in the studied area. This is expected to improve their adoption and decision-making processes, because longer years of acquired agricultural knowledge and skill enhance their wealth of experiences over time to manage and adjust to beekeeping processes. This finding is consistent with Olaosebikan *et al*. (2019), whose studies revealed that the majority of respondents in study area were experienced bee farmers, allowing them to make informed decisions about resource allocation and farm management. The prevalence of bee farming in the study area can be attributed to the fact that the study area included a large number of arable crops and fruit crop farms which provided the nectar required by bees for honey production over a long period of time.

4.1.6 Involvement in beekeeping by the bee farmers

The findings in Table 4.1 depict that majority (96.7%) of the bee farmers were part-time bee farmers. This is an indication that bee farming in the study area is on a small scale. This is expected to reduce the rate of adoption of improved bee farming technologies. This is similar to the study of Samson (2016) who opined that in a developing country like Nigeria, beekeeping is rarely a person's sole source of income and livelihood, but it is important as a source of supplementary income, food, and employment. The reason for this result could be linked to the fact that beekeepers in the study areas were civil servants and arable crop farmers who only involve in beekeeping to diversify their sources of livelihood. The upshot of this finding is that, despite the huge benefits associated to modern beekeeping, it is still in the hands of few individuals.

4.1.7 Primary occupation of the respondents

The result in Table 4.1 reveals that considerable proportion (43.9%) of bee farmers were civil servant, 38.7% were farmers while only 13.2% were beekeepers. This is due to their high level of post-secondary education, which allows them to choose from a variety of paid jobs. The implication of this result is that majority of modern bee farmers in the study areas opted for bee farming as secondary occupations. This is in line with the study of Oladimeji *et al.* (2017), who posits that beekeeping is hardly the major occupation of respondents in Northern Nigeria.

4.1.8 Access to credit

Table 4.1 shows that in the study areas, 100% of bee farmers do not have access to credit. Credit is projected to strengthen farmers' purchasing power and, as a result improve their adoption rate. If correctly exploited, it has the potential to break the vicious cycle of food insecurity and increase the production capacity of farming households. Credit is a key factor in starting or expanding a farm business. Access to financial services will go a long way toward enhancing agricultural production of a small-scale farmer. This result contradicts the findings of Asogwa (2014), who found that the majority of peasant farmers in Benue State (64.9%) have access to loans. Although, Simeon and Victor (2019) concluded that rural farmers in Benue State had a medium level of access to the BOA loan, with a high level of inadequacy in terms of the loan volume issued to them. The bureaucratic procedures involved in obtaining agricultural loans from financial institutions in the research areas could be the reason for this result. The high rate of credit default among beneficiaries could also possibly be related to bee farmers lack of credit access in the study areas.

4.1.9 Membership of cooperative

Table 4.1 reveals that the majority (83.0%) of bee farmers were members of a cooperative, with an average of 5 years of membership. This is supposed to help them make better adoption decisions. Cooperative involvement has the ability to build trust between farmers and financial institutions, allowing farmers to get agricultural financing from these banks to enhance their productivity (Ogunbameru *et al*., 2008). The association is also expected to assist members with better resource exploitation, processing capabilities and bee farming input procurement, as well as monitoring each other to guarantee that the acquired input is used efficiently. The majority of bee farmers in the studyareas formed distinct bee forums to satisfy their demands, which explains this outcome.

4.1.10 Area devoted for beekeeping

According to Table 4.1, the majority (82.1%) of bee farmers dedicated 0.1 – 1 hectare of their farm area to bee farming, with an average of 0.9 hectare per bee farmers. Beekeeping does not necessitate a great amount of land area; one acre of land can support multiple colonies. This implies that the majority of beekeepers install hives in their orchards, which is intended to boost pollination services. This follows the study of Benedict *et al.* (2016), who reported that beekeeping does not require a large expanse of land.

4.1.11 Methods of beekeeping

As presented in Table 4.2, majority (91.0%) of bee farmers employ Kenya top bar for bee faming while (89.2%) use a modern smoker. This implies that Kenya top bars and bee smokers were the most methods of bee farming in the study area. This follows meaze (2010) who posits that Kenya top bars are most commonly adopted beekeeping method. The Top bars allow bees to generate honey while also permitting wax production in a natural way. Furthermore, the use of modern smoker to harvest honey helps to conceal bees' alarm pheromones, allowing for easier examination and harvesting. Also, the majority of beekeepers (85.8%) use wax as bait in their hives. According to the findings, wax is easily available, very attractive to bees, and by far the most successful method of colonizing hives. Finally, ant, birds, and lizards were the most common bee pests in the research locations.

Table 4.2: Distribution of respondent according to methods of beekeeping

Variables	Frequency	Percentage
Types of hives		
Clay pot	3	1.4
Kenya top bars	193	91.0
Longstroth	10	4.7
Log hive	3	1.4
Gourd hive	3	1.4
Method of harvesting		
Smoking	189	89.2
Fire	23	10.8
Type of baiting material		
Wax	182	85.8
Syrup	13	6.1
Granulated sugar	4	1.9
Lime	4	1.9
Lemon grass	6	2.8
Honey	3	1.4
Common bee pest		
Ant		
Yes	180	84.9
No	32	15.1
Birds		
Yes	135	63.7
No	77	36.7
Lizard		
Yes	177	83.5
No	35	16.5

Source: Field Survey, 2022

4.1.12 Sources of information on improved beekeeping practices

Table 4.3 shows that the major sources of information on improved beekeeping available to bee farmers in the study areas were social media (88.2%), family and friends (61.3%), radio (60.8%), and beekeepers groups (59.0%). This implies that the major sources of information among beekeepers were social media, family and friends and radio. Social media was ranked first this may be due to the widespread use of smart phones in the twenty-first century, which allow individuals to communicate via various social media platforms such as Facebook, Whatsapp, Instagram, and Twitter. It was reported that the majority of bee farmers formed Whatsapp groups, making it easier for them to communicate information on improved beekeeping among the group members this is in line with the study of Sunday (2016) who reported that farmer's access information on improved farming through Radio, family and friends and social media. The second most important sources of information in the study areas were friends and relatives, as well as radio. The study area has a homogeneous community with a relatively small population and exclusive mutual relationships, making it easier to disseminate knowledge on improved beekeeping across the agricultural communities. Furthermore, the majority of farmers in the study areas have access to mobile phones with radios installed, and MP3 players with radios are very popular in every household in the study area, so farmers listen to their favorite radio programs, particularly agricultural programs, when they are relaxing. This agrees with the study of Meaza (2010); Demisew (2016) and Sunday *et al* (2015) who reported that radio and friend and relative were the major source of information among small scale farmers.

Table 4.3: Distribution of respondent according to sources of information

Variables	Frequency	Percentage
Friends and relatives		
Yes	130	61.3
No	82	38.7
ADP		
Yes	42	19.8
No	170	80.2
Beekeepers group		
Yes	125	59.0
No	87	41.0
Radio		
Yes	129	60.8
No	83	39.2
Television		
Yes	14	6.6
No	198	93.4
Newspaper		
Yes	90	42.5
No	122	57.5
Extension contact		
Yes	3	1.4
No	209	98.6
Social media		
Yes	187	88.2
No	25	11.8

Source: Field Survey, 2022

4.1.13 Frequency of information on improved beekeeping practices

The findings in Table 4.4 shows that social media with mean of ($\bar{X}$ = 2.6) is the most often utilized source of information on improved beekeeping, followed by radio with the mean ($\bar{X}$ = 2.1), friends and family with the mean ($\bar{X}$ = 1.9), beekeepers groups with the mean ($\bar{X}$ = 1.7) and newspapers with the mean of ($\bar{X}$ = 1.7) used occasionally. On the other hand, television, extension agents, and ADP were never used. The finding here agrees with those of Akanda and Roknuzzaman (2012), who reported that farmers used a variety of agricultural information sources to enhance primary agricultural production. Based on the beekeepers' responses, it can be stated that accessible information sources were effectively utilized for enhanced beekeeping especially in the areas of production of quality honey and wax. Poor extension contact and epileptic power supply in the study areas might be the reason for low utilization of extension agent and television. While poor linkages between the ADPs and bee farmers s as well as lack of beekeeping Subject Matters Specialist (SMS) contributed to low utilization of ADP as a sources of information among bee farmers.

Table 4.4: Distribution of respondent based on frequency of information

Frequency of information	Weighted Sum	Weighted Mean	Remark
Friends and relatives	401	1.9	Occasionally
ADP	245	1.1	Never
Beekeepers group	364	1.7	Occasionally
Radio	448	2.1	Occasionally
Television	241	1.1	Never
Newspaper	367	1.7	Occasionally
Extension contact	239	1.1	Never
Social media	550	2.6	Always

Source: Field Survey, 2022

4.2.1 Level of adoption of improved beekeeping technologies

The results of the level of adoption of improved beekeeping technology were reported in Table 4.5. Table 4.5 shows that the most often adopted improved beekeeping technologies in the study area were bee suits with a mean of ($\bar{X}$ = 2.7), baiting with a mean of ($\bar{X}$ = 2.6), and Kenya top bars with a mean of ($\bar{X}$ = 2.6), water provision with a mean of ($\bar{X}$ = 2.4), hive inspection with a mean of ($\bar{X}$ = 2.3) and swarm and queen catcher with a mean of ($\bar{X}$ = 2.1). This is similar to the finding of workney (2011) who posits that improved beehives and swarm catcher were the most adopted bee technologies in Ethopia. Moreover, the remaining ten technologies, on the other hand, had a lower adoption rate. This revealed that, only 38% of the entire technologies under consideration were adopted in the study area, implying that the adoption rate of improved beekeeping technologies is low. This is due to lack of technical knowledge, a negative attitude toward beekeeping, insufficient extension contacts, and inadequate access to credit facilities. This agrees with the study of Dereje *et al.* (2020) who reported that beekeepers were yet to fully adopt beekeeping technological package in Ethiopia.

Table 4.5: Distribution of bee farmers based on adoption level of improved technology

Variables	Weighted sum	Weighted mean	Remark
Supplementary feeding	277	1.3	Low
pest and disease control	212	1.0	Low
Baiting	543	2.6	High
Hives inspection	488	2.3	High
Apiary cleaning	271	1.3	Low
Queen breading	219	1.0	Low
pollen collection	212	1.0	Low
record keeping	241	1.1	Low
water provision	519	2.4	High
bee pollination service	212	1.0	Low
Kenya top bar	564	2.6	High
Bee suit	577	2.7	High
swarm and queen catcher	446	2.1	High
honey extractor	285	1.3	Low
Thermometer	212	1.0	Low
hives shading	351	1.7	Low

Source: Field Survey, 2022

4.2.2 Rate of adoption of improved beekeeping technology

This section presented the results from survival analysis on the time variation on the adoption of improved beekeeping technologies indicating the survival ratio, failure rate and the Kaplan-Meier estimation for the technology with higher and moderate adoption rates.

4.2.2.1 Bee suit

The result presented in Table 4.6 depicts that bee suits had higher adoption rate in the study areas with 99% adoption rate. According to the study, there were approximately 111 adoptions at time "1," with a survival rate of 47 %. This means that around 53% of beekeepers adopt the technology (bee suit) within the first year of their beekeeping practice. The survival function was 0.00 at time ‘9’, implying that there were no further survivors at this time period which signifies that all the bee farmers within the time frame had adopt the technology. However, there were no discontinuous on the use of bee suit throughout the study period. This implies that bee suit had faster adoption rate with about 50% of beekeepers adopting it within the first year. The dread of bee stings, which may cause significant pain and swelling of the body, is one of the primary reasons why most beekeepers prioritize bee suit kits to protect themselves from bees, especially during hive inspection and harvesting, when bees are constantly aggressive and defensive.

Table 4.6: Survival function of bee suit

Time	Beginning Total	Adoption	Discontinuous	Survivor function
1	209	111	0	0.47
2	98	33	0	0.31
3	65	38	0	0.13
4	27	9	0	0.09
5	18	3	0	0.07
6	15	3	0	0.06
8	12	7	0	0.02
9	5	5	0	0.00

Source: Field Survey, 2022

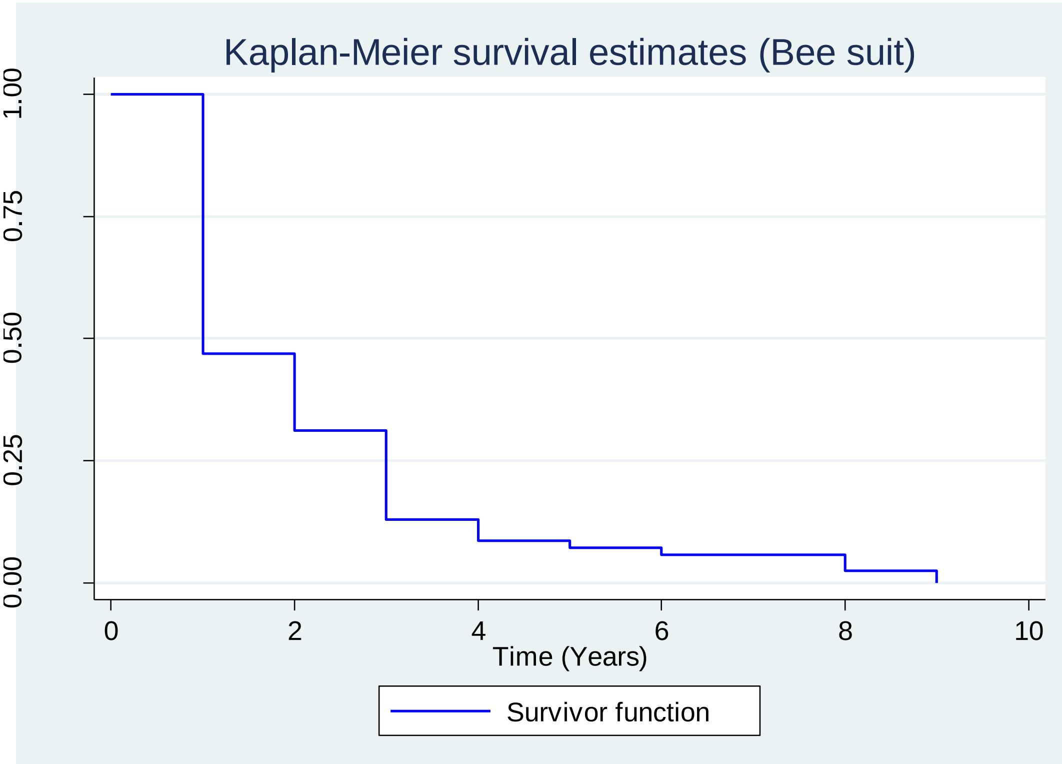

Figure 4.1: Kaplan-Meier survival estimates (Bee suit)

Figure 4.1 is a Kaplan-Meier graphical estimate of bee suit. The graph shows that at time ‘0’ all observation were still surviving till time ‘1’ where more than 50% of the observation (bee farmers) had adopted the technology. It proceeded to time ‘2’ where additional 15% of the beekeepers had adopted bee suit till time ‘9’ where every member of the observation had adopted the technology. This implies that bee suit had fast adoption because at time 1 more than 50% had adopted the technology. The steepness of the graph was determined by the surviving duration.

4.2.2.2 Baiting

The result presented in Table 4.7 portray that baiting was the second highest adopted technology in the study areas with 98% adoption rate.   According to the study, there were approximately 94 adoptions at time "1," with a survival rate of 54 %. This suggests that around 46% of bee farmers adopted the technology (baiting) within the first year of their beekeeping practice. In time ‘2’ there were16 more adoption with surviving ratio of 0.47. At time '13,' the survival function was 0.00, indicating that there were no more survivors, indicating that all beekeepers within the time frame had adopted the technology. This implies that bating had fast adoption rate because half of respondents adopted the technology within the first and second year of their beekeeping practice.

Comparing to bee suit, baiting had long periods of adoption. There were no discontinuous throughout the study period. This implies that baiting had faster adoption rate with 50% of beekeepers adopting it within the first-two years of their beekeeping practice. The reason for this result could be due to the fact that baiting is used to leisure bees into any types of artificial hives created (Log, pot, langstroth, kenya top bars). The baiting ranges from wax, cow dung, syrups, as well painting of hives. However, some beekeepers strategically positioned their hives to catch swarm of absconding bees which can be attributed to the variation in the rate of adoption.

Table 4.7: Survival function of Baiting

Time	Beginning Total	Adoption	Discontinuous	Survivor function
1	208	94	0	0.54
2	114	16	0	0.47
3	98	28	0	0.34
4	70	16	0	0.26
5	54	12	0	0.20
6	42	8	0	0.16
7	34	10	0	0.12
8	24	6	0	0.08
9	18	14	0	0.02
10	4	1	0	0.01
13	3	3	0	0.00

Source: Field Survey, 2022

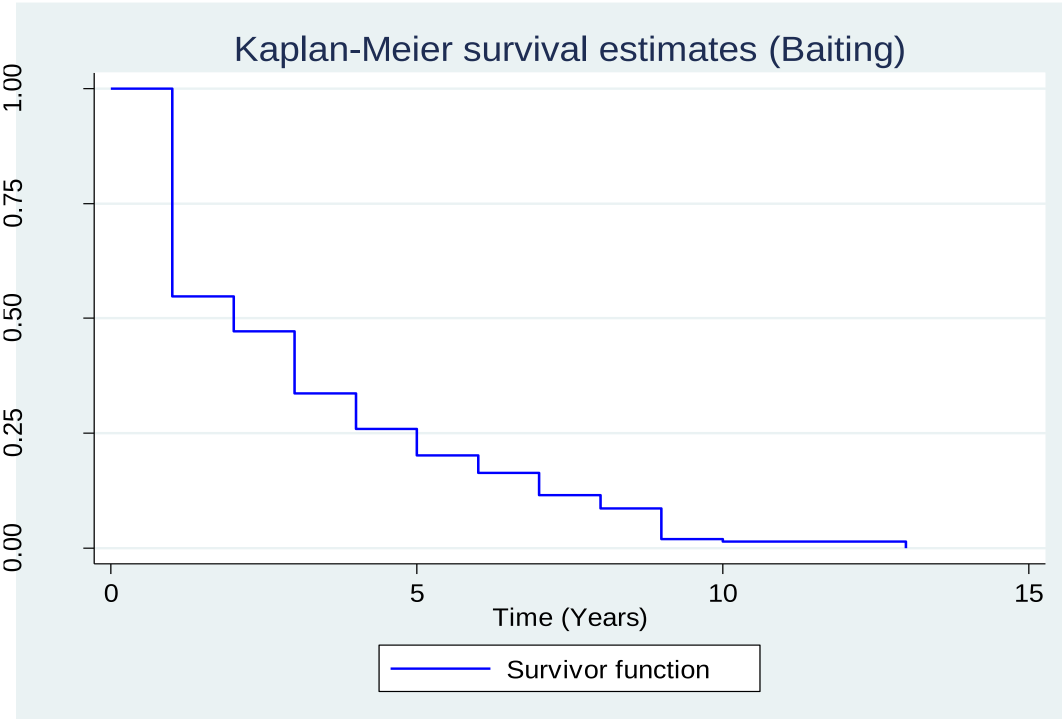

Figure 4.2: Kaplan-Meier survival estimates (Baiting)

Figure 4.2 is a Kaplan-Meier graphical estimate of baiting. The graph shows that at time '0' all observation was still surviving till time '1' where about 50% of the observation adopted baiting. It proceeded to time '2' where additional 7% of the beekeepers had adopted baiting till time '13' where every member of the observation had adopted the technology. This implies that bating had fast adoption rate because half of bee farmers adopted the technology the first and second year of their beekeeping practice. The steepness of the graph was determined by the surviving duration.

4.2.2.3 Kenya Top bars

The result presented in Table 4.8 depicts that Kenya top bars has the third highest adoption rate of 94%. According to the study, there were about 28 adoptions at time "1", with a survival rate of 86%. This suggests that at time "1," period about 24% of the observation (bee farmers) had adopted the technology. At time '2,' period there were 40 more adoption with surviving ratio of 0.66. However at time 3 and 4 periods, there were 24 and 6 adoption respectively. This implies that about 50% of the observation (beekeepers) had adopted the Kenya Top Bars during the 4 time period. At time '15,' the survival function was 0.00, indicating that there were no more survivors, indicating that all beekeepers within the time frame had adopted the Kenya Top Bars technology. Lastly, there were no discontinuous throughout the study period.

Comparing the rate of adoption of bee suit and baiting to that of Kenya top bars, it can be deduced that Kenya top bars had slower adoption rate in the first four time period of adoption compared to others. This can be attributed to the fact that some baited hives take time before colonization of bee colonies particularly if they are not properly baited or using of poor quality materials. According to their responses, some bee farmers baited their hives more than three times before colonization, while some others opined that they catch swarm of wild bees for colonization.

Table 4.8: Survival function of Kenya Top bars

Time	Beginning total	Adoption	Discontinuous	Survivor function
1	199	28	0	0.86
2	171	40	0	0.66
3	131	25	0	0.53
4	106	6	0	0.50
5	100	25	0	0.38
6	75	14	0	0.31
7	61	22	0	0.20
8	39	11	0	0.14
9	28	13	0	0.08
10	15	9	0	0.03
11	6	2	0	0.02
12	4	1	0	0.01
15	3	3	0	0.00

Source: Field Survey, 2022

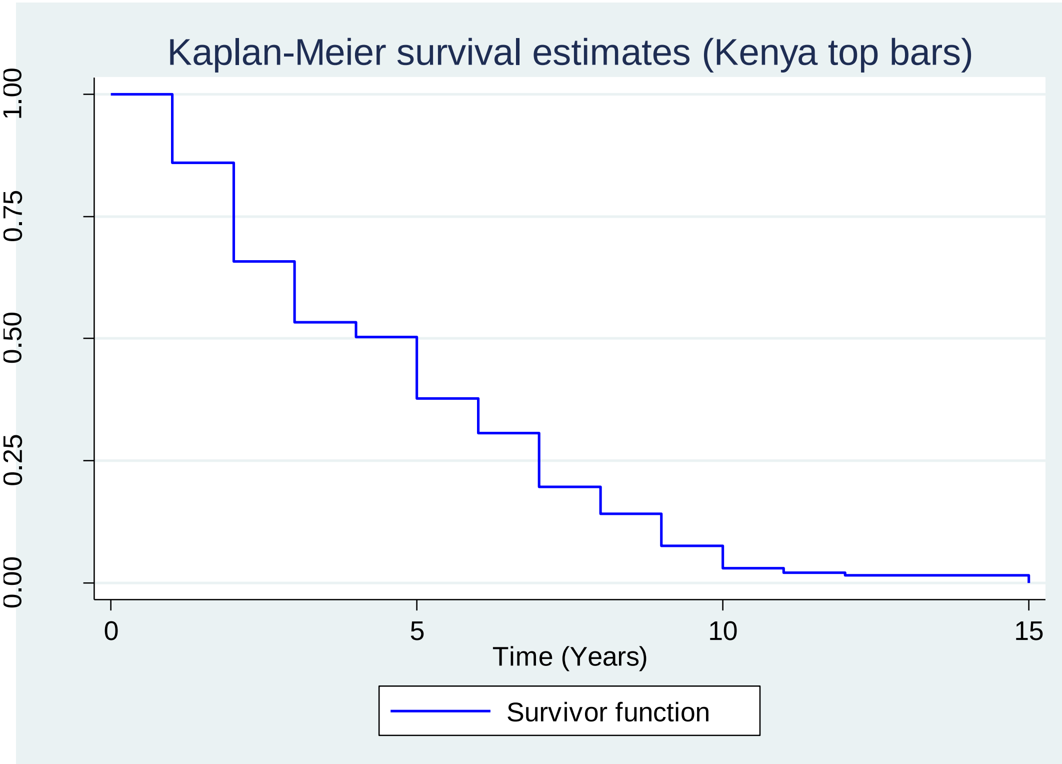

Figure 4.3: Kaplan-Meier survival estimates (Kenya top bars)

Figure 4.3 is a Kaplan-Meier graphical estimate of Kenya top bars. The graph shows that at time ‘0’ all observations (bee farmers) were still surviving till time ‘1’ period where more than 75% of the observations (bee farmers) were surviving. It proceeded to time ‘2’ where 65%f the observations (bee farmers) were surviving. At time ‘4’ periods, about 50% of the observations (bee farmers) were surviving. Lastly, at time’15,’ period, no more survivor implying that every member of the observations (bee farmers) had adopted the technology. The steepness of the graph was determined by the surviving duration.

4.2.2.4 Water provision

The result presented in Table 4.9 portray that water provision was the fourth highest adopted bee technology in the study areas with adoption rate of 89%. According to the study, there were about 16 adoptions at time "1," period with a survival rate of 92%. This implies that at time ‘1’ period about 92% of the observations (bee farmers) were still thinking whether to adopt the technology or not. At time ‘2,’ period there were 14 adoptions with surviving ratio of 84%. However at time ‘3’, ‘4’ and ‘5’ periods, there were 18, 30 and 15 adoptions respectively. This implies that about 50% of the observation (beekeepers) had adopted water provision during the ‘5’ time period, indicating that water provision had fast adoption rate. At time '18,' the survival function was 0.00, indicating that there were no more survivors, suggesting that all beekeepers within the time frame had adopted the technology. Lastly, there were discontinuous throughout the study period.

Water is an essential element in hives building that is why worker bees travel to any distances to get water for the maintenance of their hives especially during the dry season. It is expected that water provision should have faster adoption rate since it requires no technical knowhow. The results indicated slower adoption at the 1-5 years of beekeeping practices. According to their responses, most of the beekeepers opined that honey bees will always find their means of water and that water scarcity in the studied areas could be one of the reasons.

Table 4.9: Survival function of Water provision

Time	Beginning total	Adoption	Discontinuous	Survivor function
1	189	16	0	0.92
2	173	14	0	0.84
3	159	18	0	0.75
4	141	30	0	0.58
5	111	15	0	0.50
6	96	21	0	0.40
7	75	28	0	0.25
8	47	12	0	0.19
9	35	5	0	0.15
10	30	11	0	0.10
11	19	6	0	0.07
12	13	5	0	0.04
13	8	1	0	0.03
14	7	1	0	0.03
15	6	3	0	0.01
16	3	2	0	0.01
18	1	1	0	0.00

Source: Field Survey, 2022

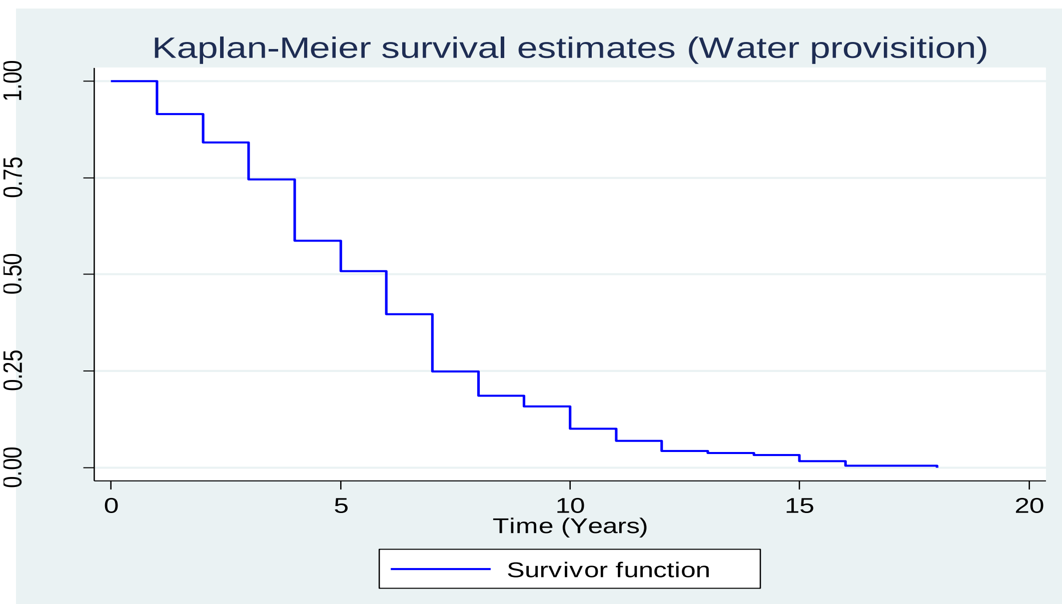

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Figure 4.4: Kaplan-Meier survival estimates (Water provision)

Figure 4.4 is a Kaplan-Meier graphical estimate of water provision. The graph shows that at time ‘0’ all observations (bee farmers) were still surviving till time ‘1’ period where about 92% of the observations (bee farmers) were surviving. It proceeded to time ‘2’ where

84%fthe observations (bee farmers) were surviving. This implies that about 50% of the observation (bee farmers) had adopted water provision during the ‘5’ time period, indicating that water provision had fast adoption rate. Lastly, at time’18,’ period, no more survivor implying that every member of the observations (bee farmers) had adopted the technology. The steepness of the graph was determined by the surviving duration.

4.2.2.5 Hives inspection

The result presented in Table 4.10 shows that hives inspection has adoption rate of 80% which is the fifth highest adopted technology in the study areas. According to the findings, there were about 8 adoptions at time "1," period with a survival rate of 95%. This suggests that at time ‘1’ period about 95% of the observations (bee farmers) were still nurturing whether to adopt the technology or not. At time ‘2,’ period there were 6 adoptions with surviving ratio of 92%. However at time ‘3’, ‘4’ and ‘5’ periods, there were 18, 27 and 30 adoptions respectively. Thus, about 50% of the observation (bee farmers) had adopted hives inspection during the ‘5’ time period. At time '18,' the survival function was 0.00, indicating that there were no more survivors, implying that all beekeepers within the time frame had adopted the technology. Lastly, there were discontinuous throughout the study period.

Hives are inspected for colonization, honey stores in the brood box, mite attacks, the queen's activity, and the nature of the comb. Although there is a risk of hurting or killing the queen each time the hive is opened, as well as disruption of the bees' complex social activities, but it is necessary to keep the hive in good condition. The rate of bee hive inspection takes longer period since most beekeepers are unable to distinguish the queen in the hives, and opening of hives necessitates the use of certain techniques in order to not eliminate the entire colony. From the findings it gathered most beekeepers in the study areas inspect hives for honey deposition.

Table 4.10: Survival function of hives inspection

Time	Beginning total	Adoption	Discontinuous	Survivor function
1	169	8	0	0.95
2	161	6	0	0.92
3	155	18	0	0.81
4	137	27	0	0.65
5	110	30	0	0.47
6	80	27	0	0.31
7	53	22	0	0.18
8	31	12	0	0.11
9	19	1	0	0.05
10	10	2	0	0.05
11	9	2	0	0.04
14	7	2	0	0.03
15	5	2	0	0.01
16	3	2	0	0.01
18	1	1	0	0.00

Source: Field Survey, 2022

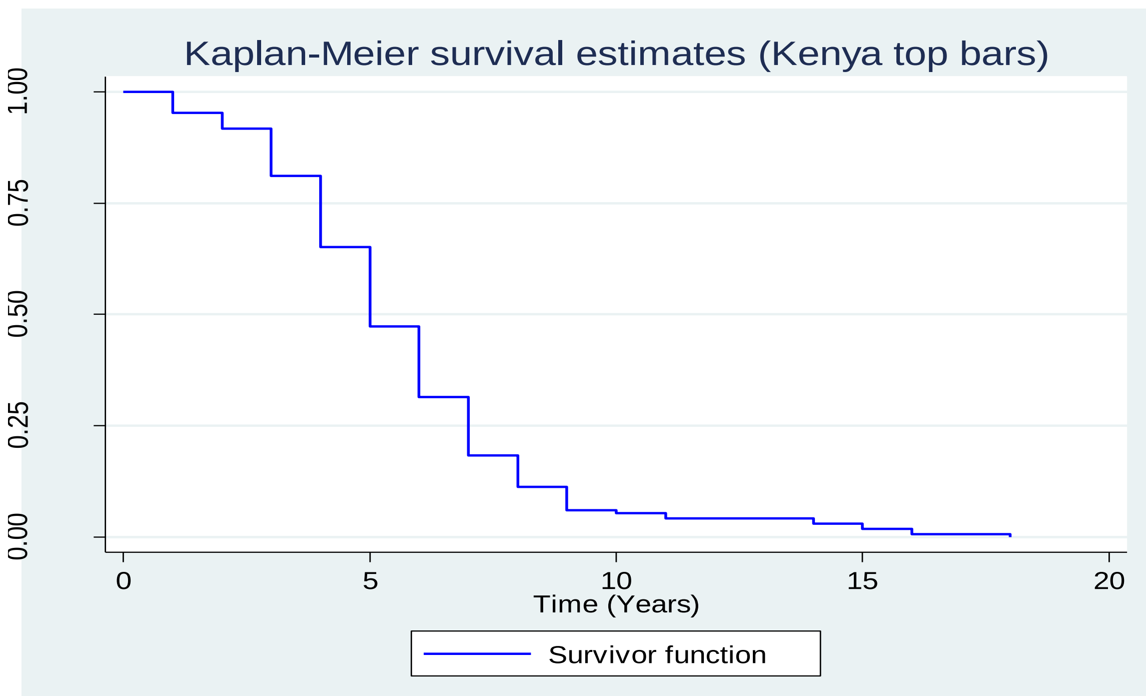

Figure 4.5: Kaplan-Meier survival estimates (hives inspection)

Figure 4.5 is a Kaplan-Meier graphical estimate of hives inspection. The graph shows that at time ‘0’ all observations (bee farmers) were still surviving till time ‘1’ period where about 95% of the observations (bee farmers) were surviving. It proceeded to time ‘2’ where 92%f the observations (bee farmers) were surviving. This implies that at time ‘5’ periods, about 50% of the observations (bee farmers) were surviving implying that hives inspection had fast adoption. Lastly, at time’18,’ period, no more survivor implying that every member of the observations (bee farmers) had adopted the technology. The steepness of the graph was determined by the surviving duration.

4.2.2.6 Swarm and queen catcher

The result presented in Table 4.11 shows swarm and queen catcher has adoption rate of 73% which is the sixth highest adopted technology in the study areas. According to the findings, only one adoption was recorded at time "1," period with a survival rate of 99%. This suggests that at time ‘1’ period about 99% of the observations (bee farmers) were still nurturing whether to adopt the technology or not. At time ‘2,’ and ‘3’ period’s two adoptions were recorded. However at time ‘4’ and ‘5’ periods, there were 19 and 5 adoptions respectively. This implies that at ‘8’ time about 50% of the observations (bee farmers) had adopted the technology indicating moderate adoption rate. At time '18,' the survival function was 0.00, indicating that there were no more survivors, suggesting that all beekeepers within the time frame had adopted the technology. Lastly, at ‘6’ time period one discontinuous was recorded, at time ‘8’ period five discontinuous were recorded while one discontinuous was recorded at time ‘9’. This implies that, seven observations (beekeepers) discontinued the use of swarm and queen catcher which they attributed to lack of technical knowhow.

When compared to all other technologies under consideration, swarm catcher had the slowest adoption rate; it takes 8 years before half of the population put the technology into usage and some discontinue along the line. Although, swarm catcher box is very easy to construct but their improper placement on strategic positions to catch wild bees looking for potential home may reduces their chances of usage. However, queen catcher involves lot technical competence which might be the reason for the slow adoption rate.

Table 4.11: Survival function of swarm and queen catcher

Time	Beginning total	Adoption	Discontinuous	Survivor function
1	155	1	0	0.99
2	154	2	0	0.98
3	152	2	0	0.97
4	150	19	0	0.85
5	131	5	0	0.81
6	126	7	1	0.77
7	118	20	0	0.64
8	98	29	5	0.45
9	64	28	1	0.25
10	35	15	0	0.14
11	20	8	0	0.09
12	12	4	0	0.06
13	8	3	0	0.04
14	5	3	0	0.01
15	2	2	0	0.00

Source: Field Survey, 2022

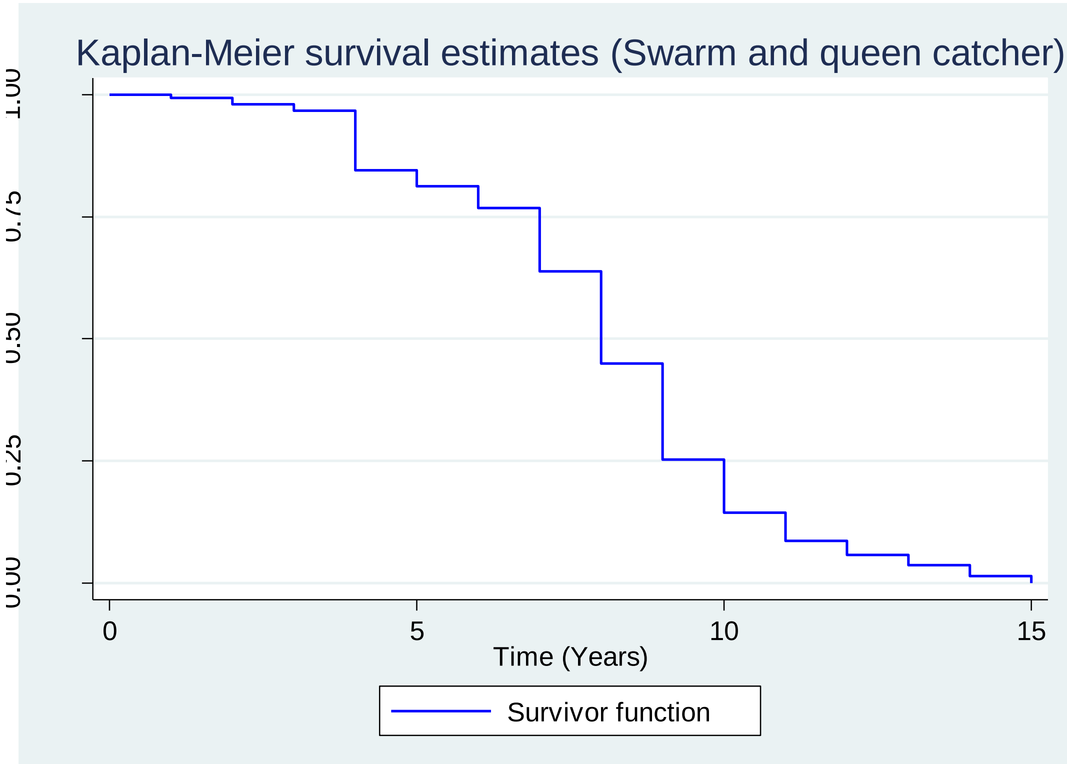

Figure 4.6: Kaplan-Meier survival estimates (swarm catcher)

Figure 4.6 is a Kaplan-Meier graphical estimate of warm catcher. The graph shows that at time '0' all observations (bee farmers) were still surviving till time '1' period where about 99% of the observations (bee farmers) were surviving. It proceeded to time '2' where 98% of the observations (bee farmers) were surviving. This implies that at time '8' periods, about 50% of the observations (bee farmers) were surviving indicating moderate adoption rate. Lastly, at time'15,' period, no more survivor implying that every member of the observations (bee farmers) had adopted the technology. The steepness of the graph was determined by the surviving duration.

4.3.1 Perception of bee farmers on bee products

The result of perception of beekeepers on bee-by-products presented in Table 4.12 portrays that majority of beekeepers were highly aware of honey with a mean of ($\bar{X}$ = 2.9) as expected. This implies that honey was the major bee products that bee farmers were highly aware off. Honey has always been appreciated by local populations for its taste, as well as its nutritional and therapeutic properties. It is prized for its sweetness and energy-giving characteristics in areas where other sugar sources are scarce. Because of the increasing demand, the majority of bee farmers were primarily interested in honey, according to their responses. Despite this, they were unable to fulfill the growing demands of customers. This is similar to the study of Labe (2017) who reported that beekeepers in Nigeria were majorly concern with the honey from the bees. Secondly, beekeepers in the study area were aware of bee wax ($\bar{X}$ = 2.4), propolis ($\bar{X}$ = 1.8), bee venom ($\bar{X}$ = 1.8) and bee pollen ($\bar{X}$ = 1.5) because they are common within the hives. However, the majority of bee farmers were unaware of royal jelly ($\bar{X}$ = 1.1), which is released from the head glands of workers bees to feed the bee queen. This agree with the study of Harshwarding *et al.* (2012) who reported that the technical competence associated with the utilization of other bee products reduce their usage by beekeepers in Rajasthan.

Table 4.12: Perception of bee farmers on bee-by-products

Bee by-products	Weighted Sum	Weighted Mean	Remark	Rank
Bee wax	519	2.4	Aware	2nd
Propolis	383	1.8	Aware	3rd
Bee venom	372	1.8	Aware	3rd
Honey	623	2.9	Highly aware	1st
Royal jerry	306	1.1	Not aware	6th
Bee pollen	315	1.5	Aware	5th

Source: Field Survey, 2022

4.3.2 Level of utilization of bee products

The findings of the level of bee product utilization presented in Table 4.13 revealed that there was gross inadequacy in bee product utilization this is because only honey with a mean of ($\bar{X}$ = 3.0) was always utilized as expected while bee wax (2.4) was occasionally used. This is similar to the study of Duku (2013) who posits that royal jelly, propolis and bee venom were hardly utilized by small scale bee farmers in the Sudan Savanna zone of Northeastern Nigeria. As a result of diverse industrial applications of bee products, bee wax and other bee products were in high demand in the international market. If all bee products are used efficiently, they have the potential to improve bee farmers' income and livelihood status while also lowering the country's unemployment rate. Bee famers who participated in wax processing, according to their responses, were unable to process wax to international standards, which has deterred many of them from the processing. They choose to sell their honey with comb or extract and trash the comb instead. Others merely extract honey without damaging the comb and return it to the hives, making it simpler for the bees to continue their work.

In respect to propolis, the study found out that the poor methods of opening of top bars either for inspection or harvesting destroy the propolis which is used by bees to seal opening within the hives. Also, the low utilization of propolis can also be attributed to small hive size holding of most of the bee farmers which limit the quantity of propolis they obtained. Bee venon, which is used to treat a wide range of ailments all over the world, necessitates a great deal of technical knowledge and medical supervision. This high technicalities and proper monitoring could be attributed to their low usages. In addition, bee pollen used by bees in producing bee bread requires lot of technicalities for their usage too. Lastly, royal jelly as expected had low utilization rate due to lack of awareness. The low utilization of bee products among bee farmers in the study area will significantly reduce their income.

Table 4.13: Distribution of respondent according to level of utilization of products

Bee products	Weighted Sum	Weighted Mean	Remark	Rank
Bee wax	515	2.4	Occasionally utilized	2nd
Propolis	254	1.2	Never utilized	3rd
Bee venom	258	1.2	Never utilized	3rd
Honey	636	3.0	Always utilized	1st
Royal jerry	212	1.0	Never utilized	5th
Bee pollen	212	1.0	Never utilized	5th

Source: Field Survey, 2022

4.4 Factors influencing adoption of improved beekeeping technologies

The factors influencing adoption of improved beekeeping technologies was achieved using the covariates affecting each of the technology under consideration and was presented in Table 4.14. The significant of the chi-square across all the technologies indicate the good fit of the model in predicting the covariates.

4.4.1 Bee suit

The result of Cox proportional hazard presented in Table 4.14 reveals that a unit increase in extension contact associated with 1.75 hazard ratio which is statistically significant at 0.05 probability level indicate 75% increase in the hazard rate. This shows that increasing extension contact will result in a 75% increase in bee suit adoption. This is has the expected *a priori*, because extension agent is expected to create awareness about new innovations which is expected to enhance adoption of such innovation. This agrees with Amanuel (2018) who reported that farmers who have access to extension services are more likely to embrace improved agricultural technologies.

4.4.2 Baiting

The result of Cox proportional hazard presented in Table 4.14 reveals that a unit increase in beekeeping experience associated with 0.87 hazard ratio which is statistically significant at 0.01 probability level indicate 13% decrease in the hazard rate. This shows that beekeeping experience will result in a 13% decline in baiting adoption. This is against the *a priori* expectation, because increase in beekeeping experiences is expected to enhance adoption of innovation. This contradicts Muya's (2014) findings, which suggested that experienced farmers were more willing to try new and difficult agricultural technologies. This finding could be explained by the fact that most beekeepers in the study areas went into beekeeping as secondary occupation, thus their long duration in the business does not commensurate with improvement in beekeeping practices.

The result of level of involvement depicts that a unit increase in level of involvement of beekeepers associated with 1.35 hazard ratio which is statistically significant at 0.10 probability will leads to 35% increase in hazard rate. This is expected *a priori*. this is because increase in involvement of beekeepers in beekeeping will necessitate them to seek for various means of improving their productivity.

The covariate for membership of cooperative depicts that a unit increase in membership of cooperative associated with 1.12 will lead to 12% increase in the hazard rate. This suggests that increase in membership of cooperative will leads to increase in the adoption rate of baiting. This is the *a priori* expectation and it is similar to the study of Ogunbameru *et al.* (2008), who argued that participation in cooperative have the potential of creating confidence between farmers and financial institutions thus allowing farmers to have access to farm credit from such institutions using their collective grains in a community warehouse as collateral. The reason for this finding could be attributed to high level of beekeeping cooperative in the study areas, the prevalent of social media which pave ways for easy communication among keepers.

The covariate for beekeeping workshop shows that a unit increase in beekeeping workshop associated with 1.74 will lead to 74% increase in the hazard rate. This suggests that increase in attendance of beekeeping workshops will leads to increase in the adoption rate of baiting. This is the *a priori* expectation and it is in agreement with the study of Workney (2011), who opined that training may have instilled technical competency, increased exposure to the subject matter, and persuaded farmers to use improved technology in their farms. In the study areas, beekeepers cluster executive members often look out for available beekeeping workshop for her members. From their responsible most of the training receive on the export of bee products and wax processing.

4.4.3 Kenya top bars

The result of Cox proportional hazard presented in Table 4.14 portray that a unit increase in household size associated with 0.79 hazard ratio which is statistically significant at 0.01 probability level indicate 21% decrease in the hazard rate. This implies that increase in household size will leads to decrease in the adoption rate of Kenya top bars. This disagrees with the studies of Workneh (2011) and Bunde and Kibet (2015), who opined that family size has positive influence on adoption of modern technologies. The reason for this result could be attributed to the fact meeting physiological and other needs of the family may likely reduce the amount resources available to adopt the technology.

The covariate for membership of cooperative presented in Table 4.14 shows that a unit increase in membership of cooperative associated with 1.51 will lead to 51% increase in the hazard rate. This depict that increase in membership of cooperative will leads to increase in the adoption rate of Kenya top bars. This has the *a priori* expectation and it is similar to the study of Ogunbameru *et al.* (2008), who argued that participation in cooperative have the potential of creating confidence between farmers and financial institutions thus allowing farmers to have access to farm credit from such institutions using their collective grains in a community warehouse as collateral. The reason for this finding could be attributed to high level of beekeeping cooperative in the study areas.

4.4.4 Water provision

The covariates for beekeeping experience shows that a unit increases in beekeeping experience associated with 0.87 hazard ratio which is statistically significant at 0.01 probability level indicate 13% decrease in the hazard rate. This shows that increase in beekeeping experience will result in a 13% decline in water provision. This is against the *a priori* expectation, because increase in beekeeping experiences is expected to enhance adoption of innovation. This contradict the findings Muya's (2014), who posits that experienced farmers were more willing to try new and difficult agricultural technologies. This finding could be explained by the fact that most bee farmers in the study areas went into beekeeping as secondary occupation, thus their long duration in the business does not commensurate with improvement in beekeeping practices.

The covariates for membership of cooperatives depicts that a unit increase in membership of cooperative associated with 3.51 will lead to 200% increase in the hazard rate. This suggests that increase in membership of cooperative will leads to increase in the adoption rate of water provision. This has the expected *a priori* and it is similar to the study of Ogunbameru *et al.* (2008), who argued that participation in cooperative have the potential of creating confidence between farmers and financial institutions thus allowing farmers to have access to farm credit from such institutions using their collective grains in a community warehouse as collateral. The reason for this finding could be attributed to high level of beekeeping cooperative in the study areas, the prevalent of social media which pave ways for easy communication among keepers.

The covariates for age depicts that a unit increase in age of beekeepers associated with 0.02 hazard ratio which is statistically significant at 0.01 probability level indicate 99% decrease in the hazard rate. This shows that increase in beekeepers age will result in 99% decline in water provision. This is similar to the study of Blanca *et al*. (2018), who opined that experienced young farmers with a small household size and positive attitudes toward innovation adopt innovations faster than older farmers. Also, Muya (2014) added that when beekeepers' ages increased, the adoption index declined. This is because older farmers tend to be more conservative and less mobile compared to young, energetic and cosmopolite youth.

4.4.5 Hives inspection

The result of Cox proportional hazard presented in Table 4.14 depict that a unit increase in household size associated with 0.60 hazard ratio which is statistically significant at 0.05 probability level indicate 40% decrease in the hazard rate. This suggests that increase in household size will leads to decrease in the adoption rate of hives inspection. This disagrees with the studies of Workneh (2011) and Bunde and Kibet (2015), who opined that family size has positive influence on adoption of modern technologies. The reason for this result could be attributed to the fact meeting physiological and other needs of the family may likely reduce the amount resources available to adopt the technology.

4.4.6 Swarm and queen catcher

The covariates for membership of cooperatives depicts that a unit increase in membership of cooperative associated with 1.18 will lead to 18% increase in the hazard rate. This suggests that increase in membership of cooperative will leads to increase in the adoption rate of swarm and queen catcher. This has the expected *a priori* and it is similar to the study of Ogunbameru *et al.* (2008), who argued that participation in cooperative have the potential of creating confidence between farmers and financial institutions thus allowing farmers to have access to farm credit from such institutions using their collective grains in a community warehouse as collateral. The reason for this finding could be attributed to high level of beekeeping cooperative in the study areas, the prevalent of social media which pave ways for easy communication among keepers.

Table 4.14: Cox proportional hazard regression for bee technology

Covariates	Bee suit	Baiting	Kenya top bar	Water provision	Hives inspection	Swarm and queen catcher
Marital status	1.5997 (1.14)	1.3123	1.6204	2.3856	.5916	.7305
		(0.63)	(0.02)	(1.28)	(-0.95)	(0.35)
Level of education	.9547	.9549	1.033	1.0138	1.0361	1.0610
	(-1.20)	(-1.18)	(0.79)	(0.33)	(0.11)	(0.99)
Beekeeping experience	1.1469	.8666***	.9783	.8716***	.6811	1.3947
	(0.51)	(-5.33)	(-0.69)	(-4.64)	(-1.25)	(0.59)
Household size	.9499	.9794	. 7903*	2.0021	.6052**	.8622
	(-0.51)	(-0.12)	(-1.99)	(1.69)	(-2.18)	(-1.19)
Level of involvement	.7995	1.3458*	2.6495	1.3584	1.7403	.4732
	(-0.46)	(1.90)	(1.58)	(0.43)	(0.89)	(-0.27)
Extension contact	.7515**	.8034	.5082**	.9732	.9743	.5669
	(-2.32)	(-0.96)	(-2.39)	(-0.12)	(-0.10)	(-0.60)
Membership of cooperative	1.1838	1.1219***	1.0664 (0.19)	3.5163****	1.7738	1.1877***
	(0.59)	(3.87)		(2.92)	(1.62)	(3.15)
Beekeeping workshop	.8065	1.7458***	.7666	.7952	.9952	1.0465
	(0.12)	(2.83)	(-1.26)	(-0.18)	(-0.23)	(0.16)
Types of baiting	1.0067	.8280	1.1145	1.1267	.8826	.6527**
	(0.07)	(-0.59)	(0.80)	(1.06)	(-0.64)	(-1.17)
Types of bee hives	.8302	1.4397	1.0397	1.2809	1.0410	2.5645
	(-1.29)	(1.24	(0.52)	(1.57)	(0.18)	(1.64)
Area devoted beekeeping	1.0353	1.310	.7428	1.0108	.6926	1.4673
	(0.18)	(1.19)	(-1.28)	(0.05)	(-1.37)	(1.05)
Age	1.0006	1.0164	.9846	.0163***	.9973	1.0161
	(0.05)	(1.14)	(-0.97)	(-2.88)	(-0.17)	(0.81)
LR chi2	15.54	66.03	57.60	73.87	17.88	30.12
Prob> chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Source: Field Survey, 2022

Note: figures outside the parenthesis are hazard ratios, Figures inside the parenthesis are the z-values, ***=significant at 0.01 probability level, **= significant at 0.05 probability level, *= significant at 0.10 probability level

4.5 Challenges Associated with Adoption of Modern Beekeeping Technologies in the Study Area

The results in Table 4.15 shows the most pressing challenges faced by beekeepers in the study areas. From the Table, Indiscriminate bush burning (97.2%), theft (91.5%) and inadequate beekeeping skills (76.9%) were the major constraints associated with beekeeping in the study area. This was followed by high cost of beekeeping materials (72.2%), absconding of bees (65.6%), fear of sting (62.7%) and indiscriminate application of agro-chemicals (58.0). The result in Table 4.14 reveals that indiscriminate bush burning was ranked first as the most important constraints bedeviling bee production in the study areas. This is similar to the study of Ezihe *et al*. (2020) who found that bush burning in Markudi, Benue State, destabilizes the natural ecosystem and causes asset loss. Labe (2017) added that bush burning of the major challenges of beekeeping in Nigeria. Bush burning entails setting fire on dry leaves. Most small scale farmers clear their farm land using controlled bush burning.

Furthermore, the result revealed that at the onset of dry season youth in the study areas participate in animal hunting and set fire to dry vegetation indiscriminately in order to gain a clear view of the animals they want to hunt. More so, Fulani herdsmen, in their quest for fresh grasses for their cattle as the dry season approaches, set fire to dry leaves, allowing new ones to develop. Because of the smoke and intensity of the heat, most hives located inside orchards got destroyed, and there is huge absconding of bees from other hives. This poses a great setback in beekeeping in the study areas.

In the study areas, theft was ranked third major constraints associated with beekeeping in the study area.. This is in line with the findings of the Bunde and Kibet (2013) who reported that the greatest problems to beekeeping were beekeepers' refusal to adopt new innovation, as well as a lack of security for bee colonies against theft and bush burning. According to the findings, hive theft is highly common, especially during the harvesting season. Only cotton wool is needed to cover the small openings in hives (Kenya top bars and Langstroth) and relocate them to any location, according to the study. The majority of the stealing is done by Fulani herdsmen while they are grazing. Due to the fact that most of the beekeepers are civil servants and thus do not visit their apiary very often, the hives are more vulnerable to theft.

Inadequate beekeeping skills was ranked fourth challenges associated with beekeeping in the study area. Despite beekeepers in the studied areas having a high level of education, beekeeping experience, cooperative participation, and attendance at various beekeeping seminars, technologies requiring skillfulness (Hygrometer, queen breading, pollen collecting, laboratory activities) had low adoption rate. This may be due to the fact that most beekeepers in the study areas regarded beekeeping as a secondary occupation pursued primarily for the sake of honey. The finding also reveals that the majority of the workshops attended by beekeepers are focused on bee product export (example, Nigeria Export Promotion Council 2019 held in Markudi). This has had a significant impact on the adoption of modern beekeeping in the research areas.

High cost of beekeeping materials was ranked fifth challenges faced by beekeepers in the research locations. Most of the new technologies like honey extractor and laboratory activities is capital intensive, thus their adoption is limited. Bee absconding is another issue that the study identified as a barrier to beekeeping in the study areas. This is comparable to the findings of Malede *et al*. (2015), who discovered that one of the obstacles of beekeeping in Gondar is bee absconding. Bees are sociable insects who like calm, even minor disruptions in their hive activities might cause them to flee, a phenomenon known as absconding. The study discovered that noise from agricultural machinery, indiscriminate use of agro-chemicals, bush burning, and overpopulation of colony is among the threats that contributed to bee absconding in the studied areas.

The fear of bee sting technically was identified as the sixth challenges of beekeeping in the study areas. This is similar to the study of Renaud *et al.* (2018) who opined that fear of bee sting is one of the constraints of beekeeping adoption in Kenya. Many people might have experienced bee sting or had relatives or friends stung by bee. The sting is highly painful and causes swelling that last for several days, so it's natural for people to acquire a phobia of bees. People are unaware that bees attack self-defense of their hive, or when mistakenly squashed, and an occasional bee in a field presents no danger. The fear of bees has an impact on people's views toward beekeeping. Many beekeepers believe that the low rate of beekeeping adoption is due to the popular misconception that bees are dangerous. A number of beekeepers opined that were afraid of bees when they first started beekeeping, but eventually understand that bees do not sting unless they are disturbed.

More so, another identified limitation to beekeeping in the study area was indiscriminate application of agrochemicals which was ranked seventh. This is in line with Labe's (2017) results, who opined that pesticide and insecticide use pose serious obstacles to beekeeping in Nigeria. Farmers have traditionally used synthetic agro-chemicals to control insect pests and diseases on their farms, which are extremely efficient in most pest and disease management circumstances. The use of such agrochemicals endangers the natural ecosystem, as well as a drop in bee nectar gathering activities, which reduces bee production dramatically.

Table 4.15: Distribution of respondent according to challenges faced in beekeeping

Variable	***Frequency**	**Percentage**	**Rank**
Indiscriminate bush burning	206	97.2	1st
Theft	194	91.5	2nd
Inadequate beekeeping skills	163	76.9	3rd
Inadequate credit facilities	159	75.0	4th
High cost beekeeping materials	153	72.2	5th
Absconding of bees	139	65.6	6th
Fear of sting	133	62.7	7th
Indiscriminate application of agro-chemicals	123	58.0	8th
Labour shortage	87	41.0	9th
Inadequate storage facilities	84	39.6	10th
Inadequate beekeeping materials	71	33.5	11th
Pest and diseases	70	33.0	12th
Low quality beekeeping materials	61	28.8	13th
Drought	35	16.5	14th

Source: Field Survey, 2022 * Multiple responses recorded

4.6 Hypothesis Testing

The hypothesis, which stated that selected socio-economic characteristics (age, marital status, household size, education, area devoted to beekeeping, and beekeeping experience) have no significant influence on the adoption of modern beekeeping, was tested using the z-value from cox proportional hazard regression. However, as revealed in Table 4.16, age (1.006), marital status (1.5997), household size (0.9499), education (.9547), area devoted to beekeeping (1.0353), and beekeeping experience (1.1467) have no significant influence on the adoption of bee suits. Therefore, the hypothesis is not rejected. Also, only beekeeping experience (-5.33) was statistically significant at the 0.01 probability level. This implies that beekeeping experience has a significant influence on the adoption of baiting, while others (age, marital status, household size, education, and area devoted to beekeeping) do not have a significant influence on baiting adoption. As regards Kenya top bars, household size (-1.99) was statistically significant. Thus, it can be said to have had a significant influence on the adoption of Kenya top bars. In addition, age (-2.88) and beekeeping experience (-4.64) were statistically significant, therefore influencing the adoption of water provision. Household size (-2.18) statistically influences hive inspection, whereas none of the selected socioeconomic variables influences swarm catcher adoption. The implication is that some of the selected socio-economic variables play significant roles in determining the adoption of some of the adopted technologies.

Table 4.16: Cox proportional estimates of hypothesis

Variables	Bee suit	Baiting	Ken ya top bar	Water provision	Hives inspection	Swarm and queen catcher
Age	1.0006 (0.05) Do not reject H_O	1.0164 (1.14) Do not reject H_O	.9846 (-0.97) Do not reject H_O	.0163*** (-2.88) Reject H_O	.9973 (-0.17) Do not reject H_O	1.0161 (0.81) Do not reject H_O
Marital status	1.5997 (1.14) Do not reject H_O	1.3123 (0.63) Do not reject H_O	1.6204 (0.02) Do not reject H_O	2.3856 (1.28) Do not reject H_O	.5916 (-0.95) Do not reject H_O	.7305 (0.35) Do not reject H_O
Household size	.9499 (-0.51) Do not reject H_O	.9794 (-0.12) Do not reject H_O	. 7903* (-1.99) Reject H_O	2.0021 (1.69) Do not reject H_O	.6052 (-2.18)** Reject H_O	.8622 (-1.19) Do not reject H_O
Education	.9547 (-1.20) Do not reject H_O	.9549 (-1.18) Do not reject H_O	1.033 (0.79) Do not reject H_O	1.0138 (0.33) Do not reject H_O	1.0361 (0.11) Do not reject H_O	1.0610 (0.99) Do not reject H_O
Area devoted for beekeeping	1.0353 (0.18) Do not reject H_O	1.310 (1.19) Do not reject H_O	.7428 (-1.28) Do not reject H_O	1.0108 (0.05) Do not reject H_O	.6926 (-1.37) Do not reject H_O	1.4673 (1.05) Do not reject H_O
Beekeeping experience	1.1469 (0.51) Do not reject H_O	.8666*** (-5.33) Reject H_O	.9783 (-0.69) Do not reject H_O	.8716*** (-4.64) Reject H_O	.6811 (-1.25) Do not reject H_O	1.3947 (0.59) Do not reject H_O

Source: Field Survey, 2022

Note: Figures outside the parenthesis are hazard ratios, Figures inside the parenthesis are the z-values

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the findings of the study, it was concluded that bee farmers were gradually out of their active productive age, married with large family size as well as high level of education and experienced in beekeepers. Social media, family and friends, radio, and beekeepers groups were the major sources of information across the study areas. It was also concluded that bee suits, baiting, and Kenya top bars had higher adoption rate with average bee farmers reaching the decision within the first-three years of beekeeping practices. Whereas water provision, hive inspection, and swarm catcher had a moderate adoption rate with average respondents reaching the decision within first five years. Honey is most utilized bee product; wax was occasionally utilized while propolis, bee venom, bee pollen and royal jelly were never utilized in the study areas.

The factors influenced adoption of improved beekeeping technologies indicated that extension contact had direct relationship with bee suit and water provision adoption. Membership of cooperative and beekeeping workshop had direct influence on baiting adoption. Household size and extension contact had inverse relationship with adoption of Kenya top bars. More so, indiscriminate bush burning and theft, lack of beekeeping skills were ranked as the topmost challenges faced by beekeepers in the study area.

5.2 Recommendations

From the findings of the study, the following recommendations were drawn:

1. The study recommended that policymakers, community based beekeepers association and other relevant stakeholders should promote beekeeping in the study area through sensitization programs, workshop and establishment of training centres as their level of participation in beekeeping was low in the study areas.
2. Effective and efficient utilization of bee products will improve the livelihood status of beekeepers. As a result, it was recommended that State Ministry of Agriculture, Governmental and Non-Governmental Organizations as well as other relevant stakeholders and beekeeping cooperatives should organize workshop and training for beekeepers in the study areas in order to facilitate high utilization of other bee product, as beekeepers in the study area had low utilization of bee products.
3. Indiscriminate bush burning was identified to be the major constraint faced by keepers in the study areas, it was therefore recommended that beekeepers should fire trace round their farm during the onset of dry season to avoid incessant bush burning. Also, effort should be geared toward providing extension services to beekeepers.
4. Radio was one of the major sources of information to beekeepers in the study area. Therefore, it was recommended that radio station should develop and air educational programs on improved beekeeping technology, in local languages, that can be understood by small scale bee farmers. Also, establish a call-in program where farmers can ask questions and receive information on improved beekeeping technology.

5. More so, the study recommends that beekeepers and other farmers within the study areas be sensitized by extension agents on the importance of beekeeping both as an agent of pollination and a source of income as well as discouraging their belief in proscribing bees as dangerous insects.

Contributions to Knowledge

1. The study contributed to the body of knowledge highlighting the importance of sustainable land management and ineffective use of pesticides in areas where beekeeping is prevalent.
2. Research on the level of utilization of bee products also contributed to the frontier of knowledge through identifying the extent of utilization of bee products
3. The adoption of modern beekeeping technologies can also contribute to the body of knowledge about the cultural and traditional aspect of beekeeping. This includes understanding beekeepers willingness to adopt new technologies, their perception on the benefits and drawbacks of these technologies, and any cultural or traditional barriers to adoption.

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APPENDIX I

DEPARTMENT OF AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT,
SCHOOL OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY,
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA,
NIGER STATE, NIGERIA

RESEARCH QUESTIONNAIRE

Dear respondent,
I am a Postgraduate student of the above stated Department and University. I am conducting a research to determine **"assessment of adoption of modern beekeeping technologies among rural households in selected local government areas of Benue state, Nigeria"**. This questionnaire aims at gathering relevant information that would assist the researcher to effectively carry out the study. All the information supplied here shall be solely for research purposes and will be treated as confidential. You are therefore required to fill in the answers to the following questions and mark or tick as appropriate.

Yours Faithfully,

ABDULLAHI, Bashiru
(Mtech/SAAT/2019/9335)

SECTION A: SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENT

1. Age……………………………………..…………………………...years
2. Marital Status: (a) Single [ ] (b) Married [ ] (c) Divorced [ ] (d) Widowed [ ]
3. Number of household members……………………………………….……………
4. What is your level of formal education?
(a) Primary [ ] (b) Secondary [ ] (c) Tertiary [ ] (d) Non-formal [ ] (e) Others (Specify)..…
5. For how long have you been into beekeeping? ……………
6. What is your level of involvement in beekeeping? (a)Full Time [ ] (b) Part Time [ ]
7. What is your primary occupation?
(a)Farming [ ] (b)Gathering [ ] (c) Trading [ ] (d) Civil Servant [ ] (e) Artisan [ ] (f) beekeeping [ ] (g) Agro processing [ ] (g) Others (specify)……………………………… ………
8. Do you have contact with extension agent? (a) Yes [ ] (b) No [ ]
9. If yes, indicate frequency of contact with the extension agent(s).
(a) Weekly [ ] (b) Fortnightly [ ] (c) Monthly [ ] (d) Quarterly [ ] (e) Annually [ ]
10. Do you have access to credit facilities? (a) Yes [ ] (b) No [ ]
11. If yes, from which source are you access credit last beekeeping season?
(a) Commercial Bank [ ] (b) Bank of Agric. [ ] (c) Cooperative [ ] (d) Friends/Relatives [ ] (e) Government Programmes [ ] (f) Others (specify)……………………………..…
12. How much did you access as credit from the source in the last beekeeping season? ₦...........................
13. Do you belong to any association or cooperative societies? (a) Yes [ ] (b) No [ ]
14. If yes, how many years have been in cooperative societies?.......................................

15. What is the total area devoted for beekeeping in hectares?..
16. Did you Participate in Nigeria Export Promotion Council bee workshop (NEPC) (2019) (a) Yes [ ] (b) No [ ]
17. If yes what benefit did you attain from the workshop…………………………………….
18. What is the type of bee hives do you use?
(a) Clay pot [ ] (b) Top bar [ ] (c) Langsroth hive [ ] (d) wire hives [ ] (e) log hive [ ] (f) gourd hive [ ] (g) Others (Specify)………
19. Which methods do you use for harvesting honey?...
20. What type of baiting materials do you use? (a) Wax [ ] (b) Syrups [ ] (c) Granulated sugar [ ] (d) Lime [ ] (e) Cow dung [ ] (f) Lemon grass [ ] (g) others specify -------------
21. What is the reason for your choice baiting material? ------------------------------------
22. What are the common bee pests in your area? (a) Ant [ ] (b) Wax moth [ ] (c) Honey badger [ ] (d) birds [ ] (e) lizards [ ] (f) Hive bettle [ ] (g) others specify -------------------
23. How often do you visit your apiary --
24. What do u normally inspect? --------------------------------------
26. Which year did you start bee keeping? ----------------------------
27. Kindly tick appropriately the management practice and technology used for your beekeeping and indicate the year you begin the usage.

Methods	Please tick	Beginning year of usage
supplementary feed		
Pest and disease control		
Baiting		
Hives inspection		
Apiary cleaning		
Queen breeding		
pollen collection		
Record keeping		
Water provision		
bee pollination service		
Kenya top bar		
Langstroth		
bee suit		
Swarm catcher and Queen catcher		
Honey Extractor		
thermometer,		
Hygrometer		
Hives shading		
Engages in laboratory activities (Inoculation, honey and brood sampling)		

SECTION B: LEVEL OF IMPROVED BEEKEEPING TECHNOLOGIES

28. Kindly indicate your level of adoption of the following beekeeping technologies

Methods	High	Moderate	Low
supplementary feed			
Pest and disease control			
Baiting			
Hives inspection			
Apiary cleaning			
Queen breeding			
pollen collection			
Record keeping			
Water provision			
bee pollination service			
Kenya top bar			
Langstroth			
bee suit			
Swarm catcher and Queen catcher			
Honey Extractor			
thermometer,			
Hygrometer			
Hives shading			
Engages in laboratory activities (Inoculation, honey and brood sampling)			

29. Did you discontinue any of the adopted technology?

30. If yes, reason for discontinuation ---

31. Indicate your perception on bee by-products

Perception statement	**Highly aware**	**Aware**	**Not aware**
Bee wax			
Propolis			
Bee venom			
Honey			
Royal jelly			
Bee Pollen			

32. Level of utilization of bee by-products

Perception statement	**Always**	**Occasionally**	**Never**
Bee wax			
Propolis			
Bee venom			
Honey			
Royal jelly			
Bee Pollen			

33. What is your source of information on beekeeping? (a) Family and friends [ ] (b) ADP [ ] (c) Beekeepers group [ ] (d) Radio [ ] (e) Television [ ] (f) Newspaper [ ] (g) Extension agent [ ] (h) Social media [ ] (i) Others (specify)…………………………

34. Please tick as appropriate on the frequency of information on improved beekeeping

Perception statement	**Always**	**Occasionally**	**Never**
Family and friends			
ADP			
Beekeepers group			
Radio			
Television			
Newspaper			
Extension agent			
Social media			

35. Tick appropriate on the challenges faced in beekeeping

Challenges	**Yes**	**No**
Fear of sting		
Pest and diseases		
Lack of beekeeping materials		
High cost of beekeeping material		
Lack of credit facilities		
Lack of beekeeping skills		
Absconding of bees		
Indiscriminate application of agro-chemicals		
Labour shortage		
Low quality beekeeping materials		
Theft		
Lack of storage facilities		
Indiscriminate bush burning		
Drought		
Others specify		

Thanks

APPENDIX II

```
GET DATA /TYPE=XLSX
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  /SHEET=name 'Socio economics'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32.
EXECUTE.
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    maritalstatussingle1married2divorce3widowed4
Householdrange3andbelow1472811312andabove4
educationprimary1secondary2tertiary3nonformal4others5Beekeepingexperience
    levelofinvolvemntinbeekeppingfulltime1parttime0
    occupationfarming1gathering2trading3civilservant4artisan5beekeep
contactwithextensionagentyes1no0
    frequenceyofcontactweekly1fortnightly2monthly3quarterly4annually
accesstocreditfacilitiesyes1no2
    sourceofaccesstocreditcommercialbank1bankofagric2cooperative3fri
memberofcoperativesocietiesyes1no0
yearsofmembershipareaoflandforbeekeepinginhectareBeekeepingworkshop
    benefitattianedfromNEPCwaxprocessing1broadeningofbeekeepingknowl
    typeofbeehivesuseclaypot1topbar2longsrothhive3wirehives4loghives
methodofharvestingsmokimg1fire2
    typeofbaitingmaterialwax1syrups2granulatedsugar3lime4cowdung5lem
    reasonforchoiceofbaitingmaterialeffectiveness1easilyaccessablequ antyes1no0
waxmothyes1no0
    honeybadgaryes1no0 birdyes1no0 lizardsyes1no0 hivebeetlesyes1no0
    howoftendoyouvisityourapiaryweeksMonthly2every2wks3
whatdoyounormallyinspecttopbar1colonizationofhives2honey3insect4amountN
  /STATISTICS=STDDEV SEMEAN MEAN MEDIAN SUM
  /ORDER=ANALYSIS.
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Frequencies

Notes

Output Created		11-FEB-2022 18:55:09
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	N of Rows in Working Data File	212
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.

Cases Used	Statistics are based on all cases with valid data.

Syntax	FREQUENCIES VARIABLES=Agerange30andbelow1314024150351604 61andabove5 maritalstatussingle1married2divorce3widowed4 Householdrange3andbelow1472811312andabove4 educationprimary1secondary2tertiary3nonformal4others5 Beekeepingexperience levelofinvolvemntinbeekeppingfulltime1parttime0 occupationfarming1gathering2trading3civilservant4artisan5beekeep contactwithextensionagentyes1no0 frequenceyofcontactweekly1fortnightly2monthly3quarterly4annually accesstocreditfacilitiesyes1no2 sourceofaccesstocreditcommercialbank1bankofagric2cooperative3fri memberofcoperativesocietiesyes1no0 yearsofmembershipareaoflandforbeekeepinginhectareBeekeepingworkshop benefitattianedfromNEPCwaxprocessing1broadeningofbeekeepingknowl typeofbeehivesuseclaypot1topbar2longsrothhive3wirehives4loghives methodofharvestingsmokimg1fire2 typeofbaitingmaterialwax1syrups2granulatedsugar3lime4cowdung5lem reasonforchoiceofbaitingmaterialeffectiveness1easilyaccessablequantyes1no0 waxmothyes1no0 honeybadgaryes1no0 birdyes1no0 lizardsyes1no0 hivebeetlesyes1no0

Resources	Processor Time	00:00:00.13
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[DataSet1]

Socioeconomics
Frequency Table

Age range 30 and below =1, 31-40=2, 41 - 50=3, 51 - 60=4, 61 and above 5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	1	.5	.5	.5
	2.0	24	11.3	11.3	11.8
	3.0	103	48.6	48.6	60.4
	4.0	58	27.4	27.4	87.7
	5.0	26	12.3	12.3	100.0
	Total	212	100.0	100.0	

marital status(single=1, married = 2, divorce =3, widowed =4)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	13	6.1	6.1	6.1
	2.0	199	93.9	93.9	100.0
	Total	212	100.0	100.0	

Household range 3 and below = 1, 4 - 7 = 2, 8 - 11 =3, 12 and above 4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	37	17.5	17.5	17.5
	2.0	125	59.0	59.0	76.4
	3.0	42	19.8	19.8	96.2
	4.0	8	3.8	3.8	100.0
	Total	212	100.0	100.0	

education(primary =1, secondary=2, tertiary=3, non-formal=4, others=5)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.0	41	19.3	19.3	19.3
	3.0	168	79.2	79.2	98.6
	4.0	3	1.4	1.4	100.0
	Total	212	100.0	100.0	

Beekeeping experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 ^ 5	63	29.7	29.7	29.7
	11 ^ 15	49	23.1	23.1	52.8
	16 ^ 20	42	19.8	19.8	72.6
	6 ^ 10	58	27.4	27.4	100.0
	Total	212	100.0	100.0	

level of involvemnt in bee kepping (full time=1, part time =0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	205	96.7	96.7	96.7
	1.0	7	3.3	3.3	100.0
	Total	212	100.0	100.0	

occupation(farming=1, gathering=2, trading=3, civil servant =4, artisan=5,beekeeping=6, agro processing=7,student 8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	82	38.7	38.7	38.7
	2.0	3	1.4	1.4	40.1
	4.0	93	43.9	43.9	84.0
	5.0	3	1.4	1.4	85.4
	6.0	27	12.7	12.7	98.1

		Frequency	Percent	Valid Percent	Cumulative Percent
	7.0	3	1.4	1.4	99.5
	8.0	1	.5	.5	100.0
	Total	212	100.0	100.0	

contact with extension agent (yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	134	63.2	63.2	63.2
	1.0	78	36.8	36.8	100.0
	Total	212	100.0	100.0	

frequencey of contact (weekly =1, fortnightly=2, monthly=3, quarterly=4, annually=5)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	130	61.3	61.3	61.3
	1.0	4	1.9	1.9	63.2
	4.0	74	34.9	34.9	98.1
	5.0	4	1.9	1.9	100.0
	Total	212	100.0	100.0	

access to credit facilities (yes =1, no=2)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	212	100.0	100.0	100.0

source of access to credit(commercial bank =1, bank of agric=2, cooperative=3, friends/relatives=4, government programmes=5, others=6)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	212	100.0	100.0	100.0

member of coperative societies(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	36	17.0	17.0	17.0
	1.0	176	83.0	83.0	100.0
	Total	212	100.0	100.0	

years of membership

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 ^ 5	127	59.9	59.9	59.9
	11 ^ 15	5	2.4	2.4	62.3
	16 ^ 20	4	1.9	1.9	64.2
	6 ^ 10	76	35.8	35.8	100.0
	Total	212	100.0	100.0	

area of land for beekeeping in hectare

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0.1 ^ 0.5	82	38.7	38.7	38.7
	0.6 ^ 1.0	92	43.4	43.4	82.1
	1.1 ^ 1.5	32	15.1	15.1	97.2
	1.6 ^ 2.0	6	2.8	2.8	100.0
	Total	212	100.0	100.0	

Beekeeping workshop

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	112	52.8	52.8	52.8
	1.0	100	47.2	47.2	100.0

	Total	212	100.0	100.0	

benefit attianed from NEPC wax processing 1, broadening of beekeeping knowledge 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	95	44.8	44.8	44.8
	1.0	34	16.0	16.0	60.8
	2.0	25	11.8	11.8	72.6
	3.0	58	27.4	27.4	100.0
	Total	212	100.0	100.0	

type of bee hives use(clay pot=1, topbar=2, longsroth hive=3, wire hives=4, log hives=5, gourd hive=6, others=7)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	3	1.4	1.4	1.4
	2.0	193	91.0	91.0	92.5
	3.0	10	4.7	4.7	97.2
	5.0	3	1.4	1.4	98.6
	6.0	3	1.4	1.4	100.0
	Total	212	100.0	100.0	

method of harvesting smokimg 1 fire 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	189	89.2	89.2	89.2
	2.0	23	10.8	10.8	100.0
	Total	212	100.0	100.0	

type of baiting material(wax=1, syrups=2, granulated sugar=3, lime=4,cow dung=5, lemon grass=6, Honey=7)

		Frequency	Percent	Valid Percent	Cumulative Percent

Valid	1.0	182	85.8	85.8	85.8
	2.0	13	6.1	6.1	92.0
	3.0	4	1.9	1.9	93.9
	4.0	4	1.9	1.9	95.8
	6.0	6	2.8	2.8	98.6
	7.0	3	1.4	1.4	100.0
	Total	212	100.0	100.0	

reason for choice of baiting material(effectiveness=1, easily accessable, quick attraction 3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	149	70.3	70.3	70.3
	2.0	57	26.9	26.9	97.2
	3.0	6	2.8	2.8	100.0
	Total	212	100.0	100.0	

ant(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	32	15.1	15.1	15.1
	1.0	180	84.9	84.9	100.0
	Total	212	100.0	100.0	

wax moth (yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	210	99.1	99.1	99.1
	1.0	2	.9	.9	100.0
	Total	212	100.0	100.0	

honey badger (yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	94	44.3	44.3	44.3

		Frequency	Percent	Valid Percent	Cumulative Percent
	1.0	118	55.7	55.7	100.0
	Total	212	100.0	100.0	

bird(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	77	36.3	36.3	36.3
	1.0	135	63.7	63.7	100.0
	Total	212	100.0	100.0	

lizards(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	32	15.1	15.1	15.1
	1.0	177	83.5	83.5	98.6
	11.0	3	1.4	1.4	100.0
	Total	212	100.0	100.0	

hive beetles(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	194	91.5	91.5	91.5
	1.0	18	8.5	8.5	100.0
	Total	212	100.0	100.0	

how often do you visit your apiary(weeks), Monthly 2, every 2wks 3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	152	71.7	71.7	71.7
	2.0	45	21.2	21.2	92.9
	3.0	15	7.1	7.1	100.0
	Total	212	100.0	100.0	

what do you normally inspect (top bar=1), colonization of hives 2, honey 3, insect 4, attacks and condition of hives 5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	58	27.4	27.4	27.4
	2.0	47	22.2	22.2	49.5
	3.0	84	39.6	39.6	89.2
	4.0	16	7.5	7.5	96.7
	5.0	7	3.3	3.3	100.0
	Total	212	100.0	100.0	

amount (N)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	212	100.0	100.0	100.0

Sources of information

family and friend(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	82	38.7	38.7	38.7
	1.0	130	61.3	61.3	100.0
	Total	212	100.0	100.0	

ADP(yes=1, no=0,)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	170	80.2	80.2	80.2
	1.0	42	19.8	19.8	100.0
	Total	212	100.0	100.0	

beekeeper group(yes=1,no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent

Valid	.0	87	41.0	41.0	41.0
	1.0	125	59.0	59.0	100.0
	Total	212	100.0	100.0	

radio(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	83	39.2	39.2	39.2
	1.0	129	60.8	60.8	100.0
	Total	212	100.0	100.0	

television(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	198	93.4	93.4	93.4
	1.0	14	6.6	6.6	100.0
	Total	212	100.0	100.0	

newspaper(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	122	57.5	57.5	57.5
	1.0	90	42.5	42.5	100.0
	Total	212	100.0	100.0	

extension agent(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	209	98.6	98.6	98.6
	1.0	3	1.4	1.4	100.0
	Total	212	100.0	100.0	

social media(yes=1, n0=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	25	11.8	11.8	11.8
	1.0	187	88.2	88.2	100.0
	Total	212	100.0	100.0	

family and friends(always=3, occassionally=2, never=1)

		Frequency	Percent	Valid Percent	Cumulative Percent
valid	1.0	89	42.0	42.0	42.5
	2.0	54	25.5	25.5	67.9
	3.0	68	32.1	32.1	100.0
	Total	212	100.0	100.0	

ADP(always=3, occasionally=2, never=1)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	2	.9	.9	.9
	1.0	177	83.5	83.5	84.4
	2.0	33	15.6	15.6	100.0
	Total	212	100.0	100.0	

Beekeepers group(always=3, occassionally=2, never=1)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	83	39.2	39.2	39.2
	2.0	106	50.0	50.0	89.2
	3.0	16	7.5	7.5	96.7
	33.0	7	3.3	3.3	100.0
	Total	212	100.0	100.0	

radio(always=3, occassionally=2, never=1)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	73	34.4	34.4	34.4
	2.0	42	19.8	19.8	54.2
	3.0	97	45.8	45.8	100.0
	Total	212	100.0	100.0	

Television(always=3, occassionally=2, never=1)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	191	90.1	90.1	90.1
	2.0	13	6.1	6.1	96.2
	3.0	8	3.8	3.8	100.0
	Total	212	100.0	100.0	

Newspaper(always=3, occassionally=2, never=1)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	7	3.3	3.3	3.3
	1.0	121	57.1	57.1	60.4
	2.0	19	9.0	9.0	69.3
	3.0	65	30.7	30.7	100.0
	Total	212	100.0	100.0	

Extension agents(always=3, occassionally =2, never=1)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	7	3.3	3.3	3.3
	1.0	198	93.4	93.4	96.7
	2.0	7	3.3	3.3	100.0
	Total	212	100.0	100.0	

social media(always=3, occassionally=2, never=1)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.0	10	4.7	4.7	4.7
	2.0	66	31.1	31.1	35.8
	3.0	136	64.2	64.2	100.0
	Total	212	100.0	100.0	

Level of adoption

tabulate supplementaryfeedhigh3moderate2l
supplementary feed(high=3, moderate=2, low=1)
Freq. Percent Cum.
1 150 70.75 70.75
2 59 27.83 98.58
3 3 1.42 100.00
Total 212 100.00

tabulate pestanddiseasecontrolhigh3modera

pest and
disease
control
(high=3,
moderate=2,
low=1) Freq. Percent Cum.

1 212 100.00 100.00

Total 212 100.00

. tabulate baitinghigh3moderate2low1

baiting(hig
h=3,
moderate=2,
low=1) Freq. Percent Cum.

1 11 5.19 5.19
2 71 33.49 38.68
3 130 61.32 100.00

Total 212 100.00

. tabulate hiveinspectionhigh3moderate2low1

Hive inspection(high=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	26	12.26	12.26
2	96	45.28	57.55
3	90	42.45	100.00
Total	212	100.00	

. tabulate apiarycleaninghigh3moderate2low1

Apiary cleaning(hi gh=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	108	50.94	50.94
2	37	17.45	68.40
3	67	31.60	100.00
Total	212	100.00	

. tabulate queenbreedinghigh3moderate2low1

Queen breeding(hi gh=3, moderate=2, low=1)	Freq.	Percent	Cum.
0	3	1.42	1.42
1	202	95.28	96.70
3	7	3.30	100.00
Total	212	100.00	

. tabulate pollencollectionhigh3moderate2lo

pollen
collection(

high=3,
moderate=2,
low=1) Freq. Percent Cum.

1	212	100.00	100.00
Total	212	100.00	

. tabulate recordkeepinghigh1moderate2low1

record keeping (high=1, moderate=2, low=1)	Freq.	Percent	Cum.
1	37	17.45	17.45
2	105	49.53	66.98
3	70	33.02	100.00
Total	212	100.00	

. tabulate waterprovisionhigh3moderate2low1

water provision(high=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	7	3.30	3.30
2	103	48.58	51.89
3	102	48.11	100.00
Total	212	100.00	

. tabulate beepollinationservicehigh3modera

bee pollination service(high=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	212	100.00	100.00

Total	212	100.00	

. tabulate kenyatopbarhigh3moderate2low1

Kenya top bar(high=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	6	2.83	2.83
2	60	28.30	31.13
3	146	68.87	100.00
Total	212	100.00	

. tabulate langstrothhigh3moderate2low1

Langstroth(high=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	70	33.02	33.02
2	129	60.85	93.87
3	13	6.13	100.00
Total	212	100.00	

. tabulate beesuithigh3moderate2low1

bee suit(high=3 , moderate=2, low=1)	Freq.	Percent	Cum.
2	59	27.83	27.83
3	153	72.17	100.00
Total	212	100.00	

. tabulate swarmandqueencatcherhigh3moderat

swarm and
queen
catcher(hig
h=3,

moderate=2,
low=1) Freq. Percent Cum.

1	60	28.30	28.30
2	68	32.08	60.38
3	84	39.62	100.00
Total	212	100.00	

. tabulate honeyextractorhigh3moderate2low1

honey extractor(high=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	140	66.04	66.04
2	7	3.30	69.34
3	65	30.66	100.00
Total	212	100.00	

. tabulate thermometerhigh3moderate2low1

thermometer (high=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	212	100.00	100.00
Total	212	100.00	

. tabulate hivesshadinghigh3moderate2low1

hives shading(high=3, moderate=2, low=1)	Freq.	Percent	Cum.
0	1	0.47	0.47
1	138	65.09	65.57
2	9	4.25	69.81
3	64	30.19	100.00

Total 212 100.00

. tabulate laboratoryactivitieshigh3moderat

laboratory activities(high=3, moderate=2, low=1)	Freq.	Percent	Cum.
1	212	100.00	100.00
Total	212	100.00	

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  /CELLRANGE=full
  /READNAMES=on
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lackofbeekeepingskillsyes1no0
abscondingofbeesyes1no0 indiscriminateapplicationofagrochemicalsyes1no0
labourshortageyes1no0 lowqualitybeekeepingmaterialsyes1no0 Theftyes1no0
lackofstoragefacilitiesyes1no0 bushburningyes1no0
    droughtyes1no0
  /STATISTICS=STDDEV SEMEAN MEAN MODE SUM
  /ORDER=ANALYSIS.
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Frequencies

Notes

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Comments		
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	N of Rows in Working Data File	212

Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=fearofstingyes1no0 pestanddiseasesyes1no0 lackofmaterialyes1no0 highcostofmaterialyes1no2 lackofcreditfacilitiesyes1no0 lackofbeekeepingskillsyes1no0 abscondingofbeesyes1no0 indiscriminateapplicationofagrochemicalsyes1no0 labourshortageyes1no0 lowqualitybeekeepingmaterialsyes1no0 Theftyes1no0 lackofstoragefacilitiesyes1no0 bushburningyes1no0 droughtyes1no0 /STATISTICS=STDDEV SEMEAN MEAN MODE SUM /ORDER=ANALYSIS.
Resources	Processor Time	00:00:00.03
	Elapsed Time	00:00:00.06

[DataSet2]
Factors Affecting
Hives inspection

Cox regression -- Breslow method for ties

No. of subjects = 169 Number of obs = 169

No. of failures = 169

Time at risk = 965

LR chi2(16) = 17.88

Log likelihood = -716.5961 Prob> chi2 = 0.3309

_t	Haz. Ratio	Std. Err.	z	P>|z|	[95% Conf. Interval]	
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areaofland~e	.6926005	.1860117	-1.37	0.171	.4091434	1.172438
typeofbeeh~2	1.041069	.2308454	0.18	0.856	.6741169	1.60777
noofbaitin~l	1.006963	.087861	0.08	0.937	.8486782	1.194768
typeofbait~2	.882636	.1728746	-0.64	0.524	.6012621	1.295685
beekeeping~p	.6811501	.2094648	-1.25	0.212	.3728073	1.244518
yearsofmem~p	1.00285	.0437002	0.07	0.948	.9207551	1.092265
memberofc~1n	1.773848	.626753	1.62	0.105	.8874863	3.545448
contactwit~0	.9743894	.2519452	-0.10	0.920	.5870022	1.61743
levelofinv~l	1.740347	1.087005	0.89	0.375	.511662	5.91955
ho~147281131	2.605226	1.14351	2.18	0.029	1.102118	6.158327
households~e	.7848551	.0987092	-1.93	0.054	.6133891	1.004253
beekeeping~e	.9924464	.0319396	-0.24	0.814	.9317793	1.057063
educationp~i	1.036176	.3302076	0.11	0.911	.5548472	1.935056
educationi~s	1.0564	.0445184	1.30	0.193	.9726522	1.14736
maritalsta~o	.5916609	.3261604	-0.95	0.341	.2008341	1.743044

Cox regression -- Breslow method for ties recordkeeping

No. of subjects = 166 Number of obs = 166

No. of failures = 166

Time at risk = 952

LR chi2(16) = 67.18

Log likelihood = -676.67811 Prob> chi2 = 0.0000

_t	Haz. Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
maritalsta~o	2.039319	1.353935	1.07	0.283	.5550848	7.492225
educationp~i	1.287824	.4910271	0.66	0.507	.6099678	2.718982
beekeeping~e	.8299759	.0337997	-4.58	0.000	.7663044	.8989377
households~e	.8971538	.1561355	-0.62	0.533	.6378649	1.261842
levelofinv~l	2.208759	1.44687	1.21	0.226	.6117306	7.975105
contactwit~0	1.051997	.3355255	0.16	0.874	.5630296	1.965613
memberofc~1n	.7706446	.3360475	-0.60	0.550	.3278528	1.811463
beekeeping~p	.8595579	.1977291	-0.66	0.511	.5476061	1.349218
typeofbait~2	.9963026	.1856879	-0.02	0.984	.6914278	1.435607
noofbaitin~l	1.157138	.1035599	1.63	0.103	.9709694	1.379002
typeofbeeh~2	.9081068	.4981061	-0.18	0.861	.309916	2.660908
areaofland~e	.8566944	.2571718	-0.52	0.606	.475667	1.542939
age	1.025952	.0205517	1.28	0.201	.9864516	1.067034

Cox regression -- Breslow method for ties water provision

No. of subjects = 189 Number of obs = 189

No. of failures = 189

Time at risk = 1114

LR chi2(16) = 73.87

Log likelihood = -789.64871 Prob> chi2 = 0.0000

_t Haz. Ratio Std. Err. z P>z [95% Conf. Interval]

maritalsta~o	2.385625	1.16598	1.78	0.075	.9153254	6.217687
educationi~s	1.013873	.0424867	0.33	0.742	.9339288	1.100661
educationp~i	.9400417	.2657046	-0.22	0.827	.5401985	1.63584
beekeeping~e	.8716768	.0258089	-4.64	0.000	.8225321	.9237578
households~e	.7456997	.087715	-2.49	0.013	.59216	.9390505
ho~147281131	2.002187	.8244378	1.69	0.092	.8933189	4.487482
levelofinv~l	1.358496	.9764184	0.43	0.670	.3320912	5.55724
contactwit~0	.9732289	.2183082	-0.12	0.904	.6270168	1.510605
memberofc~1n	3.516358	1.515401	2.92	0.004	1.510989	8.183233
yearsofmem~p	.982691	.0308895	-0.56	0.579	.9239758	1.045137
beekeeping~p	.7952221	.1681759	-1.08	0.279	.5253804	1.203658
typeofbait~2	1.126768	.1272315	1.06	0.291	.9030658	1.405885
noofbaitin~l	1.152956	.0913411	1.80	0.072	.9871376	1.346629
typeofbeeh~2	1.280994	.2018003	1.57	0.116	.9407056	1.744377
areaofland~e	1.010832	.2219396	0.05	0.961	.6573374	1.554426
age	1.046166	.016381	2.88	0.004	1.014547	1.07877

Cox regression -- Breslow method for ties Kenyatopbars

No. of subjects = 199 Number of obs = 199

No. of failures = 199

Time at risk = 944

LR chi2(16) = 57.60

Log likelihood = -857.21003 Prob> chi2 = 0.0000

_t	Haz. Ratio	Std. Err.	z	P>|z|	[95% Conf. Interval]	
maritalsta~o	1.620498	.7651622	1.02	0.307	.6422889	4.088523
educationi~s	1.033373	.043041	0.79	0.431	.9523657	1.121271
educationp~i	1.076391	.3273005	0.24	0.809	.5931214	1.953425
beekeeping~e	.9783868	.0308785	-0.69	0.489	.9196999	1.040819
households~e	.7903549	.097119	-1.91	0.056	.6211926	1.005583
ho~147281131	1.672831	.7083425	1.22	0.224	.7294911	3.83605
levelofinv~l	2.649504	1.629254	1.58	0.113	.7938472	8.842847
contactwit~0	.5082347	.1437276	-2.39	0.017	.2919756	.8846716
memberofc~1n	1.06646	.3606081	0.19	0.849	.5496962	2.069027
yearsofmem~p	1.067388	.0437347	1.59	0.111	.9850213	1.156643
beekeeping~p	.7666569	.1616035	-1.26	0.207	.5071967	1.158846
typeofbait~2	1.114525	.1510832	0.80	0.424	.8544811	1.453709
noofbaitin~l	1.039739	.0779873	0.52	0.603	.8975913	1.204398
typeofbeeh~2	.8614535	.1281373	-1.00	0.316	.6436051	1.15304
areaofland~e	.7428495	.1727314	-1.28	0.201	.4709501	1.171728
age	.9846245	.0157663	-0.97	0.333	.9542029	1.016016

Cox regression -- Breslow method for ties baiting

No. of subjects = 208 Number of obs = 208

No. of failures = 208

Time at risk = 675

LR chi2(16) = 66.03

Log likelihood = -918.09375 Prob> chi2 = 0.0000

_t	Haz. Ratio	Std. Err.	z	P>|z|	[95% Conf. Interval]	
maritalsta~o	1.312327	.5690481	0.63	0.531	.5609785	3.069998
educationi~s	.9549388	.0374649	-1.18	0.240	.8842612	1.031265
educationp~i	1.061507	.2885141	0.22	0.826	.6231162	1.808326
beekeeping~e	.8666724	.0232798	-5.33	0.000	.8222252	.9135224
households~e	.9794908	.0964456	-0.21	0.833	.8075823	1.187993
ho~147281131	.6871648	.2307587	-1.12	0.264	.3558087	1.327105
levelofinv~l	.3458204	.1935877	-1.90	0.058	.1154394	1.035969
contactwit~0	.803478	.1830258	-0.96	0.337	.5141349	1.255656
memberofc~1n	.7573847	.2001309	-1.05	0.293	.4512274	1.271269
yearsofmem~p	1.121957	.03334	3.87	0.000	1.058478	1.189242
beekeeping~p	1.745826	.3431718	2.83	0.005	1.187634	2.566369
typeofbait~2	.8280315	.0981306	-1.59	0.111	.6564026	1.044536
noofbaitin~l	.9522324	.0733662	-0.64	0.525	.8187679	1.107453
typeofbeeh~2	1.439752	.233996	2.24	0.025	1.046998	1.979837
areaofland~e	1.310134	.2973361	1.19	0.234	.8397205	2.044074
age	1.016442	.0145091	1.14	0.253	.9883983	1.045281

Cox regression -- Breslow method for ties Beesuit

No. of subjects = 209 Number of obs = 209

No. of failures = 209

Time at risk = 461

LR chi2(16) = 9.76

Log likelihood = -969.94799 Prob> chi2 = 0.8787

_t	Haz. Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
maritalsta~o	1.599722	.6565582	1.14	0.252	.7156394	3.575978
educationi~s	.9547729	.0367703	-1.20	0.229	.8853572	1.029631
educationp~i	1.146956	.3086117	0.51	0.610	.6768829	1.943478
beekeeping~e	.9875489	.02587	-0.48	0.632	.9381243	1.039577
households~e	.949901	.0963042	-0.51	0.612	.7787187	1.158713
ho~147281131	1.192779	.4186131	0.50	0.615	.5995503	2.372982
levelofinv~l	.7995256	.3920108	-0.46	0.648	.3058332	2.090163
contactwit~0	.751553	.1623287	-1.32	0.186	.4921616	1.147655
memberofc~1n	1.18383	.3386425	0.59	0.555	.6757677	2.073868
yearsofmem~p	1.025456	.0287685	0.90	0.370	.9705925	1.08342
beekeeping~p	.8065682	.1547022	-1.12	0.262	.5538321	1.174638
typeofbait~2	1.006724	.0901745	0.07	0.940	.8446299	1.199926
noofbaitin~l	.9780228	.0769467	-0.28	0.778	.8382625	1.141085
typeofbeeh~2	.8302712	.1201093	-1.29	0.199	.625292	1.102445
areaofland~e	1.03535	.2039791	0.18	0.860	.7037011	1.523303
age	1.000649	.0140089	0.05	0.963	.9735652	1.028486

Cox regression -- Breslow method for ties swarmcatcher

No. of subjects = 155 Number of obs = 155

No. of failures = 148

Time at risk = 1230

LR chi2(16) = 29.30

Log likelihood = -608.46118 Prob> chi2 = 0.0220

_t | Haz. Ratio Std. Err. z P>|z| [95% Conf. Interval]

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maritalsta~o | .7305145 .6500151 -0.35 0.724 .1277103 4.178609

educationi~s | 1.061095 .0637511 0.99 0.324 .9432216 1.193699

educationp~i | 1.394721 .7799661 0.59 0.552 .4660924 4.17352

beekeeping~e | .9315892 .0415553 -1.59 0.112 .8536012 1.016702

households~e | .8622917 .1070048 -1.19 0.232 .676123 1.099722

ho~147281131 | 1.272181 .5612205 0.55 0.585 .5358493 3.020334

levelofinv~l | .4732017 1.309732 -0.27 0.787 .0020849 107.4015

contactwit~0 | .5669129 .2015113 -1.60 0.110 .2824578 1.137835

memberofc~1n | 1.263301 .4617894 0.64 0.523 .6171018 2.586167

yearsofmem~p | 1.18778 .0648688 3.15 0.002 1.067207 1.321974

beekeeping~p | 1.046501 .2920753 0.16 0.871 .6055805 1.808454

typeofbait~2 | .6527813 .1241779 -2.24 0.025 .4496189 .9477436

noofbaitin~l | .8449616 .0834428 -1.71 0.088 .6962703 1.025406

typeofbeeh~2 | 2.564541 1.473992 1.64 0.101 .8313314 7.911247

areaofland~e | 1.467316 .5356481 1.05 0.294 .7174472 3.00094

age | 1.0161 .0200873 0.81 0.419 .9774826 1.056243

Challenges

Frequency Table

fear of sting(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	79	37.3	37.3	37.3
	1.0	133	62.7	62.7	100.0
	Total	212	100.0	100.0	

pest and diseases(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	142	67.0	67.0	67.0
	1.0	70	33.0	33.0	100.0
	Total	212	100.0	100.0	

lack of material(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	141	66.5	66.5	66.5
	1.0	71	33.5	33.5	100.0
	Total	212	100.0	100.0	

high cost of material(yes=1, no=2)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	59	27.8	27.8	27.8
	1.0	153	72.2	72.2	100.0
	Total	212	100.0	100.0	

lack of credit facilities(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	53	25.0	25.0	25.0
	1.0	159	75.0	75.0	100.0
	Total	212	100.0	100.0	

lack of beekeeping skills(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	49	23.1	23.1	23.1
	1.0	163	76.9	76.9	100.0
	Total	212	100.0	100.0	

absconding of bees(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	73	34.4	34.4	34.4
	1.0	139	65.6	65.6	100.0
	Total	212	100.0	100.0	

indiscriminate application of agrochemicals(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	89	42.0	42.0	42.0
	1.0	123	58.0	58.0	100.0
	Total	212	100.0	100.0	

labour shortage(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	125	59.0	59.0	59.0
	1.0	87	41.0	41.0	100.0
	Total	212	100.0	100.0	

low quality beekeeping materials(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	151	71.2	71.2	71.2
	1.0	61	28.8	28.8	100.0
	Total	212	100.0	100.0	

Theft (yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	18	8.5	8.5	8.5
	1.0	194	91.5	91.5	100.0
	Total	212	100.0	100.0	

lack of storage facilities(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	128	60.4	60.4	60.4
	1.0	84	39.6	39.6	100.0
	Total	212	100.0	100.0	

bush burning(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	6	2.8	2.8	2.8
	1.0	206	97.2	97.2	100.0
	Total	212	100.0	100.0	

drought(yes=1, no=0)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	177	83.5	83.5	83.5
	1.0	35	16.5	16.5	100.0
	Total	212	100.0	100.0	