BEEKEEPERS' PARTICIPATION IN GROUP-BASED FINANCIAL INSTITUTIONS AND ADOPTION OF IMPROVED TECHNOLOGIES IN ARID AND SEMI-ARID LANDS

A Case of Makueni District-KENYA

By

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DECLARATION

I hereby declare that this thesis is my original work and has not been presented for any degree at any other University.

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ABSTRACT

The problem of low agricultural productivity in sub-Saharan Africa is currently one of the fundamental concerns of policy makers. In the Beekeeping sub-sector, the issue of low honey production has engaged policy makers and researchers in strategizing on how to modernize small-scale beekeeping through the introduction of improved technologies. Production under traditional log hive technology over the period has resulted in both low honey output and quality and has not conformed to the dynamic market demands. Studies have been undertaken on technology adoption and some of them consider access to group-based financial institutions as one of the factors that affect adoption decisions in resource constrained areas. However, very little is known about the effect of this access to group-based financial institutions (GBFIs) on the adoption process under different socio-economic conditions.

This study aimed at clarifying various factors that influence the adoption of improved honey production technologies and the role of group-based financial institutions in this process in Makueni district of Kenya's Eastern Province. Following the declining honey production in an area classified as a beekeeping zone, and increasing poverty levels, there was a need to determine participation in group-based financial institutions, ascertain the adoption trend of improved honey production technologies as a result of this participation and to assess the profitability of improved honey production technologies given participation.

The study used both primary and secondary data. Primary data was collected from a total of 130 beekeepers participating and non-participating in group-based financial

institutions in August/September 2005 using a single-visit survey approach. 3 divisions were purposively selected based on the distribution of beehives and membership in group-based financial institutions. 3 locations were selected randomly from these divisions and a stratified sample of beekeepers from beekeeping groups registered with the Ministry of Gender, Culture and Social Services interviewed using a structured questionnaire. Secondary data was collected at the district level.

A combination of analytical techniques was applied, including the χ^2 test, logit regression analysis and profitability analysis. The result of the χ^2 test showed that improved beekeeping technologies were used more by beekeepers participating in group-based financial institutions than those not participating. Logit regression analysis showed that extension service, education, distance to the market and the size of the livestock herd significantly influenced the beekeepers decision to participate in group-based financial institutions. The logit adoption models results further indicated that credit programme access had a significant effect on the beekeepers' decision to adopt a technology. The results found that a 10 percent increase in the absolute value of participation in group-based financial institutions raises the probability of adoption of log hive by 2.8 percent, Kenya Top Bar Hive (KTBH) by 0.31 percent and Langstroth hive by 0.44 percent. There was no significant influence of participation in group-based credit programme on the adoption of Soil block hive. The results of the prediction models showed that the model did well in predicting the choice of participation in group-based financial institutions, log, KTBH and Langstroth hive adoption but its capacity to correctly predict Soil Block hive adoption was limited. Profitability analysis indicated that improved technologies had a high comparative advantage over the traditional technology under participation in group-based financial institution conditions.

The study came up with a number of recommendations towards enhancing participation in group-based financial institutions and adoption of improved beehive technologies. To increase the number of beekeepers participating in group-based financial institutions the study recommended that GBFIs adopt an integrated extension approach and promote literacy trainings for the beekeepers in the short-run. The study further recommended that the government should invest in complimentary services (mainly infrastructure-roads, market services and strengthen free primary education) to improve information symmetry and ensure sustainability of the programmes run by GBFIs. The study also recommended that the government should promote small livestock enterprises (like goats, sheep and poultry) to enhance the liquidity of the beekeepers and enable them meet basic conditions for GBFIs' credit acquisition. Lastly the study recommended that the private concerns making the improved technologies should come up with strategies of lowering the cost of hives to enable more beekeepers access them with ease and manage the credit repayment demands of GBFIs.

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ASALs	Arid and Semi Arid Lands
BTC	Belgium Technical Cooperation
GAA	German Agro Action
GBFI	Group-Based Financial Institution
GM	Gross Margin
GoK	Government of Kenya
HI	Heifer International
KRA	Kenya Revenue Authority
KTBH	Kenya Top Bar Hive
MLE	Maximum Likelihood Estimate
MoLFD	Ministry of Livestock and Fisheries Development
OLS	Ordinary Least Squares
TLU	Tropical Livestock Units

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Kenya's current population of 32 million has more than trebled in the past 40 years. Its growth rate of 2.3% is still among the highest in the world (World Bank, 2000). One consequence of the rapid population growth on the Kenyan economy is the effect of diminishing returns in agriculture linked to population pressures on land and other natural resources that tend to lower agricultural output per capita. The importance of agriculture to the national economy cannot be overemphasized. With a total land area of 56.9 million hectares of which about 80 percent is agricultural land, only 17 percent of the agricultural land is classified as high to medium potential where most of the intensive crop and livestock production takes place (Ruben *et al.*, 2003; Sutherland *et al.*, 1991). The rest of the land is Arid and Semi Arid Lands (ASALs). Nonetheless agriculture accounts for 27 percent of the Gross Domestic Product (Muricho, 2002), employs 75 percent of the total population, provides raw materials for the agro-industrial sector, provides nearly all of the national food requirements and is a major foreign exchange earner. Additionally 80 percent of the country's population is rural-based, depending mainly on agriculture for its livelihood.

The ASALs support 3 people per square kilometre, account for 30 percent of the country's population and have low and unreliable rainfall characterized by hot and dry weather (Brown, 1994; Sanyu, 2001). The inhabitants of the ASALs, most of whom are pastoralists, are living through a period of rapid and dramatic changes in land-use patterns, economic and environmental conditions (Schechambo *et al.*, 1999). The pace of change often exceeds the capacity of local organizations and national institutions to develop new land-use resources and improve the welfare of the people. This is especially true in the drier, more fragile ASALs where drought and famine have become increasingly common. Crop and livestock production in these areas is increasingly limited by erratic and insufficient rainfall and by the deterioration of soil, water and plant resources (De Haan et al., 2001; Itabari, 1999). The restriction of the productive agriculture and livestock keeping due to environmental deterioration, has called for the local and national institutions to increase the effort in the search for appropriate and sustainable production systems.

The government in its strategy for development of the ASALs has recognized that these zones merit special attention because (a) their inhabitants are often amongst Kenya's poorest; (b) there is need for support of the growing population, and (c) the intensified pressure on the ASALs carry dangers of environmental degradation (GoK, 2004a). In this respect the government has in the near past implemented a number of programmes in the ASALs. These include a) dry land farming systems, including agro-forestry and introduction of drought tolerant crops, b) improvement of livestock production systems, including improved breeds especially goats and cross-bred cattle c) exploring beekeeping potential d) water resources developments, and e) small scale irrigation projects (Mutungi *et al.*, 1996).

Beekeeping is of particular interest since it has no known threats to environmental sustainability. Honeybee rearing may be practiced with the highest potential in dry areas where crop farming is not effectively sustained and pastoral livestock production does not directly compete with it (Kigatiira, 1985). Enhancement of beekeeping activity in ASALs is likely to serve three important purposes namely, provision of extra non-perishable source of food for the family, products such as honey, wax, propolis and pollen, from which the farmer could obtain cash income and a means of pollination for agricultural and horticultural crops. Additionally, beekeeping is likely to be an appropriate agricultural activity in the ASALs because it requires only a small portion of land and is adaptable to dry land conditions (Schechambo *et al.*, 1999). For example fifty (50) hives can be accommodated in a tenth of a hectare with labour input of six to eight hours a year per colony (Melzer, 1989; Mutungi *et al.*, 1996). It can easily be integrated in the crop production systems and there is widespread indigenous knowledge and skills on beekeeping in ASALs. The activity cuts across gender as full time or part time engagement.

Honey production in the ASALs is characterized by use of traditional technology. Various studies in Kenya, for example, Nyikal (2000) and Muturi *et al.* (2000) have singled out low use of improved technologies as the main cause of stagnation in agricultural production. The use of traditional beekeeping technology contributes to low output and the bee products are of low quality thus limiting the producers' market access. Improved 'beehive' technologies however require more financial resources. It is acknowledged that accessibility to financial services is rare among the rural small-scale farmers.

1.2 Statement of the Problem

Despite ASALs' beekeeping potential, honey production has not lived up to the expectations. Generally, honey production in Kenya has been inconsistent and on the decline (Gichora, 2003). This has led to the inability of the beekeeping sub-sector to produce quantity and quality honey for both domestic and export markets (Christoplos *et al.*, 2000). Evidence available attribute this to both non-use of improved methods of production and attitude change among farmers.

Producers use outdated technologies for honey production (Hartmann, 2001; 2004). This has constrained production on a commercial scale in meeting the growing demand for the commodity. Some of the practices in use by producers do not meet the dramatically changing requirements of each particular ecological zone in which they are used (Gichora, 2003). The indication is even clearer in the semi-arid areas such as Eastern Kenya (Chamshama and Nduwayezu, 2002) where environmental degradation is gaining increased concern.

To remedy the unfolding phenomenon, a number of improved technologies for more efficient honey production have been disseminated to the beekeepers in the semi-arid areas over the years. Among the improved technologies is the Langstroth hive that provides an output of about 30 Kilogrammes per harvest (Gibbs et al., 1998, Melzer, 1989) compared to the traditional Log hive whose output is about 5 Kilogrammes per harvest (Hartmann, 2004). In spite of the touted efficiency, appropriateness, manageability and ease of maintenance of the improved technologies over the traditional technologies, beekeepers in Eastern Kenya do not seem to have taken advantage of this. Nonetheless, the main reason for low adoption of improved technologies is limited financial resource among small-scale farmers whose population is continuously increasing (Baliscan, 1993; Mbata, 1993; Nelson, 2000). Lack of access to credit facilities is cited as a major constraint to beekeepers who wish to adopt the improved technologies (Doward *et al.*, 1998).

The requirements and conditions of the traditional formal sources of credit such as collateral, credit rationing, preference for high-income clients and large loans, bureaucratic and lengthy procedures of providing loans, are difficult for low-income and resource-poor farmers to fulfill so as to access credit (World Bank, 2003). The traditional informal financial sectors are not better either. Their monopolistic power, excessive high interest rates and exploitation through under-valuation of collaterals have made farmers not access credit for agricultural purposes (Rweyemamu *et al.*, 2003; Yaron *et al.*, 1998).

Group-based financial institutions that use group-guarantee and compulsory savings as collateral security have been identified (Dercon, 1998; Remenyi, 1997). These innovative group-based financial institutions present the beekeepers with the best alternative in facilitating the acquisition of the appropriate technologies. However, despite the apparent attractiveness of these credit institutions, participation in them remains low and the beekeepers are yet to exploit the opportunities they offer. The question remains of how and whether participation of beekeepers in group-based financial institutions enhances the adoption of improved beekeeping technologies and as a result increases the enterprise productivity and household cash income.

1.3 Objectives

The general objective of this study was to examine the factors that constrain beekeepers' participation in group-based financial institutions necessary for access to credit facilities. It sought to determine how the beekeepers' participation affected the adoption of improved technologies in increasing honey production for food security. The study specifically sought to:

i.) Identify group-based financial institutions and various honey production technologies.

ii.) Determine the effects of socio-economic characteristics on beekeeper's participation in group-based financial institutions.

iii.) Evaluate the effects of beekeepers' participation in group-based financial institutions on the adoption of improved honey production technologies.

iv.) Compare the profitability of honey production under different beekeeping technologies among smallholder beekeepers participating in group-based credit programmes.

1.4 Hypotheses tested

The following hypotheses were posited for testing

i.) There is no significant difference in technology use among farmers participating and those not participating in group-based financial institutions

ii.) Beekeepers' socio-economic characteristics have no significant effect on their participation in group-based financial institutions

iii.) There is no significant influence of participation in group based financial institution on the adoption of improved honey production technologies.

iv.) There is no significant difference in profitability of honey production under different technologies.

1.5 Justification of the study

The study is based in Makueni district. However, the findings will reflect the position of the resource use in Kenya. Limited resources are a major constraint on small-scale farming, hence the need for this study. The methodology generates information on possible area of intervention to enhance efficient resource application and use of relevant technologies by small-scale farmers. The study adds to the existing literature information on the factors that constrain participation in group-based financial institutions and the effects of participation in increasing honey production.

The rationale of the study is based on the fact that honey is a high value commodity in the agricultural market and a vitamin rich food which has the potential of earning substantial incomes for the producers and foreign exchange to the country. At present, according to both the Ministry of Livestock Production and Fisheries Development and Kenya Revenue Authorities reports the country's honey output is low (while imports statistics are high) and does not meet the dynamic domestic market demand. This low output, as the evidence suggests is prompted by the inconsistent and declining productivity, while most beekeepers continue to rely on technologies that cannot guarantee sustainability. Further, indications are that some of the practices in use by producers do not meet the dramatically changing requirements of particular ecological zones and socio-economic set up in which they are used. This implies no single type of technology that suits all possible situations exists or is available.

Given the inherent socio-economic constraints beekeepers face, any technological innovation package must take their needs into account. The aim of this study was to provide information necessary for enhancing honey production in the greater Kibwezi region of Makueni district, through increased adoption of improved beekeeping technologies that are facilitated by group-based financial institutions. There is need to investigate factors influencing honey yield differential to assess their profitability and influence on adoption of improved methods. This will help formulate the necessary policy measures to improve Kenya's smallholder sub-sector.

1.6 Scope and limitation of the study

The scope of this study covered the economics of honey production, more specifically socio-economic aspect, participation in group-based financial institution and the adoption of improved honey production technologies. However, the study had the following limitations:

1. Spatiality

The southern lowlands of the district which are more dry and hot were covered by the study. This area borders both Kyulu game reserve and Tsavo west park and has rich floral diversity for bee forage. Specifically three southern most divisions in this area were covered namely Makindu, Kibwezi and Mtito Andei. The northern and central parts of the district which receives good rains for crop production were excluded. The sample was selected from beekeepers participating and those not participating in group-based financial institutions considered important initial factor towards adoption of improved beekeeping technologies in the arid and semi-arid lands. This study has left out other sources of finance such as traditional informal and formal individual contract sources like commercial banks; all of these cannot be handled in one study.

2. Time limitation

Data was collected for one month (August/September 2005). The schedule was guided by the limited financial resources.

3. Problem of quantification

Data quantification was a problem as beekeepers don't keep records of their activities. Hence the data on participation in group-based financial institutions and technology use were based on the respondents' own experiences and views. This was found appropriate as the respondents were able to quantitatively state the benefits and problems associated with these interventions in the last one year.

1.7 Organization of the study

The thesis is organized in five sections. Chapter one presents a background and introduction to the problem, inconsistent and declining honey productivity in semi-arid lands, while chapter two reviews literature related to the problem addressed. Chapter three presents the methodology of tackling the problem, while chapter four present the results and discussion of the study. The summary, conclusion and policy implications of the study are given in chapter five.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

For many developing countries, especially in Africa, agriculture continues to offer the leading source of food, employment and contribute large fraction of national income. In many of these countries, however, agricultural productivity has been on the decline. In the last two decades attention has been directed on modernizing small-scale agriculture to increase productivity for enhanced economic growth and development (DFID, 2004; Wenner, 2002).

One important way to increase productivity is through adoption of improved agricultural technologies and management systems (Mwale, 1995). The technologies the farmers use play a central role in shaping efficiency, equity and sustainability in the management of the natural resources (Knox *et al.*, 2002). This has been the reason for substantial investment in research to improve agricultural technologies from improved physical inputs to improved management practices. Indeed both national and international research institutions over the past years have developed several technologies and management practices. However, improved agricultural technologies are of little value unless they are declared appropriate by the farmers and subsequently adopted. A challenge for these researchers and the national governments is to understand how and when the farmers use technologies. This has led to the search for an improved understanding of the mechanisms underlying technology adoption in agricultural sub-sectors like beekeeping.

There are many factors constraining farmers' technology use, but the lack of financial resources has been identified as a common and important barrier to adoption, particularly for long-term investments in equipments and improvements of natural resources. Some technologies and management practices require that resource-constrained farmers access affordable credit if they are to make high initial financial commitments to adopt. In such instances, inadequate and ineffective financial institutions have been seen as a constraint to adoption.

The review in this section seeks to establish the link between group-based financial intermediaries and the beekeepers' decisions about the use of improved beekeeping technologies. It also seeks to support the analysis on how participation in group-based financial institutions interacts with other factors to either constrain or enable adoption of improved beekeeping technologies. Technology here is used generally to include management practices as well as production processes and methods (Muturi *et al*., 2000). On the other hand, adoption as defined by Feder *et al*. (1982) is the degree to which a new technology is used in the long-run equilibrium when the farmer has full information about the new technology and it's potential.

2.1.1 Beekeeping and the need for appropriate financing

Beekeeping is a unique primary industry. In tropical Africa beekeeping practice vary only slightly from one area to the other across the continent based on the flora resources, i.e. nectar and pollen, 80 percent of which are produced from native flora (Gichora, 2003). Much of this resource is on public land. It is produced irregularly and beekeepers often follow the seasons and honey flows to be successful. The bees forage for this resource within a radius of 1 or 2 miles (1.6-3.2km) on average (Melzer, 1989). The dominant bee species is the medium sized tropical

African bee race referred to as *Apis mellifera scutellata* and which occurs in open woodland mainly at about 500-1500 m above sea level.

Nationally, beekeeping has been identified as one of the priority areas to target for promotion to enhance sustenance of livelihoods in the rural areas. This is evident in both the Economic Recovery Strategy for Wealth and Employment Creation (GoK, 2003a) and Strategy for the Revitalization of Agriculture (GoK, 2004a). Beekeeping is especially prevalent in the rangelands under circumstances where crop agriculture is limited and where natural vegetation comprises of many species of plants suitable for bee forage. It offers income to over 200,000 households and it is no surprise that Arid and Semi arid Lands (ASALs) of Kenya produce about 65 percent of the country's total honey output (GoK, 2001a). Honey, the principal beekeeping product, is produced mostly following traditional approaches based on log hive technology. This means that the many skills required for beekeeping are mostly by experience and often passed from generation to generation.

Under the prevailing low technology production systems, the inhabitants of these areas are living through a period of dramatic changes in land-use patterns, economic conditions and the natural environment, resulting in rapidly declining incomes. Despite honey production being an indigenous activity with economic viability, potential to generate employment and maintain ecological balance, very little has been achieved (Christoplos *et al.*, 2000). Production has been inconsistent with the technologies, output and quality. The realized annual honey output trend over the years has shown only a marginal increase (see Table 2.1) with an average of 20,000 metric tons despite Kenya's estimated annual honey production potential of 60,000 – 100,000 metric tons (Gichora, 2003; GoK, 2004c). The output has nevertheless failed to comply with dynamic market demands. Non-conformity with the changing market demands is responsible for low prices, poor markets and low demand for locally produced bee products leading to many beekeeping operations not showing profits and hence discouraging most beekeepers (Wenning, 2001). This has led to cheap honey importation from such countries as United Kingdom, United Arab Emirates, Australia, Germany, USA, Uganda, India, Austria, Italy, Belgium, Egypt, Spain, Western Sahara and Sudan, below the prices at which Kenya's beekeepers can produce it. Currently Kenya is a net importer of natural honey (see Table 2.2), an indication of rapidly growing domestic market demand for honey (GoK, 2004b). Kenya's honey export has been to the regional states notably Tanzania, Uganda and Ethiopia.

Table 2.1: Estimates of hive population and production trends 1996 – 2001

Hives/ Product	Year					
	1996	1997	1998	1999	2000	2001
KTBH (No.)	104,364	108,316	117,735	121,198	132,775	145,000
Log Hive (No.)	1,072,233	1,095,777	1,105,261	1,251,102	1,507,360	1,507,360
Honey (Tons)	19,071	19,803	20,500	21,200	18,500	22,000

Source: Ministry of Livestock and Fisheries Development, Apiculture Division MoLFD (2004)

Table 2.2: Natural honey exports and imports statistics 1994 – 2003

YEAR	EXPORTS		IMPORTS	
	QUANTITY IN KG	VALUE IN KSH	QUANTITY IN KG	VALUE IN KG
1994	10,391	2,191,964	2,050	54894
1995	10,866	504,612	3288	857612
1996	2,789	203,547	30,324	3,700,929
1997	595	63,887	20,188	3,362,188
1998	971	110,559	25,140	4,896,569
1999	5,053	644,669	36,839	5,327,617
2000	351	51,201	63,316	9,840,073
2001	325	51,657	46,737	5,498,012
2002	337	68,300	52,320	7,070,099
2003	284	92,635	9,988	2,113,996

Source: Kenya Revenue Authority, Customs department, KRA (2004)

The challenge confronting the sub-sector is therefore how to increase honey production and value addition to satisfy the domestic demand and a surplus for export. It is therefore imperative that the sub-sector becomes more dynamic to reap the benefit of this demand through improvement of production systems, product quality and marketing services.

Several efforts have been made to streamline both the process and products of beekeeping to conform with the market requirements so as to attract high returns to the producers (Gichora, 2003). One of these remedial measures has been the introduction of a number of improved technologies for more efficient honey production. These have been disseminated to the beekeepers especially in the semi-arid areas over the years. The improved technologies like Langstroth hive are documented to provide higher output (Gibbs *et al.*, 1998; Melzer, 1989) compared to the traditional Log Hive whose outputs are low (Hartmann, 2004). Despite the touted efficiency, appropriateness, manageability and ease of maintenance of the improved technologies like Langstroth (Paterson, 2000) over the traditional log hive common in Eastern Kenya, beekeepers have continued to overlook these differences. One of the main reasons for low adoption of these technologies is limited financial resources among small-scale farmers whose population is continuously increasing (Baliscan, 1993; Mbata, 1993; Nelson, 2000). Lack of access to credit facilities is cited as a major constraint to beekeepers who wish to adopt the improved technologies (Doward *et al.*, 1998).

Agricultural credit has focused on promoting production and improved technologies during the last 30 years (Mittendorf, 1986). According to Webster (1986) and Nelson (2000), farm credit is a necessary input for promoting agricultural transformation in situations of limited farm incomes and savings characteristic of smallholder farmers in ASALs of Kenya. Credit is necessary for agricultural modernization as it alleviates financial constraints, and accelerates adoption of improved technologies. Sustainable credit facilities are therefore an integral part of the process of commercialization of the rural economy (World Bank, 1975; Yaron, 1997; Yaron *et al.*, 1998).

The requirements and conditions of the traditional formal sources of credit such as collateral, credit rationing, preference for high-income clients and large loans, bureaucratic and lengthy procedures of providing loans, have proved difficult for low-income farmers to fulfill so as to access credit in Kenya (World Bank, 2003). The traditional informal financial sectors are not better either. Their monopolistic power, excessive high interest rates and exploitation through under-valuation of collaterals have made farmers not access credit for agricultural purposes (Rweyemamu, *et al.*, 2003; Yaron, 1992). To enhance the use of improved beekeeping technologies, there is need for viable credit facilities that can provide rural farmers with capital.

The above restrictive conditions of the traditional formal and informal financial sectors leave innovative group-based financial institutions as important alternative credit facilities rural farmers can turn to. These institutions are engaged in microcredit delivery and savings mobilization in both urban and rural areas (Murdoch, 2000; Remenyi, 1997). Quite a number of these institutions have been operating in the rural areas of the country especially in the ASALs with limited but significant effects in the agricultural sector (GoK, 2003b; Swissconnect, 2005). With appropriate financing system, beekeeping industry is likely to improve the opportunities for gainful employment and income to the smallholder farmers in these areas. However, the current study is relevant since it is important to consider the effects of these institutions on the development of beekeeping industry to provide information for formulating strategies to improve these opportunities.

2.1.2 Group-based financial institutions and adoption of technologies

Recently there has been an upsurge of interest in group-based financial institutions as one of the most important instruments in development policy. These Institutions are often referred to as joint liability lending institutions or simply as Microfinance Institutions, though some institutions also give small loans to individuals with good reputation (Aghion and Morduch, 2000). The idea of group-based finance arose in mid-70s when Mohammad Yunus started a pilot scheme lending small amounts of money to villagers in Bangladesh (Abbink et al., 2002). These villagers, due to a lack of collateral, had no access to conventional loans. Encouraged by the high repayment rates, the Grameen Bank was founded to run such schemes on a larger scale. The Bank currently lends to about 2.4million people mostly smallholder farmers. Since the Grameen's early successes, the concept of microcredits has spread throughout the world and a large number of organizations providing small loans to the low income individuals have come into being. Group-based financial institutions are most widespread in the less developed countries, although they are not confined to them (Murdoch, 2000, Remenyi, 1997). There are more than 5million households served by microcredit schemes in the world today (Aghion and Morduch, 2000).

Prior to the group-based finance revolution, low income individual's opportunities to take up loans had been severely limited (Argwings-Kodhek *et al.*, 2004; Pearce, 2003). First, with few substantial possessions, low income households cannot offer collateral to back up their loans. Second, the potential location of potential small loans applicants in less developed countries is often in remote rural villages beyond the reach of traditional banking system. Third, although loans needed for individual projects are small, their myriad nature makes monitoring and enforcement costs prohibitively high. Low income villagers' only access to credit had been through non-commercial development programmes (for example Agricultural Finance Corporation in Kenya) which provided subsidized credit. However, since these schemes faced the same monitoring difficulties as traditional banks they often suffered from poor repayment rates and high costs and were typically doomed to failure.

Group-based financial institutions (engineered and propagated mostly by various NGOs) use credit delivery innovative means to overcome these problems. Some use an integrated approach and hence provide a combination or range of financial and social intermediation, enterprise development and social services (Ledgerwood, 1999). Though single schemes differ vastly in their concrete implementations most of them share some main characteristics. The most prominent of these shared features is that of group lending and compulsory saving (Zeller, *et al.*, 2001). These financial institutions lend to groups and make use of joint liability, peer selection, and investments in repeated financial transactions to overcome the informational constraints in financial markets (Dercons, 1998; Zeller, *et al.*, 1997a). In typical group-based financial scheme, borrowers with individual risky projects form groups which apply for loans together. The whole group is liable if one or more group members default. Intimate knowledge of each other's activities facilitates mutual monitoring, and joint liability principle creates peer pressure for repayment. Hence the joint liability provides an insurance against individual risks. Even if an individual project fails and some of the borrowers are unable to repay, the group as a whole has an obligation to do so. In this sense joint liability serves as a substitute for collateral. Unless the individual risks are perfectly correlated, the overall risk of involuntary non-repayment can be substantially lower than with individual borrowing.

Group lending concept therefore has the potential capability of reducing the transaction cost for both lenders and borrowers thus capturing the major advantage of the informal financial sector (Berenbach and Guzman, 1994). It enables the lending agency to deal with the credit group as an entity, saving the agency the costs of transacting with several different individuals, and the individuals also gain from the economies of scale by transacting as a group. This puts the lending agency in a similar vantage position as the moneylender, enjoying low transaction costs as well as low default risk (Murdoch, 2000). The question remains on whether group-lending is an innovation that reduces overall transaction of the financial system or it merely shifts a large part of the cost to the poor clientele (Khawari, 2004).

Another significant feature of group-based financial institutions is that they do not depend solely on the government for loanable funds, nor have they been subjected to interest rate and other controls imposed by the central bank. They are mostly donor funded with the objective of alleviating poverty, development of the rural economy and rural financial markets (Yaron *et al.*, 1998). The donors are local/national or international agencies. To counter the possible initial negative social impacts of liberalization process, most governments in less developed countries identified areas and projects needing external donor support, including small-scale and micro-enterprises. The small scale and micro enterprise sector was identified as a means of accelerating economic growth and generating employment opportunities. Lack of access to credit was considered a major bottleneck for enterpreneural development and this elicited the response of the donor community (Hospes *et al.*, 2002).

In Kenya, the group-lending concept has gained tremendous grounds as an alternative to traditional banking. Initially it was synonymous with small and micro enterprises financing in urban areas of the country but has since spread to rural areas. The membership of the group-based financial institutions in the country currently stands at about 3.5 million with a market penetration of about 10.5 percent (Chao-Beroff *et al.*, 2000). This breadth of outreach and market penetration provides an indication of the importance of these institutions. In the rural areas, mostly courtesy of various NGOs concerned with poverty reduction, food security and environmental sustainability, the concept has been disseminated as a strategy to provide resources for agricultural intensification and income diversification (Dercon, 1998). The main aim of these financial institutions has been to cater for the credit and other financial needs of farmers under the cooperative systems to acquire the modern agricultural production technologies (Zeller and Sharma, 1998).

In Makueni District of Eastern Kenya, groups of individuals carrying out various enterprises have been formed to ensure sustainability in their undertakings (Mugivane, 1999). These systems of cooperation have helped to ensure households survival and promotion of individual and collective welfare. Through these groups, group-based financial institutions have reached about 872 households with a market penetration of approximately 0.6 percent to finance the acquisition of modern technologies in various enterprises especially on-farm ones (Swissconnect, 2005). One of the on-farm enterprises adapted as a livelihood strategy in the District (Christoplos *et al.*,

2000) in which modern technology acquisition has been financed through group lending concept is beekeeping. However, the level of participation in these institutions by the beekeepers to improve their access to investible funds remains low. A farmer is said to participate in a group-based financial institution if he/she acquires membership in the group and actually obtains financial services from that source using the joint liability (Kiiza and Pederson, 2003; Zeller *et al.*, 2001)

The farmer's decision to participate in group-based financial institution is seen to be the outcome of an individual/household strategy, which is influenced by the interplay of the individual/household demand for the type of financial service provided by these programmes, and the opportunity cost of membership activities for individual/household. Before the introduction of group-based financial institutions resource poor beekeepers, who are the majority in the study area were restricted to the use of traditional log hive technology. With the presence of group-based financial institutions, quite a number of resource poor beekeepers have been enabled to acquire improved beekeeping technologies. It is therefore posited that beekeepers in ASALs of Eastern Kenya that participate in group-based financial institutions are more likely to access credit and investment management skills necessary for adoption of improved beekeeping technologies.

2.1.3 Agricultural technology adoption and Theories

Over the last 40 years, researchers have tried to answer challenging questions about technology adoption resulting from numerous adoption studies. Feder and Umali (1993), and Adesina and Zinnah (1993) review many of these studies. Most of the early approaches were and continue to be characterized by a "top-down" transfer of technologies from the western world. These were based on adopter-perception paradigm. The local people were seen as part of the problem to be solved. Technologies developed in areas with totally different biophysical conditions were imposed on the people. In some cases they met with a lot of resistance to the extent that more effort was put in convincing the local people to adopt them. In other incidences, they worked for a short while and then were abandoned with people resorting to their indigenous technologies.

This approach failed to achieve much because it did not put into consideration the alternative underlying principle that patterns peasant behaviour; "risk aversion" or uncertainty (Lipton, 1968). This evasion action is related to the conditions of uncertainty in which rural production processes is embedded. The consequences of risk aversion for adoption are not unambiguous, since they depend on farmers' perception and attitude of relative riskiness of old and new technologies and the level of uncertainty faced (Walker, 1981). Adoption of technology might either reduce or increase risk in the long run. Perhaps the cases of reduced risk explain the occasional empirical evidence for a positive relationship between risk aversion and adoption (Shapiro *et al.*, 1992). On the other hand uncertainty would tend to always be greater for the new technology than for the old, and so would discourage adoption by risk-averse farmers. Similarly if a lack of experience with use of new technology increases the risk of implementation failure, risk aversion would again discourage adoption. Overall, a negative influence of risk aversion on adoption has been the more common empirical findings (Abadi Ghadim, 2001). The decision makers act and react to the world they perceive, where understandings are shaped as much by their own personal experiences as by society (Bunge, 1999). For example, the painful memories of a poor harvest, limited resources, climatic and environmental conditions constitute the principle factors. But it is the farmer's reaction to these conditions that produces an exaggerated fear or makes them risk-averse. In this study attitude is understood to mean an individual tendency to react, positively to a given social value (Thomas and Znaneki, 1918).

A new paradigm, which recognizes the farmer as both innovator and adopter particularly in resource-constrained areas, is emerging (Chambers *et al.*, 1989). This emphasizes that any development strategy must involve the farmers for the active participation and collaboration between the users, the technicians and the development agents. This paradigm, postulate increased recognition of the importance of indigenous technical knowledge. It posits that farmers should take part in the design, determine management conditions and implement and evaluate the improved technology adoption process.

According to Wenner (1993) this participation leads to the development of a successful technology that is adopted by its target groups. Additionally, adoption process is not only restricted to technical purposes (what technology to solve what technical problem?) but also embraces the social and organizational set up of the target groups. In this respect, the adoption of a technology is seen as an integrated socio-economic process that incorporates social networks, attitudes, beliefs, perceptions and intentions and economic factors such as profit, income and access to credit. The relevance of the above studies to this one is based on the fact that this study sought to investigate that socio-economic process occur in the adoption of beekeeping technologies.

Using this approach, beekeeping decision-making can be described as a mental process that beekeepers follow from knowledge of beekeeping to forming an attitude towards beekeeping, and finally coming to a decision to adopt or reject a beekeeping practice. This innovation-decision process is relevant in investigating the adoption of agricultural technologies (Rogers, 1983). According to Rogers (1995), adopters can be classified into various categories and those in the same categories share similar socioeconomic status, personality values and communication behaviour. These categories are: Innovators (first 2.5 percent of individuals in a social system to adopt an innovation), early adopters (next 13.5 percent), early majority (next 34 percent), late majority (next 34 percent) and laggards (last 16 percent). In beekeeping practice, the innovation-decision process can be used to develop a model based on certain assumptions. First, that the beekeeping practice is ecologically and economically adoptable and compatible with local agricultural practices. Also that beekeeping extension agency is responsible for facilitating the flow of knowledge and available resources among the beekeeping groups at various stages of the adoption process. From the diffusion theory, the innovation process is assumed to be influenced by a beekeeper's socio-economic, communication, and psychological characteristics at all stages.

In the beekeeping innovation-decision process, first the beekeeper may become aware of the beekeeping practices by efforts of change agencies like media or extension agents (Rogers, 1995). The extent of awareness however, mostly depends upon a beekeeper's socio-economic characteristics and communication factors. Second, the beekeeper may try to interpret beekeeping practices in terms of his/her needs and situations. Factors such as beekeeper's beliefs and orientation, where they seek information, how that information is interpreted, and how it is applied to their present and future situation are critical in developing the attitude towards the beekeeping practice. Finally if the beekeeper forms a favorable attitude towards the beekeeping practice, he/she will want to know more about the source and availability of the innovation and other operational aspects before the decision is taken on adoption. However, there are instances where the beekeeper may make the decision to adopt a technology but encounter economic constraints. Such encounter leads to a third paradigm, the economic constraint model.

The economic constraint model contends that economic constraints as seen in the asymmetrical distribution of resource endowments are the major determinants of observed adoption behaviour. This model is rooted in utility and profit maximization theory. It posits that lack of access to labour, land or capital could constrain adoption decisions (Feder *et al*., 1985). For small-scale beekeepers, lack of financial capital significantly constrains adoption process. This study sought to show that improved access to financial resources through provision of appropriate financial services for the small-scale beekeepers could trigger the improved beehive adoption process. To achieve this, it relates various variables considered in all the three paradigms to adoption of improved beekeeping technologies in Makueni district.

CHAPTER THREE

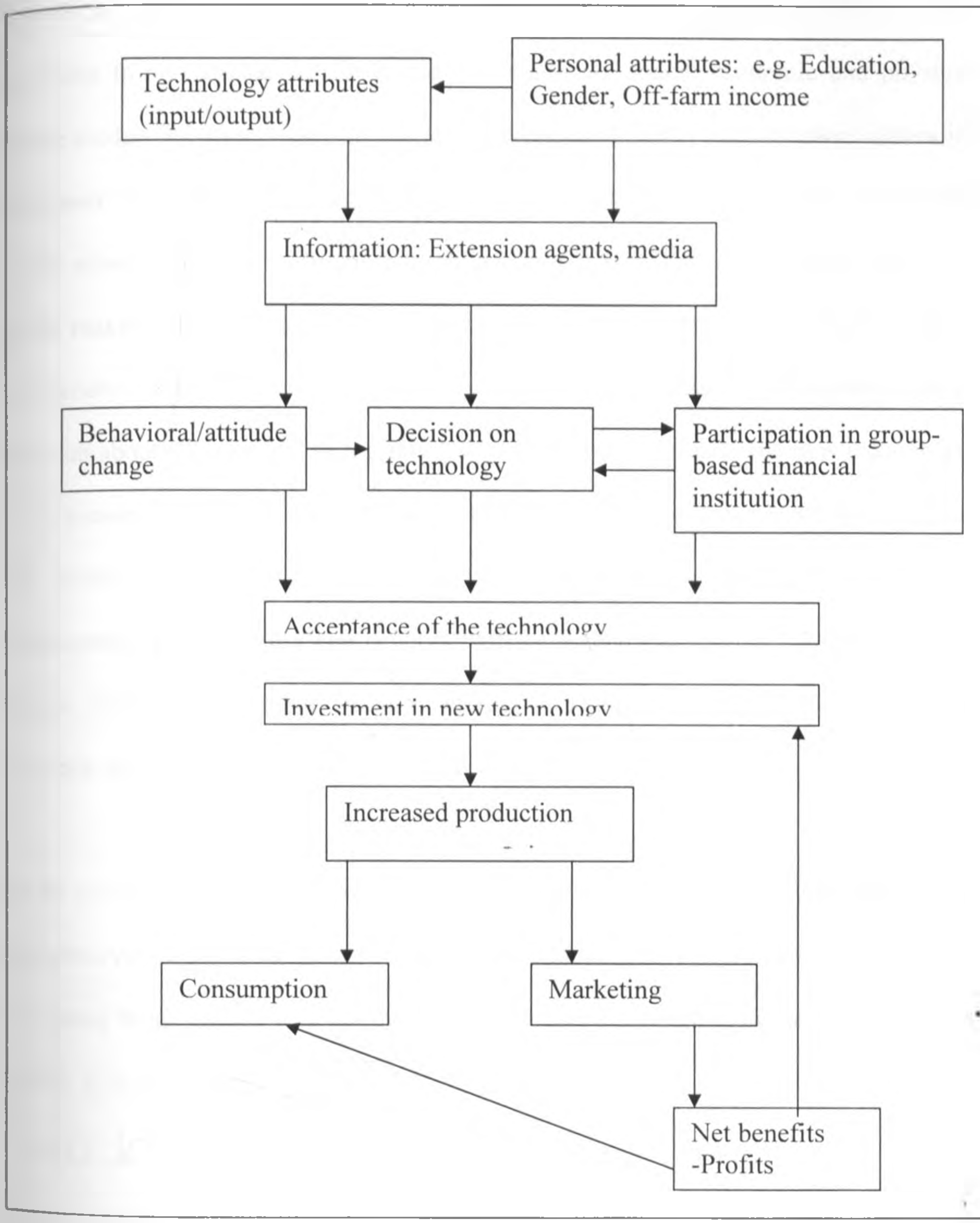
3.0 METHODOLOGY

3.1 Conceptual Framework

For the purpose of this study it was assumed that beekeepers make the decision to adopt improved beekeeping technologies based on the utility that is derived from the chosen technology. The beekeepers in the study area were postulated to choose the technology that delivers maximum utility (net returns). However, the maximization of utility was premised on the supposition that beekeeper's choice of improved technology lies on one's socio-economic attributes, knowledge possessed, technology attributes and constraints which limit beekeeping activities. The beekeeper's decision to use improved beekeeping technologies was modeled as the adoption of a new technology and treated as a dichotomous choice.

Lack of adequate capital was hypothesized to be one of the major constraints limiting the use of improved technology by low-income beekeepers. It was therefore postulated that low-income beekeepers participate in group-based financial institutions with an aim of circumventing this constraint so as to access improved technologies. However, the farmer's decision to participate in group-based financial institution is also influenced by one's socio-economic characteristics. Participation was therefore postulated to enhance knowledge access, savings and borrowing opportunities all of which enhances investment in improved technologies. This scenario was hypothesized to result in high net returns from beekeeping which enables the beekeeper to reinvest in improved technologies without further borrowing and repay the loan with surpluses for his/her consumption. Figure 3.1 gives a schematic representation of the beekeeper's adoption decision in the study area.

Figure 3.1: Schematic Representation of beekeeper's adoption decision



NB: The arrow flows indicate how beekeepers function within a given socio-economic environment and make decisions on the basis of the information and technology available to them and in the light of what they feel is the most efficient way of utilizing their skills, labour and capital to achieve their goals.

Source: Author' compilation

3.2 Theoretical Basis

The discrete choice models have become important tools in describing decision maker's choice decisions from a choice set conditional upon a set of social, economic and physical factors. These models are widely used in economics (Amemiya, 1981) and common applications are to consumer demand behaviour and programme participation decisions. These models are derived under an assumption of utility maximization (Train, 2002). The utility maximization, rather than profit maximization is modeled to explain beekeeper adoption behavour because they are both consumers and producers of beekeeping products. In the models, it is assumed that in making decision about the adoption of a technology, a beekeeper evaluates the new technology in terms of its incremental benefit. If the monetary benefit of using the new technology is higher than the old technology, the preference for or utility (U) for that technology (assuming monotonic relationship between utility and benefits) will be higher than the old technology. According to Green (2000) random utility models address these types of individual choice situations. A common specification is the linear random utility model.

In the current study, the beekeeper's utility maximization is based on the expected value of the non-observed underlying utility function that ranks the preferences of the *i*th beekeeper according to the chosen technology *j*. The non-observable underlying utility function (Caviglia, 2003), *U*, is represented by

$$U = U_{itT}\left[C_{it}\left(H_{it}, A_{it}, \psi\right), Z_{it}\right] \qquad (1)$$

where C represent the beekeeper's attained profit, Z represent a group of meso level factors, T, represent the technology choice (T=1 if improved technologies are used and T=2 when traditional technology is used exclusively, *i* indicate the individual beekeeper and *t* indicates the year). Beekeeper's profit C, is a function of observable socio-economic factors H (for example, managerial ability and income), observable beekeeping technology characteristics A (for example costs), where the technology refers to beehive type chosen by the beekeeper, meso level factors Z (for example infrastructure and prices) and random error term Ψ (for example, represent the influence of other factors not explained by the model). The choice of the technology therefore determines yields and income, which are influenced by some constraints. Although the utility is unobservable, the relation between the utility derived from a specific technology is a function of the vector of observed socio-economic and technology characteristics included in the utility measurement.

The beekeeper chooses between U_{it1} and U_{it2} depending upon which beekeeping technology yields greatest expected utility (Caviglia, 2003). The utility ranking of the chosen technology is therefore estimated for the vector of observable socio-economic and technology characteristics as follows,

$$U_{itT} = \alpha_{it} F_{it}(X_{it}) + e_{itT}$$

$T=1,\ 2 \quad t=1,\ 2 \quad i=1,\ .....n$ (2)

The ith beekeeper will choose to use traditional technology if $U_{it1} \langle U_{it2}$ or if the latent variable

$Y^{*} = U_{it1} - U_{it2} < 0$ and will choose improved technology when $U_{it1} > U_{it2}$ or if the non-observed latent variable $Y^{*} = U_{it1} - U_{it2} > 0$:

$Y_{i} = 1$ if $U_{it1} > U_{it2}$, improved technologies are adopted

0 if $U_{it1} < U_{it2}$, improved technologies are not adopted (3)

The probability that the beekeeper adopts improved technologies (the probability that Y_{it} equals one) is a function of the independent variables:

$$
\begin{aligned}
P_{it} = \Pr(Y_{it}) = 1 &= \Pr(U_{it1} > U_{it2}) \\
&= \Pr[\alpha_1 F_{it}(X_{it}) + e_{it1} > \alpha_2 F_{it}(X_{it}) + e_{it2}] \\
&= \Pr[(e_{it1} - e_{it2}) > F_{it}(X_{it})(\alpha_2 - \alpha_1)] \qquad (4) \\
&= \Pr[U_{it} > \alpha_2 F_{it}(X_{it})\beta] \\
&= F_{it}(X_{it}\beta)
\end{aligned}
$$

Where X is a nxk matrix of explanatory variables and β is a $kx1$ vector of coefficients to be estimated.

The probability that the ith beekeeper adopts improved technologies is therefore the probability that the utility gained from the traditional technology is less than the utility gained from the adoption of improved technologies (the cumulative distribution function of F for i evaluated at X_i). If U_{ij} is a normal distribution and if U_{it} is uniform then F is triangular (i.e. where $U_{it} = (e_{1it} - e_{2it})$, as derived in equation 4 above). For the purpose of this analysis, U_{it} is assumed to be logistic, making the estimation of the probability possible using a binary choice model.

3.2.1 Binary Choice Models used in Estimation of the Variables

Generally there are four types of models that can be used to measure binary response behaviour: linear probability model, logit, probit and the tobit model. The dichotomous status of the dependent variable renders Ordinary Least Squares (OLS) estimation inappropriate because some of the basic assumptions of the OLS method such as normality and homoscedasticity of the error term may be violated (Judge *et al.*, 1985; Maddala, 1992). Furthermore, the predicted values may lie outside the 0-1 range and the prediction errors can be very large. Drawing from Green (1994), the normalization rule is that $\beta_0=0$. Each ith observation must fall into the jth beekeeping technology. Additionally, if OLS is used under small sample and non-dependent variable conditions, the statistical inferences made with the estimated model are invalid.

The problem is typically remedied by using maximum likelihood estimation (MLE), although heteroscedasticity in MLE is also a potentially serious problem leading to inconsistent estimators (Green, 2000). According to Wooldridge (2000), when heteroscedasticity is observed, such models require more general estimation. However, such models are not often used in practice, since logit, probit and tobit with flexible functional forms in independent variables tend to work well. Both probit and logit models captures the likelihood of adoption while tobit model captures both the likelihood and extent of adoption. Since in the current study, the aim was to analyze the likelihood of adoption so as to influence the increase in the number of adopters, a choice was made between probit and logit models.

The probability functions used for the probit and logit models are based on the normal distribution and on the logistic distribution functions respectively. They are bound between 0 and 1 and exhibit a sigmoid curve, conforming to the theory of adoption. The probit and logit models are quite similar as the cumulative normal and logistic distributions are very close to each other except at the tails (Green, 2000). Hence under the standard error term, there is no a *priori* reason to prefer probit to logit estimation. However, the tails of a logistic model are flatter than that of a probit model (Amemiya, 1981). The results produced by either model are similar, unless the samples are very large and many observations fall near the tails (Maddala, 1983). But the logistic transformation is more convenient to compute. Unless there are theoretical reasons for preferring a distribution function to the logistic cumulative distribution function, the logit model is preferred. The logistic model also has a direct interpretation (as does the probit model) in terms of the logarithm of the odds in favour of success. Being based on the logistic probability function t, the logit model can be used for transforming the dependent variable to predict probabilities within the bound (0,1). Although Y can take a value of 1 or 0, there is no guarantee that the estimated Y values will necessarily lie between 0 and 1 some Y values could be negative while some in excess of 1. A binary function can be formulated to estimate the effect of independent variables thus

$$Y_i^* = \beta' X_i + \mu_i \qquad (5)$$

Where

Y_i^* = the dependent variable.

β'=a vector of parameters to be estimated

X_i =a vector of independent variables and

μ_i =error term

In practice Y_i^* is unobserved. What is observed is a dummy variable Y_i defined by;

Y_i =1 if Y_i^* >0 (if beekeeper *i* used an improved beekeeping technology),

Y_i =0 if otherwise.

In this formulation,

Prob (Y_i =1) =prob (Y_i^* >0)

=Prob ($\mu_i > -\beta' X_i$) = 1-*F* ($-\beta' X_i$) where *F* is the cumulative distribution function of the error term μ_i .

Various cumulative functions can be assumed for *F (.)*. If it is assumed that *F (.)* has a logistic distribution, that is, the probability of *i*th beekeeper adopting technology *j*, then the expression becomes

$$\text{Prob}(Y_i = 1/X_i) = \frac{1}{1+e^{-\beta X_i}} = \frac{e^{\beta' X_i}}{1+e^{-\beta' X_i}} \quad \ldots \qquad (6)$$

In the case of random sampling where all observations are sampled independently, the contribution of the *i*th observation can be written as $P_i^{Y_i}(1-P_i)^{(1-Y_i)}$ and the likelihood function becomes the product of individual contributions. The likelihood function then is

$$L = \prod_{I=1}^{n} P_i^{Y_i}(1-P_i)^{(1-Y_i)}$$

Taking the logarithm and replacing P_i by $e^{\beta' X_i} / 1+\beta' X_i$, the log likelihood function becomes:

$$\text{Log L}=\sum_{i=1}^{n} Y_i \beta' X_i - \sum_{i=1}^{n} \log(1 + e^{-\beta' X_i})$$

In the binary dependent variable models, the βs cannot be interpreted as the marginal effects on the dependent variable. For instance, in the logit model, the marginal effect on the conditional probability is given by the rate of change in the probability as a result of a unit change in the dependent variable, i.e. dP/dX is given by $\beta_j P_j(1-Pj)$ (Asfaw *et al.*, 2004; Green, 1994; Gujarati 1995; Mukherjee *et al.*, 1998).

To test the reliability of the model, a necessary diagnostic test is performed. Unlike the standard regression model, the *F*-test cannot be used to test the overall fitness in a discrete choice model. The most popular diagnostic test in such cases is the χ^2 (chi-square) statistic defined as

$$X^2_{(n)} = -2 \ln \frac{L_R}{L_U} = -2(\ln L_R - \ln L_U)$$

Where, L_R and L_U are the restricted and the unrestricted results respectively (Mukherjee *et al.*, 1998).

3.2.2 Factors influencing the adoption of technological innovations

The factors included in the model were based on innovation diffusion theory and past studies. In the studies by Feder *et al.* (1985), Feder and Umali (1993), and Adesina and Zinnah (1993) most of these factors are reviewed. The selected variables for this study included the farmer's participation in group-based credit programme, the decision maker's education level, availability of off-farm income, Total livestock units, Distance to the nearest market centre, Contact with extension agents, Gender of the decision maker, age of the decision maker, output, Variable costs, size of enterprise, cost of technology and the decision maker's experience with the technology.

In some past studies, group-based credit programmes have been shown to influence adoption decisions. Zeller *et al.* (1997b) considered participation in group-based financial institution as one of the possible determinants of improved technology adoption. They found farmers' participation in group-based financial institution to substantially raise the cropping share for hybrid maize and tobacco and to have substantial effects on crop income. They concluded that expansion of the existing group-based credit programmes could have beneficial effects on agricultural production of smallholders and rural incomes. The study also found participation in group-based credit programmes among households living in areas with higher variation in rainfall to be lower. They attributed this to the supply side effect, that is, group-based credit programmes keep away from these areas because of higher expected loan default. The current study sought to analyze the effect of participation in group-based credit programme in Makueni district, an area of relatively high rainfall variation though on a different activity. Other studies have also found expansion of the existing group-based financial institutions to catalyze investment (Levine, 1998; Ruben and Clercx, 2004,) in improved technologies to be necessary. Levine (1997) advances that participation in group-based credit programme reduces information costs (economies of scale) hence further enhancing investment in new technology. In this case if a farmer takes advantage

of the technical assistance opportunities and services offered by these institutions then he/she is likely to use the improved technologies. Participation in group-based financial institution by beekeepers in the study area was hence assumed to have a direct influence on the use of improved technologies.

Studies on economic growth indicate human capital as one of the most important factors in economic development (Asfaw *et al.*, 2004). The studies broadly defined education as "all deliberate learning activities". Studies of the adoption and diffusion of innovations investigate the effect of human capital investments on adoption behaviour. Some of the rural social literature (Shoemaker, 1971), aged as may be, has suggested that adoption depends on the decision makers' education and information level. Mittal and Kumar (2000) find a positive impact of rural literacy on the adoption of high yielding varieties of rice and wheat in India. Doss and Morris (2001) also indicates that education is significant determinant of the adoption of modern varieties of maize in Ghana. Hence the impact of the decision maker's education level on the use of improved beekeeping technologies is assumed to be positive. As a result most studies in the area of human capital use formal education (usually years of schooling) and informal education (age, experience, number of contacts between extension workers and farmers) to analyze the contribution of human capital to growth. Health issues are also integral part of the human capital because only healthy individuals are able to adopt and appropriately invest in improved technologies to improve productivity. Hence educated individuals are in a position to understand the nature, dangers of and how to prevent the risks posed by various diseases which may interfere with there adoption and investment plans. Education is therefore hypothesized to affect agricultural productivity by increasing the ability of farmers to produce sustainably from given resources. It also enhances capacity to obtain and analyze information and to adjust quickly to disequilibria (Schultz, 1981). The education of the beekeeper in the study area was therefore hypothesized to exert a positive influence on the probability of choosing beekeeping technologies.

The impact of experience on adoption is ambiguous a *priori*. As experience increases (and therefore age increases), the time horizon in which to reap the benefits of adoption decreases, while risk aversion and learning by doing with current management practices may increase (Takeya and Herath, 2003). On the other hand, greater experience could also lead to better knowledge of spatial variability in the field and more accurate assessment of the benefits of adoption. Shiyami *et al.* (2000) find that the more experience with growing chickpea, the higher the adoption of new varieties. Considering the above factors, experience of the beekeeper is hypothesized to have a direct or an inverse effect on the decision to adopt improved beekeeping technology. It was assumed that adoption of one technology predisposes the beekeeper to either adopt or not adopt other technologies.

Contact with extension agents was expected to have a direct effect on adoption decision based upon diffusion theory. Such contacts, by exposing farmers to information, are expected to stimulate adoption. In addition, the technical know-how about an innovation and the benefits associated with its use affect adoption decision. Studies on extension indicate higher visitation rates by extension personnel to reduce not only the likelihood of farmers choosing slash and burn agriculture, but also to promote movement into multi-and mono-cropping in Cameroon (Nganje *et al.*, 2001). Since beekeepers in the ASALs are also preoccupied with other coping mechanisms to meet the daily livelihood needs, they demand extension services based on their programme. This means that extension agents cannot visit the beekeepers without their consent. In the current study the beekeepers' contact with extension agents was posited to have a direct effect on the adoption decision.

The role of off-farm income on the decision to adopt is not very clear. It is observed that farmers with off-farm income are less risk-averse than farmers without sources of off-farm income. Off-farm activities will reduce the management resources available for the adoption process, but access to outside information may have positive effects. On the other hand, not only will the increased cash from off-farm sources allow the farmer to purchase inputs, but also the individuals working outside the village would have the opportunity to acquire technologies and information on the same from other areas. According to Dimara and Skurass (1998), an increase in the off-farm annual work units decreases the probability of adopting flu-cured tobacco varieties in Greece, but this relationship is not statistically significant. Considering all these factors, care should be taken in predicting the sign of the independent variable. Off-farm income of the beekeepers in the study area was hence assumed to have either a direct or an inverse effect on improved beekeeping technology adoption decision.

The distance between the farmer's residence and the market place and the time taken to reach the market is used to reflect the status of infrastructure. Distance to the market and time taken to reach the market is considered as determining the adoption decision of the farmer. This was incorporated in the current study based on previous survey studies in which market infrastructure in the study area was identified as one of the major problems in marketing agricultural produce and accessing input supplies and other services (GoK, 2001b). Farmers nearer to the market centre or who take a shorter time to reach the market are viewed to have better information flow on both the market and technologies. The time taken by the beekeepers to the market was found to vary greatly depending on the means of transport used (foot, bicycle, donkey and public means). The time taken to the market using different means was therefore converted into Kilometres assuming similar infrastructure status in the study area. Distance was suggested to have inverse effect on the adoption of beekeeping technologies.

Studies on physical resource endowments show livestock herd size as one of the most important factors in technology adoption decision due to its characteristic as a source of savings and a buffer against calamities (De Haan *et al.*, 2001). As a proxy for wealth, farmers with a higher number of livestock are assumed to have increased liquidity and are in a position to undertake risky businesses. A study by Oluoch-Kosura *et al.* (2001) indicates that size of livestock herd has a direct influence on the adoption of improved maize varieties. Since livestock plays a significant role in the livelihood of the inhabitants in the study area, it was hypothesized that the number of livestock units possessed by the beekeeper had a direct influence on the farmer's decision to adopt a new technology. The above factors were used in the current study to establish their influence on the adoption of beekeeping technologies in the study area.

Though risk plays an important role in the adoption of new technology, this was not modeled in this study. Since the survey was cross-sectional, there was no adequate information to measure effectively the risk-related factors like risk aversion and relative riskiness in adoption of improved beekeeping technologies. This would have been possible if information on actual and planned adoption behaviour for improved beekeeping technologies were available over a period of time.

3.2.3 Past studies estimated using logit model

Empirical studies on the effect of participation in group-based financial institutions on adoption of improved beekeeping technologies in Kenya are lacking. To our knowledge, no studies have therefore been done in the ASALs using the logit model from this perspective. However, several past studies have used the logit model to estimate parameters in the adoption of other agricultural technologies especially crops such as maize and fertilizers. This study therefore draws from the models in these studies to estimate the effects of participation in group-based financial institutions on adoption of improved beekeeping technologies. Since these studies are many and varied, some of the studies are reviewed as followed:

Zeller *et al.* (1997b) conducted a study on market access by smallholder farmers in Malawi. The study used the probit model to look at the implications for technology adoption, agricultural productivity and the crop income. The results showed that the unobserved credit programme attributes were statistically significant in explaining household's decision to participate in formal credit markets. The results further indicated that the predicted membership in agricultural credit programmes carries an expected and significant sign for the three crop technologies under study (hybrid, tobacco and local maize). They found participation in agricultural credit programmes to substantially raise the cropping share for hybrid maize and tobacco and to have substantial effects on crop income. The current study looked at the effect of the same variable on the adoption of beekeeping technology though using a logit model.

In their analysis of household participation in micro-credit programmes and investment behaviour in Uganda, Kiiza and Pederson ((2001) used a bivariate logit model. The results of the study indicated that proximity to the institution, dual sources of income and income stability influenced the rural households' participation in the microfinance credit programmes. The co-efficient of education had the expected positive sign, indicating that the likelihood of participation increased with the level of education of the borrower. The estimated model also found that farmers were less likely to participate probably because of the uncertain nature of farm income. The study also looked at the formal credit markets and observed that the use of logit model does not capture the underlying credit constraints. But noted it served the useful purpose of identifying factors that are important in the initial design and implementation of credit programs to reach poor households. The current study adopted this approach.

Graham and Darroch (2001) used the logit model to estimate the effect of land tenure security, wealth, liquidity and educational status on credit use. The probability of credit use was taken as the dependent variable while the exogenous variables considered included tenure security, wealth, liquidity and educational status. The study found that tenure security, wealth and education status were positive and significantly influenced credit use while liquidity status was not significant. The present study adopts this approach but differs from it in certain aspects. That is, the other is in South Africa where agricultural development is probably more advanced, and is also not on beekeeping.

Tovignan *et al.* (2004) analyzed the role of gender in the adoption of organic cotton in Central Benin. Logit model was used to determine the factors affecting the adoption of organic cotton. To estimate the influence of gender in the adoption of organic cotton, the predicted value of gender index was first estimated using a linear regression model before inclusion in the adoption model. The study found that gender, education level, access to credit, topographic status of land, experience, extension, age, off-farm income and active household members significantly determined the decision to adopt organic cotton. Land tenure and number of ruminant animals were not significant. The present study used this approach to predict adoption of improved beekeeping technology. The present study differed from this one in that it considered a different technology, focused on the influence of participation in group-based financial institutions on adoption and was also carried out in a low potential zone. Whereas their study estimated the predicted value of the focal explanatory variable (gender) using the OLS regression model, the present study estimated the focal explanatory variable (participation) using a logit model.

In a study to determine factors influencing fertilizer and manure use in maize production in Kiambu district, Kenya, Makokha *et al.* (2001) used logit model. The study used a multistage random sampling to select farmers for the survey resulting in a sample size of 97. The study found out that age, extension contact, membership in an organization and off-farm income influence the use of fertilizer. Extension contact, membership in an organization, hired labour for manure application, livestock ownership and off-farm income influenced both fertilizer and manure use. However, this study considered a different technology from the present one and also did not look at the effect of participation in group-based financial institution on adoption, which is the focus of current study. The study was also carried out in high agricultural potential area compared to the present study that was carried out in a low potential zone of Makueni district.

Herath and Takeya (2003) used a logit model to study the factors determining intercropping by smallholders in Sri Lanka. A stratified random sampling methodology was employed in selecting farmers. The results showed that extension contacts, education level and experience with rubber farming have significant positive impacts on the probability of adoption. Extension was found to have the biggest impact with the highest estimated elasticity. The current study employed similar stratified sampling procedure and logit model to obtain the sample and to analyze the effect of participation in group-based financial institutions respectively.

Asfaw and Admassie (2004) studied the role of education on the adoption of chemical fertilizer under different socio-economic environments in Ethiopia. They used stratified random sampling method in selecting the sample to take into account the gender of the household head. Using logit model, the results showed that education, environment, value of livestock and credit have positive and significant influence on adoption of fertilizer. The study found that the impact of education on the probability of farmers' adoption of chemical fertilizer is more than twice in the relatively backward areas than in the relatively modern areas. The current study applied a similar sampling procedure to obtain the study sample. This study has also applied the logit model approach.

3.3 Modelling and Data Analysis

The data generated by this study was analyzed using descriptive statistics, logit regression and gross margin analyses.

The study focused on describing the adoption trend of the major beekeeping technologies in the study area as influenced by the beekeepers' participation in group-based financial institutions. Primary data was used to estimate the beekeeper's decision to participate in group-based financial institution and how participation influences his/her beekeeping technology adoption decisions. This was done using independent logit regression models. Also analyzed was honey gross margin and input intensity from specific beehive technology for the 2004/2005 honey production period.

3.4 Descriptive Analysis

Descriptive statistics were used to describe the adopters' socio-economic characteristics, the attributes and pattern of resource utilization and investment in the various beehive technologies over time by beekeepers participating in group-based financial institutions and non-participating beekeepers. The statistics used were frequency distributions, means and variances.

χ^2 (Chi-square) test. It was hypothesized that there was no variation in technology use among beekeepers participating in and those not participating in group-based financial institutions. As defined earlier, participation in group-based financial institution refers to a situation whereby beekeepers acquire financial services (such as credit) and investment management skills from a financial source using the joint liability towards the improvement of beehives owned and honey output. When more beekeepers participating in group-based financial institutions use improved beehive technologies as opposed to non-participating beekeepers, group-based financial institutions could be said to have an influence on the variation. The frequencies of beekeepers participating in and those not participating in group-based financial institutions on the use of various beehive technologies was assessed to establish whether there is any variation among the two categories in the study area. The significance of the variations was analyzed using the χ^2 test. The χ^2 statistic was tested at 0.1 significance level or better. The hypothesis of no variation in the adoption of various technologies among the two groups was rejected in favour of the alternative if it did not conform to the expected.

3.5 Logit Model analysis for Participation in Credit Programmes

The beekeeper's decision to participate in group-based financial institutions programmes was modeled as a discrete occurrence, 1 if the event occurs and 0 otherwise. A logit model was developed to study the factors influencing the participation in group-based financial institutions. It was hypothesized that beekeeper's socio-economic characteristics influence participation decision. To model beekeeper's participation in group-based financial institution, the following equation (Herath and Takeya, 2003) was specified

$$D^* = \alpha\ g_i + E_i \qquad (7)$$

Where

D_i^* = the dependent variable (1 if participation occurs, 0 otherwise).

α' =a vector of parameters to be estimated

g_i =a vector of beekeeper attributes and

E_i =error term

The estimate of probability of a beekeeper participating in group-based financial institution was obtained. This probability, given the beekeeper's socio-economic characteristics (g) was, P (D_i^*=1|g), and specified as

$$\text{Prob}(D_i^*=1|g_i) = \frac{1}{1+e^{-(\alpha g_i+E_i)}} = \frac{e^{\alpha g_i+E_i}}{1+e^{-(\alpha g_i+E_i)}}$$

Where $\gamma < \alpha g_i < \gamma$

The probability of not participating in credit programme, P(D_i*=0|g_i), was therefore,

$$P(D_i^*=0|g_i)=1-P(D_i^*=1|g_i)=1-\left[\frac{e^{\alpha g_i+E_1}}{1+e^{\alpha g_i+E_1}}\right]$$

$$=\frac{1}{1+e^{\alpha g_i+E_1}}$$

The relative odds of participating versus not participating in a credit programme is given by

$$\frac{P(D_i^*=1|g_i)}{P(D_i^*=0|g_i)}=\frac{\left[e^{\alpha g_i+E_1}\right]\left[1+e^{\alpha g_i+E_1}\right]}{e^{\alpha g_i+E_1}} \quad =e^{\alpha g_i+E_1}$$

By taking the logarithms of both sides,

$$\text{Ln}\frac{P(D_i^*=1|g_i)}{P(D_i^*=0|g_i)}=\alpha g_i+E_1 \qquad (8)$$

The maximum likelihood approach was then used to estimate the above equation.

3.6 Logit Model Analysis for Beehive Technology Adoption

The beekeeper's beehive technology adoption decision was modeled as a discrete occurrence, 1 if the event occurs and 0 otherwise. A logit model was developed to study the factors affecting the improved beekeeping technology adoption. It was hypothesized that access to group-based financial institution, beekeeper and technology attributes affect the adoption decision. To model the adoption of improved technology, the following simultaneous equation was specified

$$Y_i^*=\beta' X_i+\gamma D+E_2 \qquad (9)$$

Where

Y_i^* = the dependent variable (1 if adoption occurs, 0 otherwise).

β=a vector of parameters to be estimated

X_i=a vector of beekeeper and technology-specific attributes and

D=access to group-based financial institutions

γ=coefficient of access to group-based financial institutions

E_2=error term

Access to group-based credit programme, *D*, is endogenous in the technology adoption model specified above and was bound to present potential simultaneity bias (Kumar, 1994; Smale *et al.*, 1995) if used as a regressor in the adoption equation (Zeller *et al.*, 1997b). The problem was envisaged because unmeasured beekeeper-level variables affect both access to group-based credit programme, *D* and the adoption of technology, Y_i^*. With the resulting endogeneity, logit regression of Y_i^* on access to group-based credit programme, *A* was likely to result in inconsistent estimates. For consistent estimation, a variant of the standard sample selection model was applied:

$$D^* = \alpha g + E_1 \quad (10)$$

$$Y_i^* = \beta' X_i + \gamma D + E_2 \quad (11)$$

D=1 if *D**>0 and *D*=0, otherwise.

Equation (7) states that, *D,* access to group-based credit programme depends on a set of beekeeper-specific variables represented in *g* (in Eq. 10). Equation (11) state that adoption, Y_i^*, depends on another set of beekeeper and technology-specific variables, *X*, and access to group-based credit programme, *D*. The problem of simultaneity bias arises when equation (11) is estimated by logit. This is because the random error terms E_1 and E_2 are likely to be correlated, since unobserved beekeeper variables affect both *D* and Y_i^*. A two-stage procedure (recursive econometric model) was therefore used to produce unbiased and consistent estimates of adoption, given that access to group-based credit programme is an endogenous variable (Zeller *et al.*, 1997b). In the first stage, an estimate *D** of *D* was obtained by logit maximum likelihood method for equation (10). The predicted probability was then used in the second stage (logit model) to obtain estimates of the probability of adoption, Y_i^*, for traditional and improved technologies. This probability of an individual beekeeper adopting an improved beekeeping technology, given access to group-based credit programme (*D**), beekeeper and technology-specific characteristics (*X*) was, P ($Y_i^* = 1|X, D^*$), and specified (Herath and Takeya, 2003) as

$$\text{Prob}(Y_i = 1/X_i) = \frac{1}{1 + e^{-(\beta' X_i + \gamma D' + E_2)}} = \frac{e^{\beta' X_i + \gamma D^* + E_2}}{1 + e^{-(\beta' X_i + \gamma D' + E_2)}}$$

Where $\alpha < \beta' X_i + D^* < \alpha$

The probability of not adopting an improved technology, P($Y_i^* = 0|X, D^*$), was therefore,

$$P(Y_i^* = 0|X, D^*) = 1 - P(Y_i^* = 1|X, D^*) = 1 - \left[\frac{e^{\beta' X_i + \gamma D^* + E_2}}{1 + e^{\beta' X_i + \gamma D^* + E_2}}\right]$$

$$= \frac{1}{1 + e^{\beta' X_i + \gamma D^* + E_2}}$$

The relative odds of adopting versus not adopting an improved beekeeping technology is given by

$$\frac{P(Y_i^1 = 1 | X, D^*)}{P(Y_i^1 = 0 | X, D^*)} = \frac{\left[e^{\beta^1 X_i + \gamma D^* + E_2}\right]\left[1 + e^{\beta^1 X_i + \gamma D^* + E_2}\right]}{e^{\beta^1 X_i + \gamma D^* + E_2}} = e^{\beta^1 X_i + \gamma D^* + E_2}$$

By taking the logarithms of both sides,

$$\text{Ln} \frac{P(Y_i^1 = 1 | X, D^*)}{P(Y_i^1 = 0 | X, D^*)} = \beta X_i + \gamma D^* + E_2 \qquad (12)$$

The maximum likelihood approach was then used to estimate the above equation.

3.7 Empirical Model specification

Both the dependent and independent variables were specified in this analysis. The dependent and explanatory variables were hypothesized and measured as follows.

3.7.1 The Dependent Variable

Participation in group-based financial institutions programmes and adoption of the beehive technologies were taken as the dependent variable for the study. Beekeepers were asked whether they were participating in group-based financial institutions programmes or not (PARTINDE) and the type of beehive technologies they use for their honey production. The types of the beehives with the beekeepers formed the choice set. The four principal technologies used by the beekeepers were identified as *log* (LOG), *Kenya Top Bar Hive* (KTBH), *Langstroth* (LANGS) and *Soil block* (SOILBLO) hives. A common choice set consisting of the four alternative technologies was assumed. Participation in group-based financial institutions programmes and adoption of each of these technologies was measured in dummy (1 if the event occurs, 0 otherwise).

3.7.2 The Explanatory Variables

Thirteen variables were hypothesized to affect participation in group-based financial institutions and adoption of the above technologies variously. Below is how they were hypothesized and measured.

EDUC: Education was measured by the highest number of years of formal schooling completed by the beekeeper. It was hypothesized to have a positive sign (+).

GENDER: Gender of the beekeeper was measured as dummy, equals 1 if the beekeeper was male and 0 otherwise. Gender was hypothesized to influence adoption positively (+).

OFFARMI: Off-farm income was hypothesized to have a positive (+) or negative (-) effect on the adoption of beehive technology. Beekeepers with off-farm income were given a dummy 1 and 0 otherwise.

AGE: Age was measured in number of years lived. The variable age was hypothesized to have a positive (+) effect on adoption of technology.

EXPER: Experience was hypothesized to have a positive (+) or negative (-) effect on the decision to adopt a beehive technology. It was measured in number of years in beekeeping activity.

MKTDIST: Distance to the nearest market was hypothesized to have a negative effect (-) on the adoption decision. This was measured in kilometers from the residence of the farmer to the nearest market and hours however time was not partially related to the dependent variable hence was dropped.

EXTEN: Extension was hypothesized to have a positive (+) influence on the adoption of improved beehive technology. Taking a value of 1 or 0, with 1 denoting the presence of extension contact and 0 the absence of extension contact the influence of extension was measured.

LIVEST: Livestock was measured in total livestock units (TLU) of all the species of livestock owned by the beekeeper. This was calculated using the conversion factors for converting livestock heads into standard units (FAO, 1986). The units for various animals are presented in appendix 6. It was hypothesized to have a positive (+) influence on adoption decision.

HOUTPUT: Honey output per year was hypothesized to positively (+) influence the adoption of beehive technologies. This was measured in total amount of honey achieved in one year in beekeepers units including the amount sold, consumed at home, given out to relatives and friends and losses. This was standardized later into one unit, Kilogrammes.

VARICOST: The extra costs (variable costs) associated with the use of improved technology per year was hypothesized to negatively (-) influence the adoption of a technology. This was measured in Kenya shillings.

PARTGBFI: Participation in group-based financial institution was hypothesized to have positive (+) effect on the beehive technology adoption decision. This was measured in predicted probability (*PARTINDE*) of the beekeeper accessing group-based credit programme (was limited to values from 0 to 1).

NUMHIVES: The number of hives was hypothesized to have a positive (+) effect on the decision to adopt a technology. This was measured in actual number of hives possessed by the beekeeper.

COSTHIV: The cost of the hive was hypothesized to have a negative influence on the adoption decision. It was measured in Kenya shillings.

The reliability of the specified models was tested by use of χ^2statistic. The χ^2 statistic was tested at 10% significance level or better. The hypothesis that individual explanatory variables do not have influence on the dependent variable was tested at 10% level or better using the t statistic. It was rejected in favour of the alternative if it did not conform to the expected.

3.8 Profitability Analysis

Profit is one of the elements of utility that beekeepers aim to maximize when making the decisions to invest in a technology. An investment cannot make economic sense if the benefits are not attractive enough to pay for the allocated factors of production. High profits coupled with low additional costs, the opportunity cost of the investment and the burden imposed on the farmer by the technology is therefore assumed to influence the farmers' decision to use an innovation. This shows that farmers are likely to choose only the technologies that suit their needs and circumstances.

In profitability analysis, there are two types of profits that can be analyzed, the net revenue (pseudo-profit) and the economic profit (Carter, 1989). In the analysis of the economic profit, depreciation costs and payments to fixed factors including land, family labour and management are accounted for. Assumption is made of an area of perfectly operating markets, where farmers are able to rent their fixed factors out at a 'market' price. In this case the economic profit is expressed mathematically thus:

$$\pi = TI - TE \qquad (13)$$

Where

π = Profit, TI=Total income, TE=Total expenses

On the other hand, in the analysis of net revenue, depreciation costs and payments to fixed factors are not accounted for. Here an area of imperfectly operating markets is assumed since farmers are not able to rent their fixed factors out at a 'market' price. This is because going prices for a fixed factor might well overstate the real opportunity costs of using that factor in production. Therefore valuing profits using market prices for inputs might bias the results because deviations of profits will be due to differences in farmer endowments and access to markets, particularly the market for capital. Due to this market imperfection, farmers are seen to make profit decisions based on the shadow values of their fixed assets, making quantity a reasonable proxy for the true price of those inputs.

For this study, net revenue approach was found appropriate because of the imperfection in the study area. Budgets are applied to analyze the financial and economic outcomes of a technology by computing the costs and returns associated with it. The analytical methods include gross margin analysis (GM) and income statement analysis. This involves identifying the gross returns and variable costs of production for a given enterprise or set of enterprises. Computationally the gross margin is specified thus:

$$\mathbf{GM = TR - TVR} \qquad (14)$$

Where, GM=Gross Margin, TR=Total revenue, TVC=Total Variable Costs

3.8.1 Partial budget and input intensity

The gross margin was used as a measure of profitability of each technology and was worked out from a partial budget. It was important to carry out this analysis because farmers are concerned with the costs and benefits from a technology. This took into account only those costs and returns that were directly incurred and received in the short run (one year) from each technology.

Costs and returns that were not directly realized were excluded from the analysis because of the difficulty in their measurement due to market imperfection in the study area which distorts the factor prices. From the interviewed beekeepers it was found that no physical inputs were used in the short run apart from labour inputs. The budget considered:-

1. The output from each technology
2. The labour used in the production process

The budget components were expressed on per technology basis. The price of honey used in the calculations was the average of the after harvest prices received by the interviewed beekeepers during the year 2004/2005. The cost of labour used per technology was obtained from the surveyed beekeepers in man-hour. The average opportunity cost of labour in the area was taken as Kshs 100 per 8 man-hours. The purpose of the analysis was to find out how the gross margin from investment in a technology increases as the amount of working capital invested increases. This was then used to compare the technologies and to find out the ones with high input intensity (gross revenue/working capital).

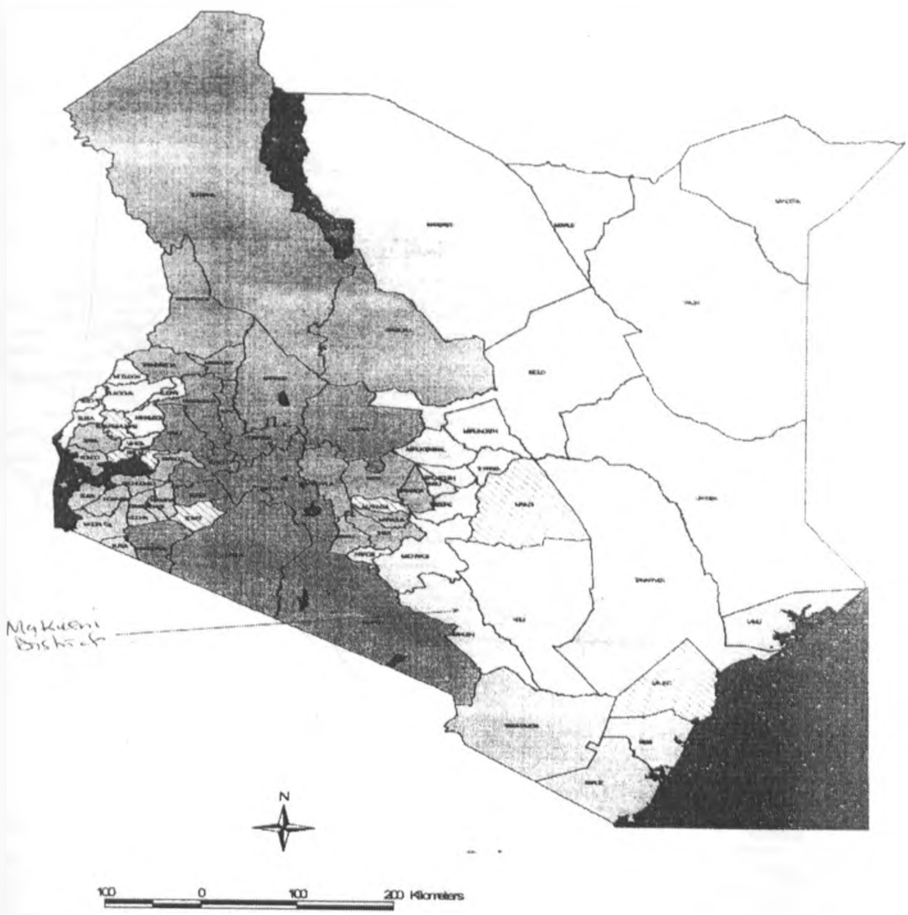
3.9 The Area of Study

The study was carried out in Makueni district of Eastern province. The district was commissioned in 1992 after splitting Machakos district. It has seventeen administrative divisions making it the most partitioned in the province. With about 92,980 farm families, the district has a population of about 743,850 with 60-65 percent of the farm families living below the poverty line that is 1,500 shillings per month (Muricho, 2002; District GoK, 2003c). The district covers a total area of 7440 square kilometers and lies between latitudes 1^0 35′ South and longitude $37^0$30′ East.

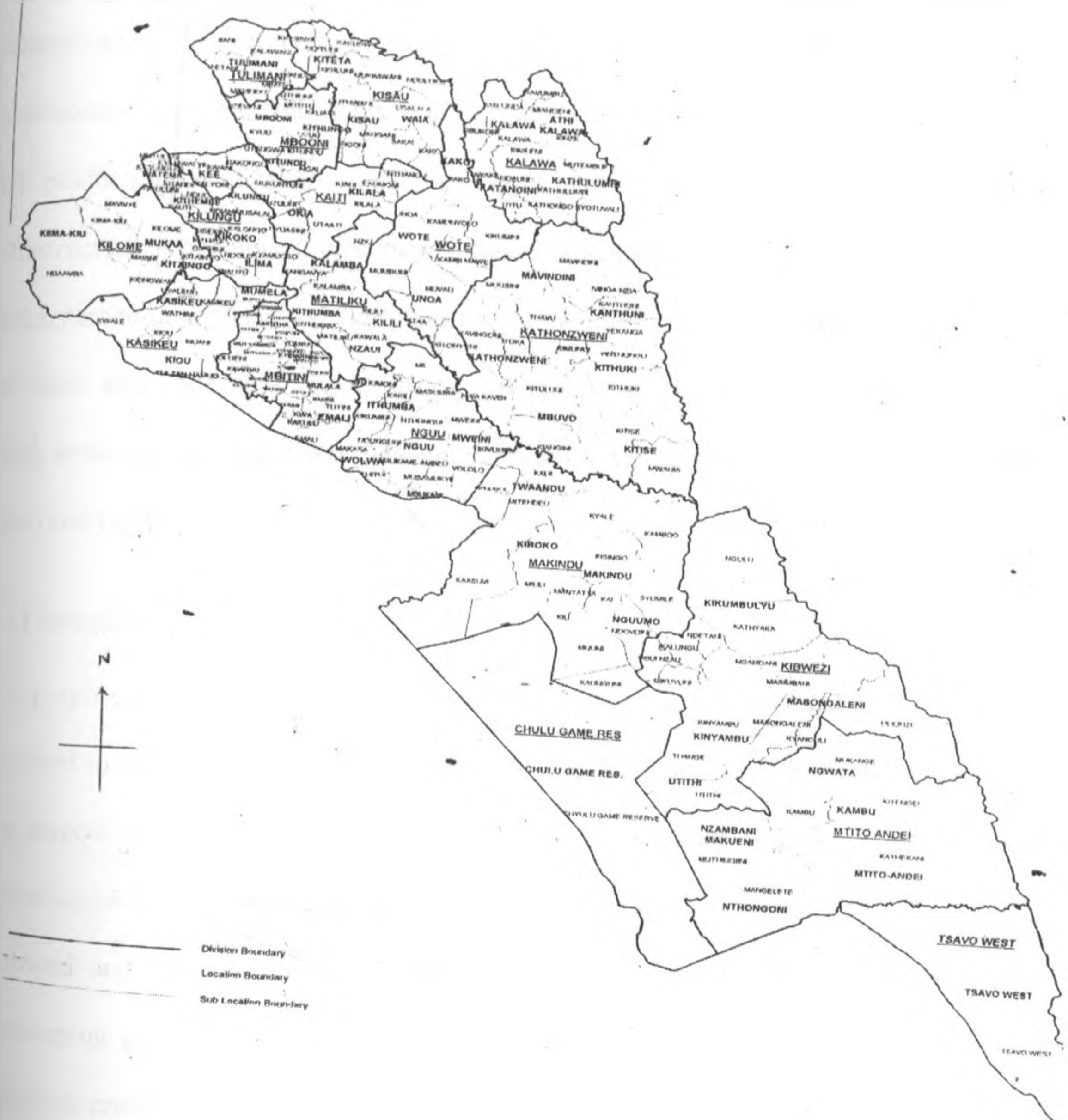
The Northern and Central parts of the district receive good rains while the Southern lowlands are dry and hot. The area is characterized with low unreliable annual rainfall that is slightly over 1000mm received in two seasons. Rainfall is bimodal with long rains coming in March/May while short rains in November/December. The temperatures are usually high during the day. About 75 percent of the district is arable but only 50 percent is being utilized. The area has red clay soils, sandy soils and black cotton soils distributed according to underlying parent rocks (Peeler and Omore, 1997; Muricho, 2002).

The major economic activity in the district is agriculture mainly on small-scale, with large scale farms of over 8 hectares, accounting only for 9.1 percent of the district's total households. Over 31% of the total households in the district have less than 1 hectare of land. Most farmers in the district practice mixed farming. Major food crops grown are maize, beans, pigeon pea and cowpea. Small scale irrigation of horticultural crops is carried out in some parts of the district having reliable water sources. Livestock activities revolve mostly around cattle, sheep, goats and beekeeping. Beekeeping activity ranks sixth as a major source of household income in the District after crop cultivation, wage employment, livestock keeping, business and transfers from relatives/friends respectively (Swisscontact, 2005). Markets/marketing (low prices for farm produce, lack/poor markets for products and low demand for farm produce) and finance (insufficient working capital and finance for equipment/fixed assets) ranks first and second amongst the major constraints facing farming enterprises in the district. The area lies in agro-ecological zone V (Mutungi *et al.*, 1996).

Map 1: The location of Makueni District in Kenya



Map 2: Administrative boundaries of Makueni District



3.10 Data and Data Sources

The study made use of both secondary and primary data. Secondary data were collected from several sources, among them Ministry of Livestock Production and Fisheries Development, Ministry of Gender, Culture and Social Services, beekeeping publications from Internet sources and libraries. Primary data consisted of beekeepers survey. The beekeepers survey data was collected using a structured questionnaire (see appendix 1). The survey investigated beekeeper's socio-economic characteristics (such as age, education, gender and off-farm income), beekeeping and productivity indicators (such as output and input use) and meso level factors like infrastructure. A reconnaissance survey was conducted in the study area to identify the type of beekeepers to be interviewed while pre-test of the questionnaire was done using 6 beekeepers in the same area. The data was collected through interviews conducted by trained enumerators using structured questionnaires. The enumerators were supervised by the researcher. The single-shot (visit) approach was used to collect the data (August/September 2005).

3.11 Sampling Procedures

The purpose for sampling was to generate data necessary for representation of the factors that are assumed to determine the adoption process of improved beekeeping technologies. In particular, the purpose was the effects of group-based financial institution in making improved beekeeping technologies acceptable to beekeepers. The beekeeper survey covered three divisions; Makindu, Kibwezi and Mtito Andei which were selected purposively. The sample was drawn from beekeeping groups registered with the Ministry of Gender, Culture and Social Services. The selection criteria were based on group membership and possession of beehives so as to capture both participation and production patterns of the beekeepers.

There were two sets of samples; a sample of beekeepers in the groups participating in group-based financial institutions and a sample of beekeepers in the groups not participating in group-based financial institutions. The stratified random sampling procedure was necessary so as to preserve homogeneity within the two groups (Nachmias and Nachmias, 2002) and to facilitate the descriptive comparison of socio-economic characteristics between the two groups. This aimed at establishing whether there is conspicuous unique difference between the two groups.

From each division selected, 3 locations were randomly selected. Within each selected location a list of all registered beekeeping groups was stratified into groups participating in group-based financial institutions and those not participating. From the membership list, 50 percent of members in each group participating in group-based financial institutions to be interviewed were selected by use of a sampling interval. The first case was picked randomly and then the subsequent cases using an interval. To get equal sample of members not participating in group-based financial institutions to be interviewed, 19 percent of members in each group not participating in group-based financial institutions were selected using the procedure applied in the first set of sample giving a total sample of 130. The sampling procedure is summarized in table 3.

Table 3.1: Distribution of the sample

		Name of Groups		No. of members		Sample selected	
Division	Location	Participating	Non-participating	participating	Non-participating	Participating	Non-particip
Mtito A	Kambu		Kitengei		24		4
			Kyeni		13		2
			Tuthukanie		8		1
	Ngwata	Kamina thina		22		11	
		Kikwasuni		7		3	
		Uini		17		9	
		Wikwatyo		10		5	
	Mtito Andei		Muungano		20		4
			Kweta		11		2
			Nzwii		17		3
			Mwangaza		26		5
			Darajani		10		2
			Wendo		23		4
	Nthongoni						
	Nzambani						
Kibwezi	Kinyambu		Muumo		37		7
			Wayani		20		4
			Ngonza		15		3
			Makinya		18		3
	Utithi	Ufunguo		35		18	
	Kikumbulyu		Nzavoni		27		5
	Masongaleni						
Makindu	Nguumo		Kabefa		36		7
		Nguumo		39		19	
	Kiboko		Muisuni		25		5
	Twaandu		Nthia		21		4
TOTAL	**12**	**6**	**17**	**130**	**351**	**65**	**65**

Groups participating were 6
Groups not participating were 17
Members participating were 130
Members not participating were 351
Sample selected
Sample of participating members 65
Sample of non-participating members 65
Sample total 130
Source: Survey 2005

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

This section presents the results of both the descriptive and empirical analyses of beekeepers' participation in group-based financial institutions and the influence of participation on the decision to adopt various beehive technologies. Attempt is made to establish the nature of relationships between various factors (especially participation in group-based financial institutions) and adoption of beekeeping technologies. It also presents the results of profitability analysis for the various beehive technologies used in the study area. The section begins with descriptive analysis (table 4.1 and 4.2) of technology adoption patterns between beekeepers participating and those not participating in group-based financial institutions and the socio-economic characteristics of the two categories in the study area. This is followed by presentation of the estimated logit model regression results for participation in group-based financial institutions (in table 4.3) to determine the factors that influence the beekeeper's participation decisions. The binary choice logit model estimation results for the influence of beekeeper's participation in group-based financial institutions on the decision to adopt the beehive technologies identified in the study area are presented in tables 4.4, 4.5, 4.6 and 4.7. All the logit models were estimated using NLOGIT econometric software, version 3 (Green, 2003). A summary and the predictive ability of the five models (model of participation in GBFIs, log, KTBH, Langstroth and Soil Block adoption) are presented in table 4.8 and table 4.9 respectively. Finally the section presents the results of profitability analysis (table 4.10) showing the mean gross margins and input intensity for each beehive technology in use.

4.2 Participation in group-based financial institution and adoption of beekeeping technologies

The survey identified three group-based financial institutions supporting improved honey production technology acquisition among beekeeping groups, namely Belgium Technical Cooperation (BTC), Heifer International (HI) and German Agro-Action (GAA), and four beekeeping technologies in the study area (namely l*og*, *KTBH*, *Langstroth* and *Soil block*). Table 4.1 summarizes sampled beekeepers' participation in the various institutions and distribution of technology use.

Table 4.1: Distribution of technology users by participation in group-based financial institutions

	Distribution of technology users							
	LOG		KTBH		LANGSTROTH		SOIL BLOCK	
Financial Institutions disaggregated	No. of users	%	No. of users	%	No. of users	%	No. of users	%
Belgium Technical Cooperation	25(3)	89	10(18)	36	11(17)	39	2(26)	7
Heifer International	16(2)	89	2(16)	11	10(8)	55	2(16)	7
German Agro-Action	17(2)	89	2(17)	11	17(2)	89	2(17)	7
Non-involvement	62(3)	95	5(60)	8	17(48)	26	21(44)	48
Total	120(10)		19(111)		55(75)		27(103)	
Significance (χ^2)	p<.629		p<.005		p<.000		p<.014	
Financial institutions aggregated								
Participation in fin. Inst.	58(7)	89	14(51)	22	38(27)	58	6(59)	9
Non-participation	62(3)	95	5(60)	8	17(48)	26	21(44)	48
Total	120(10)		19(111)		55(75)		27(103)	
Significance (χ^2)	p<.188		p<.025		p<.000		p<.001	

Note: The numbers in parentheses represent non-technology users in the category. The p values are probability values exhibiting the exact levels of significance. For example, p<.000 would mean significant at less than one per cent level. Small probability values (p<.188) in the Table indicate the rejection of null hypothesis that the two groups are same and vice versa.

Source: Survey results, 2005

It was hypothesized that there was no significant difference in technology use among beekeepers participating and those not participating in group-based financial institutions. As is depicted in the above table, 89 percent of the respondent beekeepers participating in the programme run by BTC use log hives, 89 percent of those participating in HI use log hives, 89 percent of those participating in GAA use log hives and 95 percent of the respondents in the group not participating in any group-based financial programme use log hives. The statistical test of significance using the χ^2 test found that there was no significant variation ($p<.629$) in the distribution of beekeepers using log hives among the members of the programmes run by BTC, HI, GAA and that of the respondents not participating in financial institution programmes. When the respondents participating in the three programmes were aggregated the distribution was still 89 percent and there was no significant variation (($p<.188$) with that of respondents from groups not participating in financial institution programmes. The study therefore failed to reject the hypothesis that there was no significant difference in log hive use among beekeepers participating and those not participating in group-based financial institutions. This shows that log hive use is prevalent among all categories of beekeepers and hence all beekeepers in the study area are likely to be using the technology. As a traditional technology, the high prevalence in use could be attributed to cumulated indigenous knowledge base on its use which has been passed on from one generation to another over the period. This fact is corroborated by primary data results, which showed that respondent beekeepers participating in group-based financial institution programmes and those not had an average age of 43 years and 44 years respectively, and experience in beekeeping of 12 years and 11 years respectively. Additionally, 63 percent of the respondents participating in financial institution programmes indicated that they use log hive because it is cheap and available, 27 percent use it because it is not involving while 10 percent because of good output against 77 percent of respondents in the category not participating in group-based financial institution programme who use it because it is cheap and readily available, 16 percent because it is not involving and 7 percent because of its good output. All these points to why the technology is prevalent among respondents from all the categories.

According to the survey, 36 percent of respondent beekeepers participating in BTC had KTBH hives, 11 percent of respondents in HI, 11 percent of those in GAA and a paltry 8 percent of those not participating in any financial institution programme. The variation in the distribution of KTBH hive use among the respondents in various categories was found to be significant ($p<.005$). With aggregation of the respondents participating in various financial institution programmes, the distribution of KTBH use was 22 percent versus 8 percent of respondents from category not participating in any financial institution programme. The variation in distribution of use was still significant ($p<.025$). The hypothesis that there was no significant difference in KTBH hive use among beekeepers participating and those not participating in group-based financial institutions was rejected. This means that more beekeepers using KTBH are participating in group-based financial institutions. These beekeepers go for it to help better their livelihoods due to its documented better returns. Even though the technology is said to offers higher returns, it requires high initial investment costs and management skills which are rare among the low-income beekeepers in the study area (Nelson, 2000). This implies that beekeepers most likely acquire KTBH as a result of motivation of financial facilities and investment management skills training offered by group-based financial institutions programmes.

Majority of beekeepers participating in GAA programme (89 percent) had Langstroth hive, 55 percent of those in HI, 39 percent of those in BTC and 26 percent of respondents from the category not participating in any group-based financial institution programme. The variation in this distribution was highly significant (($p<.000$). The wider variation in the distribution among the three programmes is attributed to internal programme design governing the promotion and financing of the technology acquisition. Aggregation of the respondents from the three programmes still showed that 58 percent of beekeepers participating in group-based financial institution programmes had Langstroth hives against 26 percent of the respondent beekeepers not participating in any financial institution programme. The variation in the aggregated distribution of Langstroth hive use among the two categories was still highly significant ($p<.000$). The hypothesis that there was no significant difference in Langstroth hive use among beekeepers participating and those not participating in group-based financial institutions was rejected. Langstroth hive technology is therefore more prevalent among beekeepers participating in financial institution programme. As was the case with KTBH hive, Langstroth hive is more expensive despite its superior attributes and hence require high initial capital investment and investment management skills. Group-based financial institutions therefore facilitate the acquisition of Langstroth hives through their credit facilities and capacity building.

The survey indicated that 7 percent of the respondent beekeepers participating in BTC, 7 percent in HI, 7 percent in GAA and 48 percent of the sample beekeepers not participating in any financial institution programme use Soil block hive. The distribution among the three financial institution programme participants and none programme participants was significant ($p<.014$). The aggregated distribution of Soil block use among respondents participating in financial institution programmes was 9 percent against that of none participants of 48 percent. Distribution of soil block use was very low among beekeepers accessing the three group-based financial institutions. This means that it is not an improved technology of choice. Most beekeepers cited high labour requirements as the reason though it is a technology that deters thieves and also overcomes the problem of high temperatures. The variation in the distribution of Soil block hive use between aggregated respondents participating in financial institution programmes and none programme participants was still highly significant ($p<.001$). Therefore the hypothesis that there was no significant difference in Soil block hive use among beekeepers participating and those not participating in group-based financial institutions was rejected. This implies that very few beekeepers participating in group-based financial institution programme as opposed to those not participating in any group-based financial institution programme use Soil block hive.

In terms of strategies combinations, 43 percent of the respondents participating in group-based financial institutions owned *log* and *Langstroth* hives, 15 percent *log* and *KTBH* hives, 6 percent *log*, Langstroth and soil block hives, 3 percent log, KTBH and Langstroth hives, 1.5 percent log and soil block hives while 30.8 percent owned either a *log, KTBH, Langstroth* or *soil block* with majority owning *Langstroth*. Amongst the respondents from the groups not participating in the financial institutions 18.5 percent owned l*og* and *Langstroth* hives, 4.6 percent l*og* and K*TBH* hives, 21.5 percent l*og* and *soil block* hives, 3.1 percent log, *Langstroth* and *soil block* hives, 1.5 percent *log, KTBH, Langstroth* and *soil block* hives, 6.2 percent *log* and *soil block* hives while 44.6 percent owned either *log, KTBH, Langstroth* or *soil block* hive with majority owning *log* hive.

4.2.1 Descriptive analysis of Beekeepers socio-economic factors

From the beekeepers sampled in the study area, socio-economic characteristics, number of hives owned, input use, distance to the nearest market and honey output were used to determine the attributes of a beekeeper in each category (those participating in group-based financial institutions and those not). The average values for beekeepers participating in group-based financial institutions were then used to estimate participation, influence of participation on the adoption of improved beehive technologies and profitability of the various beehive technologies (Zeller *et al.*, 1997b). Before the average values were worked out, the data was cleaned of outliers (extreme entries/ responses), which could skew the data. Using the above factors generated from the sample, the beekeepers participating in group-based financial institutions and those not participating were described and compared as shown in table 4.2.

Table 4.2: Descriptive statistics of selected variables

VARIABLE	SYMBOL	N ALL OBS.	MIN ALL OBS.	MAX ALL OBS	MEAN ALL OBS.	MEAN PART GBFI (N=65)	MEAN NON-PART (N=65)	STD. DEV ALL CASES	P-VALUE FOR EQUAL MEANS
Age of the beekeeper (years)	AGE	130	18	80.00	43.52	42.80	44.00	12.98	0.2
Gender of the beekeeper (dummy)	GENDER	130	0.00	1.00	0.35	0.25	0.45	0.48	0.0
Education (years of formal schooling)	EDUC	130	0.00	14.00	6.60	5.37	7.80	3.97	0.0
Off-farm income (dummy)	OFFARMI	130	0.00	1.00	0.50	0.43	0.569	0.50	0.1
Livestock (Tropical Livestock Units-TLU)	LIVEST	130	0.00	29.65	3.60	2.015	5.19	4.30	0.0
Experience in beekeeping (years)	EXPER	130	1.00	65.00	11.44	11.80	11.06	12.14	0.36
Distance to the nearest market (kms)	MTKDIST	130	0.00	36.00	8.93	7.36	10.49	6.06	0.0
Extension visit the in last 5years (dummy)	EXTEN	130	0.00	1.00	0.69	0.80	0.58	0.46	0.04
Number of hives owned by the beekeeper	NUMHIVES	130	0.15	20.00	3.75	1.87	3.07	3.50	0.15
Honey output per year (kgs)	HOUTPUT	130	0.00	37.50	6.65	6.05	7.25	5.73	0.26
Variable costs per hive per year (Kshs)	VARICOST	130	0.00	460.00	96.53	91.90	101.00	98.49	0.70
Cost of each hive (Kshs)	COSTHIV	130	0.00	1875.00	701.21	755.00	646.80	503.38	0.00

Source: Survey results, 2005

Age of the beekeepers age

The average age of all the respondents was about 44 years. The minimum and the maximum age were respectively 18 and 80 years. The high average age is not unique because beekeeping is still identified mostly with the older members of the society. Nevertheless, there was no significant difference (p<.536) between the average age of beekeepers participating in group-based financial institutions and non-participants. The average age of beekeepers participating in group-based financial institutions and that of non-participants was 43 and 44 years respectively. It implies that there is very minimal difference in average age between beekeepers participating in group-based financial institutions and those not.

Gender of the beekeeper

The mean value of gender was 0.35. The minimum and the maximum were 0 and 1 respectively. This indicates that male beekeepers formed 35 percent of the sample respondents with female representing 65 percent of the sampled respondents. When the gender difference was considered between the group-based financial institution participants and non-participants it was found that the mean gender was 0.25 and 0.45 respectively. When this difference was tested for significance, it was found to be significant ($p<.016$). This indicates that few men participate in the group-based financial institutions (25 percent) as compared to women. It also showed that there are more male beekeepers in the groups not participating in group-based financial institutions than in the groups participating. It can be implied that there are more male beekeepers in the groups not participating in group-based financial institutions because these groups deal mostly in log hives. These hives are easily made by members and their management practices like harvesting also suits men. Based on experience, indigenous technical knowledge on beekeeping and attitude, most men form or join groups initially dealing with local technologies which they understand better. However, female beekeepers join or form groups to acquire improved technologies for enhanced income and thus participate in group-based financial institutions to facilitate this acquisition. They are also seen to evaluate fast the potential benefits of a new technology and make rational decision to invest in them. This shows that there is difference in gender distribution between beekeepers in the category participating in group-based financial institution and non-participating category.

Education of the beekeeper

The average years of respondent beekeepers' formal schooling was 7 years. The minimum and the maximum were 0 and 14 years respectively. When the number of years of formal schooling was considered between the group-based financial institution participants and non-participants, it was found to be respectively 5 and 8 years respectively. This difference was statistically significant (p<.000). This shows that there is a difference in education level of the beekeepers participating in group-based financial institutions and those not. Hence education plays a role in influencing participation in group-based financial institutions.

Access to off-farm income

The average access to off-farm income value was 0.5. The minimum and the maximum values were 0 and 1 respectively. This shows that 50 percent of the respondents had off-farm sources of income. When the off-farm income was analyzed between the group-based financial institution participants and non-participants, it was found to be 0.43 and 0.57 respectively. This means that 43 percent of the beekeepers participating in group-based financial institutions had off-farm source of income as opposed to 57 percent of those in the groups not participating in the programmes. However, when this difference was tested for significance it was found to be statistically none significant (p<.116). This suggests that there is minimal difference in access to off-farm income.

Number of Livestock heads owned

The average size of livestock herd measured in tropical livestock units (TLU) for the respondents was found to be 3.61. The minimum and maximum TLU were 0 and 29.65. The mean TLU between group-based financial institution participants and non-participants was 2.02 and 5.20 respectively. Since this was used to reflect the wealth status of the respondents, it reveals that there is a difference in physical resource endowment between beekeepers participating in and those not. This difference was tested and found to be statistically significant ($p<.000$).

Experience in Beekeeping

The mean beekeeping experience of the respondent beekeepers was about 11 years. The minimum and the maximum years of experience were 1 and 65 respectively. The average number of years of experience between beekeepers participating in group-based financial institution and those not was 12 and 11 years respectively. The difference was not significant ($p<.725$). This implies that there is slight difference in beekeeping experience.

Distance to the market

The average distance to the nearest market among respondents was 9kms from their residences. The mean distance for beekeepers participating in group-based financial institution and non-participating ones were 7kms and 10kms respectively. This difference was found to be statistically significant ($p<.003$). This shows that, most beekeepers participating in group-based financial institutions are nearer to the market than those not participating in the programme. This is key for marketing of their products.

Number of beehives owned

The average number of hives owned by all the respondents was found to be about 2. The minimum and the maximum average number of hives possessed by the respondents were .15 and 20 respectively. Beekeepers participating in group-based financial institutions and those not participating had an average of 2 and 3 respectively. This difference was found to be statistically significant (p<.051). This implies that beekeepers participating in group-based financial institutions have a higher number of beehives than those not participating in the programme.

Honey output per year

The average honey output per hive per year for the all the sampled respondents was 7kgs. The minimum and the maximum were 0 and 38kgs respectively. When the averages were analyzed for the beekeepers participating in group-based financial institutions and those not, it was found to be 6 and 7 respectively. However, this difference was not significant (p<.234). This suggests that there is minimal difference in average honey output per hive per year.

Variable costs per year

The average variable cost incurred by the all the sampled beekeepers per beehive per year was Kshs 97. The minimum and the maximum were 0 and Kshs 460 respectively. The analysis of the mean variable costs per beehive per year for beekeepers participating in group-based financial institutions and those not found the means to be Kshs 92 and Kshs 101 respectively. This difference was not statistically significant (p<.593). This implies that there is slight difference in variable costs incurred per hive per year.

Cost of beehive

The sample respondent beekeepers' mean expenditure on the acquisition of the beehive technology was found to be Kshs 702. The minimum and the maximum were 0 and Kshs 1875 respectively. The mean expenditure on beehive for beekeepers participating in group-based financial institutions and non-participating ones was Kshs 756 and Kshs 647 respectively. This difference was found to be statistically significant (p<.000). This shows that beekeepers participating in group-based financial institutions spend more to acquire beehive than the beekeepers not participating in group-based financial institutions beehives.

Access to extension services

The average access to extension services index was 0.69. The minimum and the maximum values were 0 and 1 respectively. This shows that 69 percent of the respondents had had contact with extension agents. When access to extension services was analyzed between beekeepers participating in group-based financial institution participants and those not, it was found to be 0.79 and 0.58 respectively. This means that 79 percent of the respondent beekeepers participating in group-based financial institutions had contact with extension agents as opposed to 58 percent for the beekeepers in the groups not participating. This difference was tested for significance and found to be statistically significant (p<.037).

4.3 Model Estimations for Participation in group-based financial institutions and adoption of beekeeping technologies

It was hypothesized that participation in group-based financial institutions influence the adoption of various beekeeping technologies. But since some factors that influence participation in group-based financial institutions also influence technology adoption decision, the problem of simultaneity was bound to rise if the binary participation in group-based financial institution is used to determine adoption. Participation was therefore determined and the non-random term, predicted probability of the beekeeper's participation in group-based financial institution used as an explanatory variable to estimate the influence of participation on adoption. Table 4.3, 4.4, 4.5, 4.6 and 4.7 presents the results of the logit models analysis for the beekeeper's participation in group-based financial institutions and adoption of four various technologies (*log, KTBH, Langstroth* and *Soil block*) respectively (see also appendix 4 and 5). The coefficients in the table are the predicted probability that the beekeeper would participate in group-based financial institution, *adopt log, KTBH, Langstroth* or *Soil block hive* technology based on a one unit increase in the value of the independent variable(s).

4.3.1 Logit Model Estimation Results for Participation in group-based financial institution

Participation in group-based financial institutions is modeled as an outcome of variables that either affects the supply side with the placement of the group-based financial institution or the demand side by asking for membership in the institution. The model attempts to account for the beekeeper's endowment in physical and human capital. It had been hypothesized that some seven factors had various forms of influence on beekeeper's decision to participate in group-based financial institutions. In the participation model presented in table 4.3, four of the seven variables were found to be statistically significant. The coefficient of the variable extension was statistically significant at .01 level of significant while the coefficients of the variable education level of the beekeeper, livestock herd size and distance to the market were significant at .05 level significance.

Table 4.3: Logit model Estimation Results for beekeeper's participation in group-based financial institution

Explanatory Variable	coefficient	Standard Error	b/st.Er	$P[\lvert Z \rvert > z]$
Constant	2.012**	.746	2.695	.007
Gender	-.770	.514	-1.499	.134
Education	-.147**	.062	-2.358	.018
Off-farm income	-.165	.463	-.357	.721
Experience in beekeeping	.012	.020	.603	.546
Market distance	-.088**	.041	-2.117	.034
Number of livestock owned	-.285***	.090	-3.166	.002
Extension services	1.203**	.485	2.479	.013
Model Statistics				
Log-likelihood function (β)	-65.344			
Restricted log likelihood (0)	-90.109			
Likelihood ratio (LR) test[b], -2[L(0)-L(β)]	49.530			
Pseudo R^2 (=1-LnL/LnL_0)	.275			
Percentage of correct prediction	76.900			
Chi-square statistic	49.109***			
P-value	.000			

*, ** and *** means significance at the10%, 5% and 1% level respectively.

[b] Likelihood ratio tests was conducted with 7 degrees of freedom.

Source: own calculations.

The coefficient of the variable extension (EXTEN) had the expected positive sign. This implies that probability of beekeeper's participation in group-based financial institutions improves with increase in contact with extension agents. This result shows that in order to expand the probability of participation in group-based financial institutions, more extension contacts will be necessary. This enables the beekeeper to access enough information on the services offered by the programmes run by group-based financial institutions, their advantages and the entry criteria. The result also compares well with an earlier observation (section 4.2.1) that the number of beekeepers having had contact with extension agents was high (80 percent of the sample respondent beekeepers participating in group-based financial institutions versus 58 percent for non-participating beekeepers).

The results also indicate that education level (EDUC) of the decision maker, the size of livestock herd (LIVEST) owned and the distance from the beekeeper's residence to the market (DISTMKT) are associated with reduced probability of participation in group-based financial institutions. All these variables have negative coefficients. The negative coefficient result of the variable education is contrary to the expectations of the study since it was presumed that more educated beekeepers are likely to participate in group-based financial institutions than less educated individuals. This was thought so because they are assumed to evaluate the potential benefits of the financial services offered by these institutions. It can be deduced that despite the merits of these institutions, more educated beekeepers acquire increased information that enable them to demand for and utilize complex agricultural technologies which may not be financed within the set up of GBFIs.

The coefficient of the variable distance to the market was negative and therefore matched the study expectations. It is acknowledged that in the rural areas as is the case with the area of study, the farther away an individual stays from the market the less likely he/she is able to access the necessary information. As a result the level of contact with the programme workers and individual beneficiaries of the programmes is reduced. Areas with low incomes are normally characterized by poor road infrastructure that greatly restricts the beekeeper's movements due to increased costs of transport. This implies that improvement of infrastructure status in the rural areas will not only reduce the cost of transport but also lead to the development of the markets in the beekeeper's locality.

The variable livestock herd (LIVEST) that was used as a proxy for wealth status had a negative coefficient and hence supported the study expectation. This implies that wealthy beekeepers are stable financially and are therefore in a position to self finance their technological needs without participating in group-based financial institutions. They are therefore not likely to participate in group-based financial institutions. This was evident in situations where well off beekeepers bought some technologies directly in kind with small animals especially goats.

As indicated in table 4.3, the logit results shows that the best combination of factors to influence so as to enhance the level of participation in group-based financial institutions are education level, distance to the nearest market, size of livestock heard owned and extension services.

4.3.2 Logit Model Analysis Results for Technology Adoption

Four models were estimated for the adoption of *log, KTBH, Langstroth* and *Soil block* hives respectively. The model parameter estimates for the four technologies were jointly significantly different from zero with their chi-square statistics being significant at 0.01, 0.01, 0.01 and 0.05 levels of significance for *log, KTBH, Langstroth* and *Soil block* hives respectively. These are reflected in table 4.4, 4.5, 4.6 and 4.7 for *log, KTBH, Langstroth* and *Soil block* technology respectively. A number of explanatory variables were significant at 0.1 levels or better in the adoption of *log, KTBH, Langstroth* and *soil block* hive technologies. These variables are discussed below.

4.3.2.1 Logit Model Estimation Results for the adoption of log hive technology

It was hypothesized that some twelve factors affects the adoption of log hive technology. The table below (table 4.4) reflects the logit regression results for the adoption of log hive. Nine of the twelve variables included in the model were found to influence the adoption of log hive technology.

Table 4.4: Logit model Analysis Results for the adoption of log hive technology

Explanatory Variable	coefficient	Standard error	b/st. Er	$P[\lvert Z \rvert > z]$
Constant	-19.181*	11.362	-1.688	.091
Gender	3.925*	2.363	1.661	.097
Education	.692*	.402	1.721	.097
Livestock units owned	1.741**	.881	1.976	.048
Experience in beekeeping	-.080	.062	-1.295	.195
Market distance	.602**	.267	2.256	.021
Off-farm income	1.468	1.091	1.345	.179
Extension services	-8.128**	3.950	-2.058	.040
Number of hives	.423	.409	1.035	.301
Honey output	.361*	.189	1.914	.056
Cost of hive	-.004**	.002	-2.334	.020
Variable costs	-.009*	.005	-1.854	.064
Participation in group-based financial institution	28.288**	14.141	2.000	.045
Model Statistics				
Log-likelihood function (β)	-21.441			
Restricted log likelihood (0)	-35.255			
Likelihood ratio (LR) test[b], -2[L(0)-L(β)]	27.528			
Pseudo R^2 (=1-LnL/LnL$_0$)	.392			
Percentage of correct prediction	92.3			
Chi-square statistic	27.528***			
P-value	.006			

*, ** and *** means significance at the10%, 5% and 1% level respectively.

[b] Likelihood ratio tests were conducted with 12 degrees of freedom.

Source: own calculations.

The results show that log hive technology will be adopted more by male beekeepers in the study area. The coefficient of the variable gender (GENDER) was positive and hence matched the set hypothesis. This result confirms the fact that log hive technology in the study area is traditional and mostly used by male beekeepers because and its management requirements like climbing trees to fasten it and attitude.

The coefficient of the variables education (EDUC), livestock units owned (LIVEST), distance to the market (MKTDIST), and honey output per year (HOUTPUT) are all positive and significant in the log live adoption model. However, the coefficients of the variables cost of hive (COSTHIV) and variable costs (VARICOST) are negative and significant. This indicates that beekeepers that can afford only cheaper hives in terms of cost of acquisition and operation will adopt log hive technology.

The results further show that the coefficient of the variable extension (EXTEN) is negative and significant in the adoption of log hive. This implies that as the level of beekeeper' contact with extension agents increases, the chances of adopting a log hive technology reduces. This means that more contact with extension agents exposes the beekeepers to the improved technologies hence the shift of preference.

Concerning the beekeeper's participation in group-based financial institution, the coefficient of the predicted index (PARTINDE) carry expected positive and significance sign. This means that membership in the group-based financial institution enhances adoption of log hive technology. This can be attributed to a number of reasons. First, the group-based financial institutions apart from credit and savings facilities offer other services to the beekeepers. This includes training on investments management skills and other beekeeping resources. Since in reality the group-based financial institutions do not extend log hive technology loans it means that the beekeepers use the management knowledge acquired from such training to reorganize their log hive practices. This results in better returns hence enhanced probability of log hive technology adoption.

4.3.2.2 Logit Model Estimation Results for the adoption of KTBH hive

It was postulated that some ten factors influence the adoption of KTBH hive technology by the beekeepers. Table 4.5 presents the logit regression results for the adoption of KTBH hive technology. Three explanatory variables were found to influence the adoption of the KTBH hive technology.

Table 4.5: Logit model Analysis Results for the adoption of KTBH hive technology

Explanatory Variable	coefficient	Standard error	b/st. Er	P[|Z|> z]
Constant	-2.566*	1.312	-.955	.051
Gender	-.383	1.011	-.379	.705
Livestock units owned	.076	.111	.688	.492
Experience in beekeeping	-.038	.039	-.973	.330
Off-farm income	-.956	.646	-1.479	.139
Extension services	-2.347***	.819	-2.867	.004
Number of hives	-.044	.133	-.332	.740
Honey output	.051	.046	1.103	.270
Cost of hive	.001*	.001	1.688	.092
Variable costs	-.001	.003	-.359	.720
Participation in group-based financial institution	- 3.130*	1.873	1.672	095
Model Statistics				
Log-likelihood function (β)	-42.098			
Restricted log likelihood (0)	-54.094			
Likelihood ratio (LR) test[b], -2[L(0)-L(β)]	23.959			
Pseudo R^2 (=1-LnL/LnL_0)	.222			
Percentage of correct prediction	86.2			
Chi-square statistic	23.959***			
P-value	.008			

*, ** and *** means significance at the10%, 5% and 1% level respectively.

[b] Likelihood ratio tests were conducted with 10 degrees of freedom.

Source: own calculations.

The results of the logit regression model indicate that the coefficient of the variable extension (EXTEN) is negative and significant for the adoption of KTBH hive technology. This implies that as the number of beekeeper' contact with the extension agents increases, the likelihood of a beekeeper adopting a KTBH hive technology reduces. This means that as the contact with the extension agents is enhanced the beekeepers shift their adoption preferences from KTBH to the latest beehive technologies.

The coefficient of the variable cost of hive (COSTHIV) is positive and significant for the adoption of KTBH hive technology. This indicates that the high cost of the hive is an important attribute in the adoption of KTBH hive since the beekeepers in the study area associate high cost with superior attributes of the KTBH technology. Hence it is noteworthy that KTBH is classified as one of the improved technologies.

The coefficient of the predicted membership in group-based financial institution (PARTINDE) carry expected positive and significant sign for KTBH hive technology. This means that participation in group-based financial institutions offers the beekeeper an opportunity to access scarce credit facilities and management skills necessary for the adoption of KTBH hive technology.

4.3.2.3 Logit Model Estimation Results for the adoption of Langstroth hive

Some ten factors were hypothesized to influence the beekeepers' decision to adopt Langstroth hive technology. The logit regression results for the estimated variables are presented in table 4.6. Only two variables, cost of the hive and participation in group-based financial institution were found to be significant in influencing the adoption of the Langstroth technology.

Table 4.6: Logit model Analysis Results for adoption of Langstroth hive technology

Explanatory Variable	coefficient	Standard error	b/st. Er	$P[\lvert Z \rvert > z]$
Constant	-8.204***	2.176	-3.770	.000
Gender	.706	.801	.881	.378
Livestock units owned	.107	.114	.937	.349
Experience in beekeeping	.011	.034	.341	.733
Market distance	.057	.071	.804	.421
Off-farm income	.612	.618	.990	.322
Extension services	1.103	.736	1.498	.134
Number of hives	-.054	.111	-.488	.626
Cost of hive	.004***	.001	5.851	.000
Variable costs	.002	.003	.604	.546
Participation in group-based financial institution	4.380**	2.196	1.994	.046
Model Statistics				
Log-likelihood function (β)	-44.716			
Restricted log likelihood (0)	-88.565			
Likelihood ratio (LR) test[b], -2[L(0)-L(β)]	87.697			
Pseudo R^2 (=1-LnL/LnL$_0$)	.495			
Percentage of correct prediction	86.2			
Chi-square statistic	87.697			
P-value	.000			

*, ** and *** means significance at the10%, 5% and 1% level respectively.

[b] Likelihood ratio tests were conducted with 10 degrees of freedom.

Source: own calculations.

From the above results, the coefficient of variable cost of hive (COSTHIV) is positive and highly significant for adoption of Langstroth hive technology. This indicates that cost of the hive is an important attribute in the adoption of Langstroth technology by the beekeepers. The beekeepers in the study area associate high cost with superior attributes of the Langstroth technology over the traditional technology. The Langstroth hive technology is still relatively new in the area.

As for the participation in group-based financial institution, the coefficient of the predicted membership in group-based financial institution programmes (PARTINDE) carry expected positive and significant sign for Langstroth hive technology. This means that beekeepers who participate in group-based financial institutions have an enhanced chance of adopting the Langstroth hive technology. This confirms the hypothesis that by participating in the group-based financial institutions the beekeepers access the much needed credit and training facilities which enable them to acquire otherwise expensive Langstroth hive technologies.

4.3.2.4 Logit Model Estimation Results for the adoption of Soil block hive

It was postulated that some twelve factors affect the adoption of soil block hive technology. However, out of the twelve factors included in the model only two were found to be significant. Table 4.7 indicates the results of the logit regression result for the adoption of the Soil block hive technology.

Table 4.7: Logit models Analysis Results for the adoption of Soil block hive technology

Explanatory Variable	Coefficient	Std error	b/St. Er	$P[\|Z\| > z]$
Constant	1.071	2.383	.449	.653
Gender	-.614	.764	-.805	.421
Education	.007	.107	.067	.947
Livestock units owned	.002	.102	.020	.984
Experience in beekeeping	-.056*	.034	-1.653	.098
Market distance	-.222***	.084	-2.648	.008
Off-farm income	.262	.544	.481	.630
Extension services	-.956	.810	-1.181	.238
Number of hives	.104	.100	1.043	.297
Honey output	.024	.045	.527	.598
Cost of hive	.000	.001	.412	.681
Variable costs	.002	.003	.796	.426
Participation in group-based financial institution	-.757	2.665	-.284	.776
Model Statistics				
Log-likelihood function (β)	-55.105			
Restricted log likelihood (0)	-66.415			
Likelihood ratio (LR) test[b], -2[L(0)-L(β)]	22.619			
Pseudo R^2 (=1-LnL/LnL$_0$)	.170			
Percentage of correct prediction	80.800			
Chi-square statistic	22.619			
P-value	.031			

*, ** and *** means significance at the10%, 5% and 1% level respectively.

[b] Likelihood ratio tests were conducted with 12 degrees of freedom.

Source: own calculations.

The coefficient of the variables distance to the market (MKTDIST) and experience in beekeeping (EXPER) significantly affect the adoption of Soil block hive technology. However, the coefficient of the variables MKTDIST and EXPER are negative. This implies that in the remote areas where infrastructure is poor and decision makers having minimal experience in beekeeping, Soil Block hive which is made from locally available materials is preferred to other types of improved hives (because their cost of acquisition is high). Hence the likelihood of adopting Soil Block hives.

4.3.3.5 Comparison of influence of adoption factors on various technologies

Table 4.8 compares the influence of some factors on the adoption of various beekeeping technologies.

Table 4.8: Summary of adoption factors and beekeeping technologies

		Type of Technologies			
Explanatory Variable	**Participation**	**LOG**	**KTBH**	**LANGSTROTH**	**SOIL BLO.**
Constant	2.012**	-19.181*	-2.566*	-8.204***	1.071
Gender	-.770	3.925*	-.383	.706	-.614
Education	-.147**	.692*			.007
Livestock units owned	-.285***	1.741**	.076	.107	.002
Experience in beekeeping	.012	-.080	.038	.011	-.056*
Market distance	-.088**	.602**		.057	-.222***
Off-farm income	-.165	1.468	-.956	.612	262
Extension services	1.203**	-8.128**	-2.347***	1.103	-.956
Number of hives		.423	-.044	-.054	.104
Honey output		.361*	.051		.024
Cost of hive		-.004**	.001*	.004***	.0002
Variable costs		-.001*	-.001	.002	.002
Participation in group-based financial institution		28.288**	3.130*	4.380**	-.757
Pseudo-R^2	.275	.392	.222	.495	.170

*, ** and *** means significance at the10%, 5% and 1% level respectively.

Source: own calculations.

From the logit regression results for the five technologies, it can be seen that increasing the probability of the beekeeper's participation in group-based financial institution (PARTINDE) by absolute 10 percent raises the adoption of log hive by an absolute value of 2.83 percent, for KTBH hive by 0.31 percent and that for Langstroth hive by 0.44 percent with no resultant significant effect on Soil block. This implies that the effects of PARTINDE will first be felt on the adoption of log hive technology. This can be attributed to a number of reasons. First, these institutions apart from credit offer other services to the beekeepers. These include training services which enhances the investment management skills of the beekeeper and is first applied on the existing log hives which do not require a lot of resources to acquire and handle. This enables the beekeeper to enjoy better returns in the short run. This is also an indication that it takes a while before the farmer acquire the improved technology through joint liability credit facilities as they have to first meet the stipulated other supply-side requirements like construction of the housing units for the hives which in itself requires resources that are not immediately available to the beekeeper. Therefore a beekeeper adds improved technologies to their traditional log hive stock in phases depending on the rate at which they fulfill the criteria for the acquisition of improved technologies through credit arrangements.

Looking at the effect of the variable contact with extension agents (EXTEN) across the estimated models, it is found to be varied. Whereas it enhances participation in group-based financial institutions it reduces the farmer's probability of adopting both log and KTBH hives. The effect is insignificant on Langstroth and Soil block hives though on Langstroth it bears the expected sign. The insignificance could be attributed to measurement error because the expectation was that with enhanced extension contact the adoption trend moves towards the latest technology (Langstroth) which farmers see as having superior attributes.

The results of the logit analysis also show that the bigger the size of the livestock herd (LIVEST) owned by the beekeeper the higher the probability of adoption of log hive technology and the lower the participation in group-based financial institutions. This indicates that farmers with higher wealth status would not participate in group-based financial institutions but would self-finance the buying of log hives. This scenario is evident in the study area where resource endowed farmers buy log hive in kind with small livestock especially goats. Though the coefficient indicating the effect of this variable on KTBH, Langstroth and Soil block bears the right positive sign it is not significant. This could be attributed to measurement error.

Both farmers' participation in group-based financial institutions and adoption of Soil block hive technology is reduced with increase in distance to the nearest market while adoption of log hive technology is enhanced. There is information asymmetry with increase in distance and this leaves the farmers with the option of adopting only the log hive. In the rural area which is characteristic of the study areas, increased distance to the nearest market also depict increased poor state of infrastructure. However, distance does not have significant effect on the adoption of both KTBH and Langstroth hive technologies. This lack of significance could be attributed to measurement errors.

The lower cost of the hive enhances the adoption of the log hive technology while adoption of both KTBH and Langstroth hives increases as the cost increases. This depicts the perception farmers have about the improved beehive technology hence equating high costs to their superior attributes.

4.3.3 Predictions of Participation and Adoption of Technologies

a) Prediction models

To analyse the predictive ability of the estimated models, the share of the beekeepers choosing a particular alternative was used as a measure-of-goodness of fit. The goodness-of-fit measures indicated that the estimated models fitted the data reasonably well. The choice of the explanatory variables correctly predicted farmers' technology adoption conditions for 77 percent of the observations accessing group-based financial institutions, 92 percent of the observations adopting log hive, 86 percent of the observations adopting KTBH hive, 86 percent of the observations adopting Langstroth hive and 81 percent of the observations adopting Soil block hive.

The statistic was calculated by identifying for each beekeeper (decision maker) the alternative with the highest probability based on the estimated logistic regression models and determining whether or not a particular technology choice was actually adopted. Means of the determinants in the specific technologies were applied to predict the probability of participation and adoption decision. Only significant determinants were included in the prediction. Since there wasn't enough information to predict the decision maker's choice, a caution by Train (2002) that the statistic may incorporate a notion that is opposed to the meaning of probability and purpose of specifying choice probabilities in circumstances of inadequate information was heeded. Only enough information to state the probability that the decision maker will choose each alternative was available, and hence its use was limited to the meaning that if the choice situation were repeated numerous times (or faced by numerous beekeepers with the same attributes), each alternative would be chosen a certain proportion of time. This is in contrast with the meaning that the alternative with the highest probability will be chosen each time (which is a common assumption of the statistic). The prediction models are arrived at as follows

Model 1: Probability of participation in group-based financial institution

$$P\,(PARTINDE) = 1/\left(1 + e^{-[-0.147(EDUC) - 0.285(LIVEST) - .088(MKTDIST) + 1.203(EXTEN)]}\right)$$

Where,

P (PARTINDE) = the probability of participation in group-based financial institution

EDUC = level of formal schooling

LIVEST = total livestock units possessed

MKTDIST = distance to the market

EXTEN = contact with extension agents

$$P(PARTINDE) = {}^{1}\!\!\diagup_{(1+e^{-.683})}$$

$$=.664$$

Model 2: Probability of log hive adoption

$$P(LOG) = 1/(1 + e^{-[3.925(GENDER+0.692(EDUC)+1.741(LIVEST)+0.602(MKTDIST)-0.8.128(EXTEN)+0.361(HOUTPUT)-0.009(VARICOST)-0.004(COSTHIV)+28.288(PARTINDE)]})$$

Where,

P (LOG) = the probability of adopting log hive

GENDER = gender

EDUC = level of formal schooling

LIVEST = total livestock units possessed

MKTDIST = distance to the market

EXTEN = contact with extension agents

HOUTPUT = honey output

VARICOST = variable costs

COSTHIV = cost of hive technology

PARTINDE = participation in group-based credit programme index

$$P(LOG) = \frac{1}{(1+e^{-27.470})}$$

$$=1$$

Model 3: Probability of KTBH hive adoption

$$P\,(KTBH) = 1/\left(1 + e^{-[-2.347(EXTEN) + 3.130(PARTINDE) + .001(COSTHIV)]}\right)$$

Where,

P (KTBH) = probability of KTBH hive adoption

EXTEN = contact with extension agents

PARTINDE = index of participation in group-based credit programme

COSTHIV = cost of hive

$$P(KTBH) = \frac{1}{(1+e^{-.784})}$$

$$=.687$$

Model 4: Probability of Langstroth hive adoption

$$P\,(LAN) = 1/\left(1 + e^{-[4.380(PARTINDE) + 0.004(COSTHIV)]}\right)$$

Where,

P (LAN) = probability of Langstroth hive adoption

PARTINDE = predicted participation index in group-based credit programme

COSTHIV = cost of hive

$$P(LANS) = \frac{1}{(1+e^{-4.384})}$$

$= .988$

Model 5: Probability of soil block hive adoption

$$P(SOILB) = 1/(1+e^{[-0.956(EXPER)-0.222(MKTDIST)]})$$

EXPER = beekeeping experience

MKTDIST = distance to the market

$$P(SOILB) = \frac{1}{(1+e^{.278})}$$

$= .431$

b) Results of prediction

The predicted share of beekeepers' accessing group-based financial institutions and adopting improved technologies were compared with the observed share. The table 4.9 presents the forecasted and actual predicted shares for participation in group-based financial institutions and each technology.

Table 4.9: Predictions for participation in group-based financial institutions and technology adoption

	Prediction	
	Actual Share	Predicted Share
Participation in credit programme	77	66
Log	92	100
KTBH	86	69
Langstroth	86	99
Soil block	81	43

≤0.5 Not likely to adopt, P>0.5 likely to adopt
Source: Survey results, 2005

The model does well in predicting the choice of participation in group-based financial institutions, log, KTBH and Langstroth hives but its capacity to correctly predict Soil block hive is clearly limited. There was close correspondence between the forecasted shares for participation in group-based financial institutions and beekeeping technologies' demand compared to the actual share except for Soil block hive. The outcome could be due to the fact that Soil block adoption may be sensitive to factors other than those specified in the model; hence only two of the improved technologies (KTBH and Langstroth hives) are well predicted by the model. The predictive power of the model on log and Langstroth hives was very high.

4.4 Profitability analysis

It was hypothesized that gross margins are the same across different beekeeping technologies. Table 4.10 presents the comparison of the mean and coefficient of variations for honey outputs, gross revenue, variable costs and input intensity by technology. The honey output was valued at the quantity-weighted sample sales prices.

Table 4.10: Indicators of productivity

	Means and coefficient of variation for indicators of productivity and input intensity by hive							
	Log hive		KTBH		Langstroth		Soil block	
Variable	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Honey output (kg/hive)	20	61	21	57	19	74	26	80
Gross revenue (Kshs)	1492	66	1747	65	1526	67	2309	107
Total variable cost (Kshs)	338	81	388	71	327	93	613	60
Gross margin (Kshs)	1154	85	1359	124	1199	116	1696	134
Gross margin/unit of working capital	3.4		3.5		3.7		2.8	
Sig. of Gross margin	p<.109		p<.117		p<.057		p<.087	

Source: Survey results, 2005

The result of the gross margin analysis in Table 4.10 shows that beekeepers get higher output per year from Soil block followed by KTBH, Langstroth and log hive. Several factors could explain this phenomenon. These include experience of the beekeeper with the technology and the differences in the technologies. In Table 4.10, the coefficients of variation for honey output of soil block hive, is higher than that of KTBH, Log and Langstroth hives. This suggests that distribution of the soil block hive output is heterogeneous across the population than in the log, KTBH and Langstroth hives. That is why beekeepers get higher output per year from it compared to other improved technologies still in their infancy. This could be attributed to the beekeeper's experience with the use of the technology.

The variable inputs (in Kshs) shown in table 4.10 comprise the opportunity cost of labour input in beekeeping activities per hive per year. The survey found that labour was the only variable input in honey production in the study area. This was computed in man-hours spent in beekeeping activity from setting the hive for occupation, inspection during occupation for pests and harvesting per year. The opportunity cost of labour was Kshs 100 for eight man-hours in a day. Soil block hive is the most labour intensive while log hive is the least.

The gross margin computation reveals considerable comparative advantage of soil block hive versus KTBH, Langstroth and Log hives respectively. But when input intensity is considered, Langstroth hive has a comparative advantage, followed by KTBH, log and soil block hives respectively. The statistical test of significance for the differences in gross margin across the four technologies show significance sign in only Langstroth ($p<.057$) and soil block ($p<.087$) hives. The non-significance observed in log and KTBH hives may be attributed to the fact that these two have been with the beekeepers for quite some time and the management practices have somewhat spread among the users. The high capital intensity in Langstroth hive (3.7) followed by KTBH (3.5), log (3.4) and Soil block hive (2.8) shows that improved technologies especially Langstroth and KTBH hives could offer better returns to the beekeepers for every unit of input used than the traditional technologies. This qualifies the hypothesis that improving the adoption of the improved hive technologies by the beekeepers could help enhance the incomes and livelihood status. However, since these technologies are expensive to acquire as compared to traditional technologies and thus require more capital and management skills (which is scare among rural beekeepers), it justifies the need to promote and strengthen the beekeepers participation in group-based financial institutions so as to access the affordable investment capital.

These group-based financial institutions should in the initial phase enhance a coordinated effort to improve the investment management skills of the beekeepers and awareness on the current market demand with an aim of improving the returns under the existing set-up. This is based on the fact that in the process of offering affordable, accessible short-term credit these institutions also offer other services meant to improve the beekeepers ability to utilize financial services. Key among these is skills in group dynamics, investment management skills and literacy training. The beekeeper therefore is enabled to attain higher quality output that is acceptable to the market for increased return.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Summary and conclusions

The broad objective of the study was to undertake an analysis of the effect of access to group-based financial institutions on the adoption of improved beekeeping technologies towards increased honey production. The *log*, *KTBH*, *Langstroth* and *Soil block* hives formed the technology choice set with *log* hive being considered a traditional technology. To achieve this objective, four binary response functions for *log*, *KTBH*, *Langstroth* and *Soil block* were estimated for survey data using the logit specification of the adoption functions. However, since access to group-based financial institutions is an endogenous variable in the adoption function, it was first predicted and the predicted index introduced in the adoption models as a variable. Frequency distributions, means and variances were used to describe beekeepers' technology choice behaviour and profitability of the technologies. The gross margin worked out from a partial budget was used to determine and compare the profitability of the technologies used in honey production in the study area.

The descriptive analysis indicated that there is significant variation in the distribution of improved technology use between beekeepers participating in group-based financial institutions and those not participating. This could be explained by differences in both human and physical resource endowment between beekeepers in the two categories. There was no significant variation in the distribution of traditional beehive technology use between beekeepers participating and those not participating in group-based financial institutions. This implies that this technology is used by all the beekeepers irrespective of their group-based financial institution participation status. This could be attributed to its ease of acquisition and the prevalent indigenous technical knowledge on its use in the study area.

The logistic regression showed that education, wealth status (size of livestock herd owned), distance to the market, cost of hive and contact with extension agents are important factors considered by the beekeepers in their decision to access group-based financial institution. They were found to significantly influence the probability of beekeepers access to group-based financial institutions. These factors should be incorporated in the design of policies and strategies for improvement of beekeepers' participation in group-based financial institutions.

For the adoption of hive technologies, the regression indicated that gender, education, size of livestock herd owned, distance to the nearest market, honey output and participation in group-based financial institution positively influenced the adoption of log hive, while extension, cost of hive and variable costs negatively related to adoption of log hive. Cost of hive and participation in group-based financial institution positively influenced adoption KTBH hive while extension negatively related to KTBH hive adoption. Both participation in group-based financial institution and cost of hive were indicated to positively influence the adoption of Langstroth hive. Experience and distance to the nearest market negatively relates to adoption of Soil block hive. On the test for predictive ability of the estimated models in assessing participation and technology adoption, the study found the model to do well on participation, log, KTBH and Langstroth but its capacity to correctly predict Soil Block was clearly limited.

The study found that the focal variable, access to group-based financial institutions raise the probability of adoption of log, KTBH and Langstroth technologies. The results found that a 10 percent increase in the absolute value of participation in group-based financial institutions raises the probability of adoption of log hive by 2.8 percent, KTBH by 0.31 percent and Langstroth hive by 0.44 percent. There was no significant influence of participation in group-based credit programme on the adoption of Soil block hive. This probability of adoption observed in log hive could be attributed to the complimentary integrated investment management skills training offered by group-based financial institutions. Most of the beekeepers join the groups already having the traditional log hive technology. Their immediate concern, since they cannot meet the requirements for the improved hives instantly, is how to better manage log hives for increased returns. It can therefore be concluded that intensification of management skills trainings embedded in group-based financial institutions could have positive effects on honey production by resource constrained rural beekeepers who may not meet the credit requirements in the short run.

The study also found that on average honey production using improved technologies (KTBH, Langstroth and Soil block) in the study area was fairly profitable than the traditional technology. Soil block gave the highest average gross margin followed by KTBH and Langstroth. However, this was not a good measure because of typical differences in hive types which made it difficult to compare the performance of the hives using gross margin values. Input intensity analysis was therefore found an appropriate measure as it allowed comparison of returns per unit input among the technology types. The input intensity analysis results revealed that Langstroth hive has a comparative advantage over KTBH, log and Soil block hives respectively. The computed input intensities shows that there is a high return per unit input used in Langstroth hive (3.7) compared to KTBH (3.5), log (3.4) and soil block (2.8) hives which are improved technologies. However, statistical significance in differences in gross margins was observed only in Langstroth (p<.057) and soil block (p<.087) hives. The use of improved technologies is a recent occurrence among most beekeepers and is still limited to only a few individuals who have met the credit requirements. It is therefore reasonable to conclude that in order for the beekeepers to obtain high returns per unit capital invested, adoption of improved technologies should be encouraged. To do this, there is need to enhance beekeepers participation in group-based financial institutions to enable them access the credit and investment management skills which are key to this process.

As a result of the need to design specific honey production strategies the results were considered in two aspects. First was how to improve honey production under the existing dominant traditional technological set-up while encouraging the adoption of improved technologies. Therefore to improve the adoption of improved technologies, short-run and long-run strategies were developed. The short-run strategy was to improve what is adoptable within the livelihood setup and the long run strategy was to relax the constraints associated with the adoption of improved technologies. These strategies would ensure better technology adoption and higher honey output for improved farm income and food security.

5.2 Policy implications

In order to enhance profitable honey production in the ASALs of Makueni district, a number of general policy recommendations were made based on the influence of group-based financial institutions on the adoption patterns of traditional and improved technologies. First, the findings show that through participation in group-based financial institutions beekeepers will adopt more of log hives in the short-run than improved beehive technologies (KTBH and Langstroth). Second, the results indicate that improved technologies offer increased returns than traditional technology. The first instance is attributed to investment management skills training offered by the group-based financial institutions which enables the beekeepers to undertake beekeeping activity as a business enterprise resulting in improved liquidity. This helps them to meet the conditions put in place for credit access by the group-based financial institutions. The second instance is attributed to the superior attributes of the improved beehive technology, management conditions and literacy level of the beekeepers. Hence, in order to increase the participation in group-based financial institutions and improve the adoption of improved technologies, the following recommendations were made:

- Enhanced extension service: Beekeepers' contact with extension agents in the study area was observed to enhance participation in group-based financial institutions. Most of the beekeepers were observed to gain technical and market dynamics information from such contacts. Given the importance of extension service, group-based financial institutions should enhance the extension service delivery by equipping their field extension agents with a holistic package that encompass technical and market behaviour.
- Education: It was observed that beekeepers with higher levels of education were less likely to participate in group-based financial institutions hence the need for the group-based financial institutions to design a strategy that targets the beekeepers with low education levels who are the majority in the rural areas. This category normally forms the bulk of low-income lots in the rural ASALs. However, since low literacy level also impede appropriate participation in group-based financial institutions; these institutions should design a package for the provision of non-financial services like literacy

trainings. Given the high unquantifiable costs attached to offering such services which rarely makes it financially sustainable, the institutions should target the training of trainers to upscale the literacy level of members of the groups.

- Complimentary services: It was observed that the far away to the market centre the beekeeper resides, the lower the probability of participating in group-based financial institutions. Given the poor state of infrastructure in the rural area, the beekeepers are unable to reach the markets and to receive the appropriate market information that is crucial in making the decision to participate in group-based financial institutions and adoption of the improved technologies. The government should therefore invest in complimentary services (e.g. infrastructure-roads and market services, free primary education) in the local ASALs. Public sector investment in these complimentary services will also ensure sustainability of the activities of the appropriate group-based financial institutions. This will enhance information symmetry on group-based financial institutions and improved technologies leading to increased returns from honey production enterprise.
- Improvement of wealth status: It was observed that beekeepers with low wealth status participate more in group-based financial institutions. However, very low beekeepers' liquidity was observed to delay the acquisition of financial services from group-based financial institutions due to the inability to meet initial credit conditions like construction of housing for the improved beehives. The government and the development agencies should therefore promote small livestock enterprises like goats, sheep and poultry which can be liquidated easily to enable the beekeepers meet the basic credit acquisition conditions. This will enhance the wealth status of the low-income beekeepers.

- Cost of hives: It was observed that the cost of improved hives is very high in the study area. Even though the study showed that the adoption of improved hives positively relates to the cost of the hive, the cost needs to be reduced to make the improved hives accessible to many beekeepers. The private sector concerns overseeing the manufacturing of these hives should look for ways of down-scaling the costs if the beekeeping industry is expected to be profitable to majority of the rural population.

5.3 Areas for further research

Further studies should be undertaken to clarify a number of issues that remain unclear from the results of this research. These should include:

1. Determine a clearer relationship between access to agricultural markets, related improvements in rural infrastructure and market institutions on the one hand and adoption of improved beekeeping technology and transformation of subsistence-oriented smallholder beekeeping.

2. Evaluation of the beekeepers' credit limit and how it impacts on improved beekeeping technology adoption and returns from honey production.

3. Determining the costs, benefits and future potentials of emerging group-based financial institutions in rural areas in financing the improved honey production technology adoption. This will help understand the gap between the supply and the demand side effects.

The study had its limitations especially time and funds. This led to coverage of only one district in the larger eastern province which has high honey production potential in several districts. The results of the study suggests that the next round of survey should cover more districts to estimate the probability of adopting improved honey production technologies under different beekeepers' conditions. More variables should also be included in the analysis so that the effects of other physical and environmental factors can be captured. A wider geographical spread of the survey should be undertaken for more accurate economic assessment of the effects of group-based financial institutions on the use of improved honey production technologies. Since the level of access to group-based financial institutions is low and might be varying in the districts/regions, future studies should cover more districts/regions.

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APPENDICES

Appendix 1: Survey Questionnaire

1.0 Identification

1.1 Questionnaire Number__________________

1.2 Date_______________

1.3 Name of Enumerator________________

1.4 Name of Beekeeping Group___________

1.5 Name of Beekeeper____________________

1.6 Division_____________________

1.7 Location___________________

2.0 Beekeeper Characteristics

2.1 Gender, (0) Female (1) Male

2.2 Age (years)_________

2.3 Marital status, (1) Single (2) Married (3) Widow(er)/divorced

2.4 Highest level of formal education attained (class, form or year at university/college)____________

2.5 Access to off-farm income (0) NO (1) YES

2.6 Do you have livestock (0)NO (1)YES

2.7 Type and number owned

- Cattle___________
- Goats___________
- Sheep___________
- Donkeys_________
- Chicken__________

2.8 Beekeeping experience (years)__________

2.9 how log have you been a member of the beekeeping group? _______ (years)

2.10 How old is the group? ________ (years)

2.11 Do you hold any leadership position in the group? (0) NO (1) YES

2.12 What were the reasons for joining the group? Indicate

1. ____

2. ____________________
3. ____________________
4. ____________________
5. Other (specify) ____________________

2.13 What are the main advantages of being in a beekeeping group?

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. Other (specify) ____________________

3.0 Honey production

3.1 Who owns the beehives?

	Type	Number
Self	1.	
	2.	
	3.	
	4.	
	5.	
Group	1.	
	2.	
	3.	
	4.	
	5.	

3.2 How the hives were acquired (1) Inherited/self made (2) Bought (3) 1 and 2 (3) Others (specify) ____________________

3.3 Fill in the table below as it regards the productivity of the beehive type possessed

Beehive type	Number	Honey Output		No. of harvests/year
1.				
2.				
3.				
4.				
5.				

3.4 Variable inputs in honey production for various beehive types from one season to the next

Activity	LOG		KTBH		LANGSTROTH		SOIL BLOCK		OTHERS	
	Meas. Units & No.	Cost/unit (Kshs)	Meas. Units & No.	Cost/unit (Kshs)	Meas. Units & No.	Cost/unit (Kshs)	Meas. Units & No.	Cost/unit (Kshs)	Meas. Units & No.	Cost/unit (Kshs)
Setting the hives										
Inspecting hives										
Harvesting										
Physical inputs										
1.										
2.										
3.										
4.										

3.5 Unit cost of each hive type (Kshs)

- Log ______________
- KTBH __________________
- Langstroth ________________
- Soil block _________________

3.6 If you have hives, who made the decision to have them on your farms?

Decision for	(a) Self	(b) Family members*	(c) Govt ext. agents	(d) Technology promoter	(e) Other (specify)
Log hive					
KTBH hive					
Langstroth					
Soil block					
Other (specify)					

*Identify family member as follows: 1=spouse 2=parent 3=children 4=others___________

3.7 How do you rate these factors as constraints in honey production?

Problem	A severe problem	An average problem	A minor problem	Not a problem
Adequate water				
Forage				
Availability of inputs				
High cost of inputs				
Price of honey				
Demand for honey				
Pests (including human)				

Market and Institutional Support

4.0 Market factors

4.1 D you sell honey? (0) NO (1) YES
4.2 Do you sell your honey (1) Individually (2) In a group (3) Both
4.3 If sold through the group, what are the main advantages?

1.________________________________
2.________________________________
3.________________________________
4.________________________________
5. Other (specify)________________________

4.4 If sold through the group, what are the main disadvantages?

1.________________________________
2.________________________________
3.________________________________
4.________________________________
5. Other (specify)________________________

4.5 How far is the market from home? __________(km), ____________(hours)
4.6 How much does it cost to get to the market? ___________(Kshs)
4.7 What quantity of honey did you sell from last season's harvest? _________(kg)
4.8 What quantity of honey was consumed at home from last season's harvest? _________(Kshs)
4.9 What quantity of honey was given out to friends and relatives from last seasons output? ________(Kshs)
4.10 What was the selling price of honey during the last seasons' harvest? Specify the unit. ________________________________
4.11 Compared to the previous years do you think the honey sales are (1) increasing (2) decreasing (3) same?
4.12 If increasing, what factors have led to the increase?

1.______________________________
2.______________________________
3.______________________________
4.______________________________
5. Other (specify)______________________________

4.13 If decreasing, what factors have led to the decrease?

1.______________________________
2.______________________________
3.______________________________
4.______________________________
5. Other (specify)______________________________

5.0 Credit

5.1 Have obtained credit in the last five years? (0) NO (1) YES

5.2 For what purpose was credit obtained?

1.______________________________
2.______________________________
3.______________________________
4.______________________________
5. Other (specify)______________________________

5.3 Was is it obtained in (1) Cash (2) Kind (3) Both

5.4 If in cash how much was received? ______________(Kshs)

5.5 If in kind how many units were obtained? ______________

5.6 What were the minimum requirements for one to access those credit facilities?

1.______________________________
2.______________________________
3.______________________________
4.______________________________
5. Other (specify)______________________________

5.7 What were the terms of repayment?

1.______________________________
2.______________________________
3.______________________________
4.______________________________
5. Other (specify)______________________________

5.8 Are there occasions you have failed to get credit when you needed it? (0) NO (1) YES
5.9 If YES, why?
1.______________________________
2.______________________________
3.______________________________
4.______________________________
5. Other (specify)______________________________

6.0 Extension
6.1 Please indicate your source(s) of information about beekeeping?
(a) Text books (b) experts (extension agents) (c) Magazines (d) local resource people (e) administration (f) students (g) experience
(h) Other (specify) ______________________________
6.2 Have you had contact with extension agents in the last five years? (0) NO (1) YES
6.3 How did you become aware of the improved beekeeping technologies?
(a) Through media channels (radio, newspapers, posters, extension circulars and farm magazines)
(b) Fellow beekeepers
(c) Government extension agencies
(d) Non-Governmental Organizations (specify) ____________
(e) Field/Farmers' day
(f) Fellow beekeepers groups
(g) Other (specify) __________
6.4 Have ever received extension services from technology promoters? (0) NO (1) YES
6.5 If YES, what technologies were they promoting?
(1) Log hive
(2) KTBH hive
(3) Langstroth hive
(4) Soil block
(5) Other (specify)__________________
6.6 On average how many times per year have you had contact with them? __________
6.7 What other factors enhanced your ability to adopt the improved technology?
1.______________________________
2.______________________________
3.______________________________
4.______________________________
5. Other (specify)______________________________
6.8 Generally how do you interact with extension agents?

Method of interaction | Frequency per year

Method of interaction	Frequency per year
____________________	______________________
____________________	______________________
____________________	______________________

6.9 If you are aware of improved beehive technologies but have not adopted them, what are the reasons of not adopting them

1. ____
2. ____
3. ____
4. ____
5. Other (specify)____

7.0 Closing comments

7.1 What do you think should be done to improve beekeeping/honey production in this area?

1. ____
2. ____
3. ____
4. ____
5. Other (specify)____

Thank you for your time and cooperation. You have been very helpful

Appendix 2: Descriptive Statistics

```
DSTAT;Rhs=AGE,GENDER,EDUC,OFFARMI,LIVEST,EXPER,MKTDIST,EXTEN,NUMHIVES
     ,HOUTPUT,VARICOST,COSTHIV,LOGL_OBS;Output=2$
Descriptive Statistics
All results based on nonmissing observations.
```

Variable	Mean	Std.Dev.	Minimum	Maximum	Cases
All observations in current sample					
AGE	43.5230769	12.9777480	18.0000000	80.0000000	130
GENDER	.346153846	.477583362	.000000000	1.00000000	130
EDUC	6.60000000	3.96808977	.000000000	14.0000000	130
OFFARMI	.500000000	.501934243	.000000000	1.00000000	130
LIVEST	3.60592308	4.29997849	.000000000	29.6500000	130
EXPER	11.4384615	12.1412896	1.00000000	65.0000000	130
MKTDIST	8.93076923	6.06449633	.000000000	36.0000000	130
EXTEN	.692307692	.463323917	.000000000	1.00000000	130
NUMHIVES	2.47000000	3.49568416	.150000000	20.0000000	130
HOUTPUT	6.65288462	5.73401607	.000000000	37.5000000	130
VARICOST	96.5538462	98.4940136	.000000000	460.000000	130
COSTHIV	701.205769	503.383198	.000000000	1875.00000	130
LOGL_OBS	-.601055246	.402874657	-2.32301823	-.856693450E-01	130

```
DSTAT;Rhs=AGE,GENDER,EDUC,OFFARMI,LIVEST,EXPER,MKTDIST,EXTEN,NUMHIVES
    ,HOUTPUT,VARICOST,COSTHIV,LOGL_OBS;Str=PARTGBFI;Output=2$
```

Descriptive Statistics
All results based on nonmissing observations.
Stratification is based on PARTGBFI

Stratum is PARTGBFI = .000. Obs.= 65.000, Sum of wts. = 65.000

Variable	Mean	Std.Dev.	Minimum	Maximum	Cases
AGE	44.2307692	13.7588258	24.0000000	80.0000000	65
GENDER	.446153846	.500960616	.000000000	1.00000000	65
EDUC	7.83076923	3.83067076	.000000000	14.0000000	65
OFFARMI	.569230769	.499037535	.000000000	1.00000000	65
LIVEST	5.19538462	5.11796807	.000000000	29.6500000	65
EXPER	11.0615385	12.2332499	1.00000000	65.0000000	65
MKTDIST	10.4923077	7.51066549	.000000000	36.0000000	65
EXTEN	.584615385	.496623213	.000000000	1.00000000	65
NUMHIVES	3.06846154	4.15606681	.150000000	20.0000000	65
HOUTPUT	7.25384615	6.84717270	.000000000	37.5000000	65
VARICOST	101.196154	102.718912	.000000000	460.000000	65
COSTHIV	646.834615	531.118962	.000000000	1875.00000	65
LOGL_OBS	-.600434234	.394612341	-1.67110597	-.974517190E-01	65

Stratum is PARTGBFI = 1.000. Obs.= 65.000, Sum of wts. = 65.000

Variable	Mean	Std.Dev.	Minimum	Maximum	Cases
AGE	42.8153846	12.2128164	18.0000000	70.0000000	65
GENDER	.246153846	.434121571	.000000000	1.00000000	65
EDUC	5.36923077	3.73985808	.000000000	13.0000000	65
OFFARMI	.430769231	.499037535	.000000000	1.00000000	65
LIVEST	2.01646154	2.43787012	.200000000E-01	12.9000000	65
EXPER	11.8153846	12.1319469	1.00000000	50.0000000	65
MKTDIST	7.36923077	3.57320423	.000000000	22.0000000	65
EXTEN	.800000000	.403112887	.000000000	1.00000000	65
NUMHIVES	1.87153846	2.57490851	.200000000	13.7500000	65
HOUTPUT	6.05192308	4.31905595	.000000000	17.0000000	65

VARICOST	91.9115385	94.6507812	.000000000
COSTHIV	755.576923	471.864811	.000000000
LOGL_OBS	-.601676257	.414043907	-2.32301823

Appendix 3: Testing for Multicollinearity

Correlation Matrix for Listed Variables

	AGE	GENDER	EDUC	OFFARMI	LIVEST
AGE	1.00000	.34762	-.42918	-.16108	.08610
GENDER	.34762	1.00000	.06826	.07989	.21137
EDUC	-.42918	.06826	1.00000	.28182	.18295
OFFARMI	-.16108	.07989	.28182	1.00000	-.03173
LIVEST	.08610	.21137	.18295	-.03173	1.00000
EXPER	.50596	.46267	-.08216	.00044	.26916
MKTDIST	-.06071	.20239	.13112	.04961	.06925
EXTEN	-.20122	-.07143	.09121	.12427	-.08039

	AGE	GENDER	EDUC	OFFARMI	LIVEST
NUMHIVES	.01556	.34953	.16483	.19148	.29850
HOUTPUT	-.01489	-.02776	-.16783	-.26608	.03085
VARICOST	.03645	.09484	-.04123	-.01556	.00844
COSTHIV	-.15420	-.07832	.24485	.27081	.13911
LOGL_OBS	-.16210	-.58179	-.67685	-.17836	-.21581

	NUMHIVES	HOUTPUT	VARICOST	COSTHIV	LOGL_OBS
NUMHIVES	1.00000	.04334	-.03708	-.04190	-.20363
HOUTPUT	.04334	1.00000	.11476	-.22010	.19185
VARICOST	-.03708	.11476	1.00000	.02560	-.04861
COSTHIV	-.04190	-.22010	.02560	1.00000	-.14296
LOGL_OBS	-.20363	.19185	-.04861	-.14296	1.00000

437.500000	65
1500.00000	65
-.856693450E-01	65

EXPER	MKTDIST	EXTEN
50596	-.06071	-.20122
46267	.20239	-.07143
08216	.13112	.09121
00044	.04961	.12427
26916	.06925	-.08039
00000	.15154	-.18019
15154	1.00000	-.12149
18019	-.12149	1.00000

EXPER	MKTDIST	EXTEN
31754	.46393	.03056
30192	-.02619	-.18240
03248	-.07897	-.18230
17256	-.10561	.19078
07994	-.10128	.02427

Appendix 4: Participation Logit Model Estimation Results

```
LOGIT;Lhs=PARTGBFI;Rhs=ONE,GENDER,EDUC,OFFARMI,LIVEST,EXPER,MKTDIST,EXTEN$
Normal exit from iterations. Exit status=0.

+----------------------------------------------+
| Multinomial Logit Model                      |
| Maximum Likelihood Estimates                 |
| Dependent variable              PARTGBFI     |
| Weighting variable                  None     |
| Number of observations               130     |
| Iterations completed                   6     |
| Log likelihood function        -65.34427     |
| Restricted log likelihood      -90.10913     |
| Chi squared                     49.52973     |
| Degrees of freedom                     7     |
| Prob[ChiSqd > value] =          .0000000     |
| Hosmer-Lemeshow chi-squared =   19.67248     |
| P-value=  .01165 with deg.fr. =        8     |
+----------------------------------------------+
---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
         Characteristics in numerator of Prob[Y = 1]
 Constant      2.01187756       .74652816     2.695   .0070
 GENDER        -.76963900       .51352343    -1.499   .1339     .34615385
 EDUC          -.14708024       .06238613    -2.358   .0184    6.60000000
 OFFARMI       -.16495184       .46262991     -.357   .7214     .50000000
 LIVEST        -.28465794       .08990974    -3.166   .0015    3.60592308
 EXPER          .01205440       .01997473      .603   .5462   11.4384615
 MKTDIST       -.08781376       .04147681    -2.117   .0342    8.93076923
 EXTEN         1.20294953       .48529697     2.479   .0132     .69230769

+------------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                      |
```

```
|                            M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)      -65.34427       -90.10913     -90.10913 |
| LR Statistic vs. MC       49.52973          .00000        .00000 |
| Degrees of Freedom         7.00000          .00000        .00000 |
| Prob. Value for LR          .00000          .00000        .00000 |
| Entropy for probs.        65.34427        90.10913      90.10913 |
| Normalized Entropy          .72517         1.00000       1.00000 |
| Entropy Ratio Stat.       49.52973          .00000        .00000 |
| Bayes Info Criterion     164.76128       214.29101     214.29101 |
| BIC - BIC(no model)       49.52973          .00000        .00000 |
| Pseudo R-squared            .27483          .00000        .00000 |
| Pct. Correct Prec.        76.92308          .00000      50.00000 |
| Means:       y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7 |
| Outcome     .5000  .5000  .0000  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr     .5000  .5000  .0000  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).     |
|        Normalized entropy is computed against M0.                  |
|        Entropy ratio statistic is computed against M0.             |
|        BIC = 2*criterion - log(N)*degrees of freedom.              |
|        If the model has only constants or if it has no constants,  |
|        the statistics reported here are not useable.               |
+--------------------------------------------------------------------+
```

Appendix 5: Adoption Logit Models Estimation Results

```
LOGIT;Lhs=LOG;Rhs=ONE,GENDER,EDUC,OFFARMI,LIVEST,EXPER,MKTDIST,EXTEN
    ,NUMHIVES,HOUTPUT,VARICOST,COSTHIV,PARTINDE$
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Multinomial Logit Model                     |
| Maximum Likelihood Estimates                |
| Model estimated: Mar 14, 2006 at 08:36:18PM.|
| Dependent variable                 LOG      |
| Weighting variable                None      |
| Number of observations             130      |
| Iterations completed                 9      |
| Log likelihood function      -21.44066      |
| Restricted log likelihood    -35.25462      |
| Chi squared                   27.62791      |
| Degrees of freedom                  12      |
| Prob[ChiSqd > value] =     .6268451E-02    |
| Hosmer-Lemeshow chi-squared =  23.67239     |
```

```
| P-value=  .00000 with deg.fr. =       1       |
+-----------------------------------------------+
+---------+--------------+----------------+--------+--------------------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+--------------------+
          Characteristics in numerator of Prob[Y = 1]
 Constant     -19.1814821     11.3624050     -1.688   .0914
 GENDER         3.92545690     2.36287233     1.661   .0967      .34615385
 EDUC            .69190890      .40192433     1.721   .0852     6.60000000
 OFFARMI        1.46793175     1.09142788     1.345   .1786      .50000000
 LIVEST         1.74055485      .88092643     1.976   .0482     3.60592308
 EXPER          -.07994922      .06172567    -1.295   .1952    11.4384615
 MKTDIST         .60205606      .26683901     2.256   .0241     8.93076923
 EXTEN         -8.12780721     3.94963373    -2.058   .0396      .69230769
 NUMHIVES        .42274655      .40857405     1.035   .3008     2.47000000
 HOUTPUT         .36108792      .18868813     1.914   .0557     6.65288462
 VARICOST       -.00891454      .00480758    -1.854   .0637    96.5538462
 COSTHIV        -.00423073      .00181295    -2.334   .0196   701.205769
 PARTINDE      28.2882411     14.1406271      2.000   .0454      .50000000

+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                          M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)     -21.44066        -35.25462     -90.10913 |
| LR Statistic vs. MC      27.62791           .00000        .00000 |
| Degrees of Freedom       12.00000           .00000        .00000 |
| Prob. Value for LR         .00627           .00000        .00000 |
| Entropy for probs.       21.44066         35.25462      90.10913 |
| Normalized Entropy         .23794           .39124       1.00000 |
| Entropy Ratio Stat.     137.33694        109.70903        .00000 |
| Bayes Info Criterion    101.29174        128.91965     238.62868 |
| BIC - BIC(no model)     137.33694        109.70903        .00000 |
| Pseudo R-squared           .39183           .00000        .00000 |
| Pct. Correct Prec.       92.30769           .00000      50.00000 |
| Means:        y=0    y=1    y=2    y=3    yu=4   y=5,   y=6   y>=7 |
| Outcome      .0769  .9231  .0000  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr      .0769  .9231  .0000  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                    |
|        Entropy ratio statistic is computed against M0.               |
|        BIC = 2*criterion - log(N)*degrees of freedom.                |
|        If the model has only constants or if it has no constants,    |
|        the statistics reported here are not useable.                 |
```

```
LOGIT;Lhs=KTBH;Rhs=ONE,GENDER,OFFARMI,LIVEST,EXPER,EXTEN,NUMHIVES,HOUTPUT
     ,VARICOST,COSTHIV,PARTINDE$
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Multinomial Logit Model                     |
| Maximum Likelihood Estimates                |
| Model estimated: Mar 14, 2006 at 08:42:11PM.|
| Dependent variable                KTBH      |
| Weighting variable                None      |
| Number of observations             130      |
| Iterations completed                 6      |
| Log likelihood function      -42.09777      |
| Restricted log likelihood    -54.07729      |
| Chi squared                   23.95903      |
| Degrees of freedom                  10      |
| Prob[ChiSqd > value] =       .7709873E-02 |
| Hosmer-Lemeshow chi-squared =   6.16271     |
| P-value=  .62901 with deg.fr. =      8      |
+---------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
          Characteristics in numerator of Prob[Y = 1]
 Constant     -2.56567899     1.31214133    -1.955   .0505
 GENDER        -.38302839     1.01098915     -.379   .7048      .34615385
 OFFARMI       -.95572047      .64601359    -1.479   .1390      .50000000
 LIVEST         .07623588      .11087729      .688   .4917     3.60592308
 EXPER         -.03838949      .03944623     -.973   .3304     11.4384615
 EXTEN        -2.34664624      .81861280    -2.867   .0041      .69230769
 NUMHIVES      -.04430453      .13345068     -.332   .7399     2.47000000
 HOUTPUT        .05058158      .04587216     1.103   .2702     6.65288462
 VARICOST      -.00108630      .00302700     -.359   .7197     96.5538462
 COSTHIV        .00127082      .00075301     1.688   .0915     701.205769
 PARTINDE      3.13014114     1.87263455     1.672   .0946      .50000000

+--------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                  |
|                          M=Model MC=Constants Only   M0=No Model |
| Criterion F (log L)     -42.09777        -54.07729     -90.10913 |
| LR Statistic vs. MC      23.95903           .00000        .00000 |
| Degrees of Freedom       10.00000           .00000        .00000 |
| Prob. Value for LR         .00771           .00000        .00000 |
| Entropy for probs.       42.09777         54.07729      90.10913 |
```

```
| Normalized Entropy           .46719             .60013        1.00000 |
| Entropy Ratio Stat.        96.02273           72.06370          .00000 |
| Bayes Info Criterion      132.87088          156.82992       228.89361 |
| BIC - BIC(no model)        96.02273           72.06370          .00000 |
| Pseudo R-squared             .22153             .00000          .00000 |
| Pct. Correct Prec.         86.15385             .00000        50.00000 |
| Means:        y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7 |
| Outcome      .8538  .1462  .0000  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr      .8538  .1462  .0000  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).       |
|        Normalized entropy is computed against M0.                     |
|        Entropy ratio statistic is computed against M0.                |
|        BIC = 2*criterion - log(N)*degrees of freedom.                 |
|        If the model has only constants or if it has no constants,     |
|        the statistics reported here are not useable.                  |
+-----------------------------------------------------------------------+
```

LOGIT;Lhs=LANGS;Rhs=ONE,GENDER,OFFARMI,LIVEST,EXPER,MKTDIST,EXTEN,NUMHIVES ,VARICOST,COSTHIV,PARTINDE$

```
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Multinomial Logit Model                     |
| Maximum Likelihood Estimates                |
| Model estimated: Mar 14, 2006 at 08:45:45PM.|
| Dependent variable              LANGS       |
| Weighting variable               None       |
| Number of observations            130       |
| Iterations completed                7       |
| Log likelihood function     -44.71609       |
| Restricted log likelihood   -88.56454       |
| Chi squared                  87.69691       |
| Degrees of freedom                 10       |
| Prob[ChiSqd > value] =       .0000000       |
| Hosmer-Lemeshow chi-squared =  9.44405      |
| P-value=  .22233 with deg.fr. =      7      |
+---------------------------------------------+
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  | Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+--------------+----------------+--------+---------+----------+
         Characteristics in numerator of Prob[Y = 1]
 Constant     -8.20438667      2.17640419    -3.770   .0002
 GENDER         .70576363       .80130450      .881   .3784     .34615385
 OFFARMI        .61169912       .61785108      .990   .3222     .50000000
 LIVEST         .10685675       .11401052      .937   .3486    3.60592308
```

```
EXPER            .01141367        .03351176        .341    .7334     11.4384615
MKTDIST          .05713114        .07104296        .804    .4213     8.93076923
EXTEN           1.10330944        .73631066       1.498    .1340      .69230769
NUMHIVES        -.05433125        .11142223       -.488    .6258     2.47000000
VARICOST         .00182124        .00301459        .604    .5457     96.5538462
COSTHIV          .00417894        .00071423       5.851    .0000     701.205769
PARTINDE        4.38008685       2.19634057       1.994    .0461      .50000000
```

```
+---------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                   |
|                          M=Model MC=Constants Only   M0=No Model    |
| Criterion F (log L)      -44.71609        -88.56454     -90.10913   |
| LR Statistic vs. MC       87.69691           .00000        .00000   |
| Degrees of Freedom        10.00000           .00000        .00000   |
| Prob. Value for LR          .00000           .00000        .00000   |
| Entropy for probs.        44.71609         88.56454      90.10913   |
| Normalized Entropy          .49624           .98286       1.00000   |
| Entropy Ratio Stat.       90.78609          3.08918        .00000   |
| Bayes Info Criterion     138.10752        225.80443     228.89361   |
| BIC - BIC(no model)       90.78609          3.08918        .00000   |
| Pseudo R-squared            .49510           .00000        .00000   |
| Pct. Correct Prec.        86.15385           .00000      50.00000   |
| Means:       y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7  |
| Outcome     .5769  .4231  .0000  .0000  .0000  .0000  .0000  .0000  |
| Pred.Pr     .5769  .4231  .0000  .0000  .0000  .0000  .0000  .0000  |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                |
+---------------------------------------------------------------------+
```

LOGIT;Lhs=SOILBLO;Rhs=ONE,GENDER,EDUC,OFFARMI,LIVEST,EXPER,MKTDIST,EXTEN ,NUMHIVES,HOUTPUT,VARICOST,COSTHIV,PARTINDE$

```
Normal exit from iterations. Exit status=0.

+---------------------------------------------+
| Multinomial Logit Model                     |
| Maximum Likelihood Estimates                |
```

Model estimated: Mar 14, 2006 at 08:49:23PM.	
Dependent variable	SOILBLO
Weighting variable	None
Number of observations	130
Iterations completed	6
Log likelihood function	-55.10542
Restricted log likelihood	-66.41480
Chi squared	22.61876
Degrees of freedom	12
Prob[ChiSqd > value] =	.3114256E-01
Hosmer-Lemeshow chi-squared =	8.76232
P-value= .36274 with deg.fr. =	8

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
Characteristics in numerator of Prob[Y = 1]					
Constant	1.07078459	2.38315845	.449	.6532	
GENDER	-.61437733	.76350860	-.805	.4210	.34615385
EDUC	.00714719	.10678685	.067	.9466	6.60000000
OFFARMI	.26170585	.54352852	.481	.6302	.50000000
LIVEST	.00201211	.10164553	.020	.9842	3.60592308
EXPER	-.05561892	.03364759	-1.653	.0983	11.4384615
MKTDIST	-.22191460	.08382012	-2.648	.0081	8.93076923
EXTEN	-.95639641	.81008983	-1.181	.2378	.69230769
NUMHIVES	.10430487	.10001768	1.043	.2970	2.47000000
HOUTPUT	.02357078	.04469513	.527	.5979	6.65288462
VARICOST	.00205631	.00258228	.796	.4258	96.5538462
COSTHIV	.00024381	.00059223	.412	.6806	701.205769
PARTINDE	-.75681737	2.66506242	-.284	.7764	.50000000

Information Statistics for Discrete Choice Model.	M=Model	MC=Constants Only	M0=No Model
Criterion F (log L)	-55.10542	-66.41480	-90.10913
LR Statistic vs. MC	22.61876	.00000	.00000
Degrees of Freedom	12.00000	.00000	.00000
Prob. Value for LR	.03114	.00000	.00000
Entropy for probs.	55.10542	66.41480	90.10913
Normalized Entropy	.61154	.73705	1.00000
Entropy Ratio Stat.	70.00742	47.38867	.00000
Bayes Info Criterion	168.62125	191.24001	238.62868
BIC - BIC(no model)	70.00743	47.38867	.00000
Pseudo R-squared	.17028	.00000	.00000
Pct. Correct Prec.	80.76923	.00000	50.00000

```
| Means:        y=0    y=1    y=2    y=3    yu=4   y=5,    y=6    y>=7 |
| Outcome      .7923  .2077  .0000  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr      .7923  .2077  .0000  .0000  .0000  .0000  .0000  .0000 |
| Notes: Entropy computed as Sum(i)Sum(j)Pfit(i,j)*logPfit(i,j).      |
|        Normalized entropy is computed against M0.                   |
|        Entropy ratio statistic is computed against M0.              |
|        BIC = 2*criterion - log(N)*degrees of freedom.               |
|        If the model has only constants or if it has no constants,   |
|        the statistics reported here are not useable.                |
+---------------------------------------------------------------------+
```

Appendix 6: Standard tropical livestock units (TLU) conversion factors

- Chicken 0.01
- Sheep and Goat 0.1
- Donkey 0.4
- Cattle 0.7
- Camel 1.6