Determinants of modern box hives adoption in Kitui County, Kenya

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ABSTRACT

Modern beekeeping across Kenya is still a new idea as most of the beekeepers continue to exclusively use traditional hives leading to low quality and quantity of the honey produced. This study was carried out to establish the determinants of modern box hive adoption in Kitui county. Data was mainly collected through questionnaires administered to 110 beekeepers (42 adopters and 68 non-adopters) from the five selected locations of Mwingi Central Sub-county namely; Waita, Nuu, Kivou, Mwingi and Mui. The collected quantitative data was analyzed using the Statistical Package for Social Sciences (SPSS) version 20.0. Chi-square tests revealed a statistically significant relation between adoption of modern box hives and; modern beekeeping training, apiary visit, off-farm employment, credit use and extension contact. T-test analysis indicated significant mean differences between adopters and non-adopters in terms of; age, education level, knowledge and experience in beekeeping. Logistic regression further provided more details on the significant predictor variables. It was concluded that the low adoption rate is linked to a number of socio-economic and institutional factors which must be addressed in order to increase adoption of the more productive modern box hives. The study recommends among other things; establishment of more honey processing and marketing centres and facilitation of more extension contact with beekeepers.

Key words: Modern box hives, adoption, determinants.

1.0 INTRODUCTION

Apiculture is one of the widely spread economic activities in the world with global annual honey production about 1.6 million tons, yielding an exchange market worth over 1billion US$ (FAOSTAT, 2015). Apart from economic benefits, beekeeping promotes conservation of natural vegetation from where bees obtain nectar (JAICAF, 2009). Furthermore, with the current crop failure due to climate change, beekeeping is a sustainable livelihood diversification option in the arid and semi-arid areas experiencing unprecedented rainfall variability. (Carroll, 2006; Intergovernmental Panel for Climate Change, IPCC, 2001).

There is a wide variety of bee hives used by beekeepers worldwide. Nevertheless, hive types are broadly grouped into two; traditional and modern ones. The widely used traditional hives include;

the grass hive, the gourd hive and the log-hives. The modern hives include the V-shaped top bar, the pointed starter, the groove top bar, the Kenya Top Bar Hive (KTBH) and the Langstroth hive (FAO, 1990). The log hive is the most common traditional hive in Kenya. During harvesting and extraction, the honey mixes with the brood, pollen and wax since they are all removed and squeezed together thus interfering with the honey quality and quantity.

Modern hives are also becoming popular in Kenya. The fundamental concept behind the modern box hives is the reutilization of bee colonies since bees are not killed during honey harvesting. They are also easier to manipulate and manage compared to the log hives (JAICAF, 2009). The two most common modern hives in Kenya are the KTBH and the Langstroth. The KTBH consists of bars that can be removed by lifting allowing the beekeeper to easily inspect the hive for ripe honey (FAO 1986). It also has the queen excluder which is a wire mesh held in place six bars from the entrance of the hive thus separating the honey combs from brood combs (Rangoma, 2011). During harvesting only honey combs are removed leaving behind the brood nest hence ensuring cleanliness of the honey is maintained. The hives are hung 1m above the ground making it is easy to harvest honey, control ants attack and perform other hive management activities (Carroll, 2006).

The langstroth is however the widely used modern hive in Kenya. It has frames which can be removed for inspection to identify those full with honey. The langstroth consist of two boxes, one at the top where the bees make honey and another at the bottom (brood chamber) where the queen bee lay eggs. The two boxes are separated horizontally by a wire mesh known as a queen excluder (Carroll, 2006; JAICAF, 2009). During harvesting, frames with honey filled combs are removed and the honey extracted using the centrifugal honey extractor equipment. The extracted combs are returned to the hive thus enabling the bees to continue with honey making activities almost all year round. Typically, the average amount of honey per harvest from the traditional log-hive is 5-10 kg, while from KTBH and the langstroth is 20-25 kg and 30-35 kg, respectively (Muya, 2014).

Apiculture is a highly potential sub-sector in Kenya given that two thirds of the country's total land area is arid and semi-arid where beekeeping can be an appropriate livelihood diversification option. Recent studies show that there are about 90,340 beekeepers in the country owning about 2 million hives. Annual production is approximately 25,000 and 140 metric tons of honey and bee wax, respectively, which is just 25% of the estimated potential of 100,000 metric tons (Kiptarus *et al.*, 2015). Kitui County is one of the arid and semi-arid areas in Kenya where beekeeping is a common activity. However, the sub-sector has little socio-economic impact on the beekeepers' welfare due to the beekeeper's failure to adopt the more productive modern box hives. As observed by Mugendi (2011) most of the beekeepers (62%) in Kitui county exclusively use the traditional log hives indicating low levels of modern box hives adoption.

Rogers (1962, p. 15) defined adoption as "the mental process through which an individual pass from first hearing about an innovation to final adoption." In Kenya, efforts to promote adoption of modern hives and associated technologies dates back to the colonial period when the government started to introduce modern apiculture through training of beekeepers in the 1950's. Honey refineries were also established at Makueni, Baringo, Samburu and Kitui among others (Kigatiira & Morse, 1979). These developments were important in promoting modernization of the sector. However, the various development agency interventions through the government and Non-Governmental Organizations (NGOs) have since failed to stimulate modernization of apiculture especially in the semi-arid regions in Kenya (United Nations Development Programme, 2012). The low adoption rate necessitates evaluation of the factors influencing adoption of modern box hives. To establish this, the study empirically analyses the determinants of modern box hive adoption in the selected study area, Mwingi Central Sub-county of Kitui County. The specific study objectives

are to; describe the socio-economic characteristics of the beekeepers and identify the determinants of modern box hive adoption.

2.0 MATERIALS AND METHODS

2.1 Study area

The study was conducted in Mwingi Central Sub-county which is one of the 8 sub-counties of Kitui County. The sub-county covers an area of 4,141.4 km^2 and lies between latitudes 0°48'S to 1°12'S and longitudes 38°0'E to 38°48'E. The area experiences high temperatures throughout the year with most of the months dry. Annual rainfall ranges between 500–700 mm. The altitude ranges from 860m in the lower areas to 1090m in the hilly sections (County Government of Kitui, CGoK, 2014). According to Kenya National Bureau of Statistics, (2010) the area had a total of 141,207 inhabitants (67,397 male and 73,810 female). The livelihood economic activities range from mixed farming to horticulture on small scale. Crops grown include drought resistant maize varieties, millet, sorghum, green grams, mangos, watermelon and pigeon peas (CGoK, 2014). Beekeeping is also a common economic activity in the area and has been an important economic activity there since time immemorial with most beekeepers using traditional log hives (Nightingale, 2006). Modernization in the sector begun after the beekeepers started forming small beekeeping groups and the subsequent creation of the Mwingi beekeepers Community Based Organization (CBO) in 2002 with assistance from International Centre of Insect Physiology and Ecology (ICIPE).

2.2 Sampling technique

Both probability and non-probability sampling techniques were employed. Mwingi Central Sub-county was selected purposively because of presence of the Mwingi beekeepers CBO from where beekeepers get training on modern apiculture therefore increasing their probability of adopting modern box hives. Five out of the 16 locations of the sub-county were purposively selected since they had the highest proportion of registered beekeepers (522 out of 785). The beekeepers were stratified into adopters and non-adopters proportional to their approximated population in the area. In this study adopters were beekeepers who had continuously used at least one modern box hive for the last two years before the study while non adopters were beekeepers who had exclusively used traditional hives in the same period. According to the records at the Mwingi beekeepers (CBO), there were 198 (38%) adopters and 324 (62%) non adopters. Based on this proportion simple random sampling was employed to select 42 adopters and 68 non-adopters making a sample size of 110 beekeepers.

2.3 Data collection

With the help of three trained research assistants each of the 110 beekeepers was administered with a structured questionnaire to provide primary data. Key informants were interviewed to obtain in-depth information. Secondary data was obtained from research reports and journals, CBO records, national and county government publications and other relevant written materials. A month before the substantive field data collection, a pilot study was carried out to pre-test the research instruments and check their feasibility and reliability.

2.4 Data analysis

Descriptive statistics such as cross-tabulations, means and frequencies were utilized to describe and summarize the beekeepers' socio-economic characteristics. Inferential statistics such as chi-square and t-test were used to make generalizations about characteristics of the population. A binary

logistic model was further employed to provide more statistical details on the factors influencing adoption of modern box hives in the study area.

Binary logistic model

As guided by Karl (2015) the study applied a logistic model to analyze the determinants of modern box hives adoption in the study area since the dependent variable was dichotomous and the independent variables were a mix of continuous and categorical variables. Following Gujarati (1995) the logistic regression model characterizing adoption of modern box hives was specified as:

$$P = \frac{1}{1+e^{-(\alpha+\beta X_i)}}$$

Where: P is the probability that an individual will make a certain choice given X_i; X_i is a vector of exogenous variables; β is the coefficients of the independent variable; α is the constant; subscript i denote the i^{th} observation in the sample and e is the base of natural logarithms. The same function can be written as:

$$I_i = \ln\left[\frac{P_i}{(1-P_i}\right] = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \ldots \beta_k X_{mi} + e_i$$

Where: l_i is log of the odds ratio in favor of modern box hive adoption; e is a disturbance term; the *ß's* are the parameters estimated using maximum likelihood techniques. The coefficients reflect the effect of individual explanatory variable on its log of odds. The log for odds is expressed as; $ln\left[\frac{p}{1-p}\right]$, which is the natural log of the probability of adopting modern box hive (P) divided by the probability of not adopting (1-p). For this study, the model was specified as:

$ADMBH = \beta_0 + \beta_1 AGE_i + \beta_2 EDUC_i + \beta_3 EXPR_i + \beta_4 KNOW_i + \beta_5 PERC_i + \beta_6 COLN_i + \beta_7 TRAIN_i + \beta_8 AVST_i + \beta_9 OFF_i + \beta_{10} CRED_i + \beta_{11} EXTC_i + e_i$

Where: ADMBH (Adoption of Modern Box Hive) represents the dependent binary variable; β_0 is the constant term; β's are the coefficients of the independent variables; and e is disturbance term. Meanings of the abbreviations for the independent variables are shown in Table 1.

A test for multicollinearity must be done before adopting a given model to exclude the highly correlated explanatory variables. For this study Variance Inflation Factor (VIF) was employed to test for multicollinearity and established no such problem as the all VIF values were less than 4 as guided by Hair *et al.,* (2010) (Table 1). Following Gujarati (1995), the VIF_j is given as:

$VIF\ (X_j) = \frac{1}{1-R_j^2}$.

Where: R_j^2 is the coefficient of determination when the variable X_j is regressed on the other explanatory variables.

Table 1: Variance inflation factor results (VIF)

	Collinearity statistics	
Model variables	**Tolerance**	**VIF**
Age in years (**AGE**)	.332	3.010
Education level (**EDUC**)	.368	2.718
Experience in beekeeping (**EXP**)	.244	3.898
Training on modern apiculture (**TRAN**)	.460	2.173
Extension contact (**EXTC**)	.451	2.217
Apiary visit (**AVST**)	.895	1.118
Credit access (**CRED**)	.845	1.183
Off-farm employment (**OFF**)	.762	1.312
Knowledge score (**KNOW**)	.462	2.166
Perception (**PERC**)	.597	1.676
Colony holding (**COLN**)	.761	1.314

3.0 RESULTS AND DISCUSSION

3.1 Socio-demographic characteristics

A total of 110 respondents were included in the study sample. Out of this, 60.9% and 39.1% were male and female, respectively with a mean age of 54.7 years. In terms of marital status 86.4%, 6.4%, 2.7% and 4.5% of the total respondents were married, single, divorced and widowed, respectively. With regards to level of education, 11.8%, 32.7% and 30.0% of the respondents had gone through lower primary, upper primary and secondary education, respectively. A meager 6.4% had gone beyond secondary education level while 19.1% of the total respondents had not undergone any formal education.

3.2 Determinants of modern box hive adoption

Determinants/factors influencing adoption of modern box hives were categorized into socio-economic and institutional factors. The statistical analysis tools used were chi-square for categorical variables and t-test for continuous variables.

3.2.1 Socio-economic factors

The mean age of adopters was 48.21 years while that of non-adopters 58.63 years. The t-test results revealed a significant difference in the mean ages of adopters and non-adopters at $P<0.05$ (Table 2). The results imply that older beekeepers are less likely to adopt the modern box hive technology compared to the younger ones. The results agree with Shiferaw and Holden (1998) who found that age of the farmers negatively influenced adoption of new farm technology. However, Gebiso (2015) found that increase in age of the farmers increased the probability of adoption of modern bee hives in Oromia Region, Ethiopia.

Education levels in terms of years of schooling of adopters and non-adopters was 11.38 years and 5.07 years, respectively. The mean difference was significant at $P<0.01$ (Table 2) indicating that increase in education level favors technology adoption. Yehuala *et al.* (2013) made similar observation on beekeepers in Amhara region of Ethiopia. Education empowers beekeepers evaluate the risks and benefits of adopting modern box hives rationally therefore enabling them to have confidence in making decision to adopt.

It was found that 52.7% (32.7% adopters and 20% non-adopters) of the total respondents had an off-farm employment while the remaining 47.3% had none. Chi-square analysis revealed a positive relation between off-farm employment and adoption of modern box hives at $P<0.01$ (Table 3).

Beekeepers with off-farm employment were likely to overcome their financial constraints hence acquiring the input materials required in modern apiculture. They were more exposed to information about new farm technology thus improving their knowledge and attitude towards it. Similar findings were recorded by Yehuala *et al.* (2013).

Majority of the respondents (43.6%) had between 11-20 years beekeeping experience while 24.5% and 22.7% of the total respondents had between 1-10 and 21-30 years of experience, respectively. Only 9.1% had kept bees for more than 30 years. The mean years of experience was 13.45 years and 21.43 years for adopters and non-adopters, respectively. The mean difference was statistically significant at $P<0.01$ (Table 2). The results indicate that propensity to adopt modern box hives decreased with increase in beekeeping experience. The results were different from those of Jebesa (2017) who found an insignificant difference in years of experience between adopters and non-adopters of modern bee hives.

Most of the respondents (63.6%) had between 1-10 honey bee colonies. 25.5%, 6.4% and 2.7% owned between 11-20, 21-30 and 31-40 colonies, respectively. Only 1.8% of the total respondents had more than 40 honey bee colonies. The average number of honey bee colonies among adopters and non-adopters was 10.09 and 12.13 respectively (Table 2). The t-test analysis indicated an insignificant mean difference in colony holding between the groups. Thus, having more or lesser honey bee colonies did not affect adoption of modern box hives. The results were in line with those of Workneh (2007).

Successful use of modern box hives requires the user to have the necessary practical knowledge. To measure their knowledge on modern apiculture, the respondents were provided with five practical questions concerning modern box hives with each question carrying one mark. The mean score for adopters and non-adopters was 4.24 and 1.93 marks respectively, revealing a significant mean difference according to t-test analysis at $P<0.01$ (Table 2). Having the required practical knowledge on new farm technology improves the farmer's probability of adoption.

Perception of the respondents on the modern box hives was also examined. The respondents were provided with some perceived relative advantages and disadvantages of the box hives for them to state their opinion on a five-point scale. Each category had three items. For advantages the items were high honey yield, high quality honey and ease of inspection while for disadvantages they were high cost, high skill requirement and unavailability. The total score on disadvantages was subtracted from the total score on advantages for each respondent with the resultant figure representing the respondents' perception on modern box hives. The mean scores for adopters and non-adopters were 1.714 and 1.941 respectively, and the difference was insignificant (Table 2). Despite not using the modern box hives, the non-adopters had learned about their benefits from various sources. However, the results contradict those of Melaku (2005) who established that farmers' perception had a positive association with adoption of modern bee hives in Ethiopia.

The role of apiary visit was also investigated. An interested beekeeper may visit an apiary of a neighbour, a display in an agricultural show, a beekeepers' group apiary or any other place and learn more on modern apiculture. During the study, 68.2% (34.5% adopters and 33.6% non-adopters) had visited an apiary site in the last two years while the remaining 31.8% (3.6 adopters and 28.2% non-adopters) had not. The association was significant according to Chi-square analysis (Table 3). The findings are in line with those of Affognon *et al.* (2015).

3.2.2 Institutional factors influencing adoption of modern box hives

The institutional factors hypothesized to have influence on adoption were extension contact, credit use and modern beekeeping training. Extension officers may visit individual beekeepers or beekeepers' groups or organize seminars in a central place where the beekeepers come and learn.

Since they pass specific skills to the farmers, extension officers facilitate adoption and continued use of new farm technology. By the time of the study, 62.7% (35.5% adopters and 27.3% non-adopters) had contact with extension officers at least once in the previous two years while the remaining 37.3% had not. Chi-square analysis indicated a significant association between extension contact and adoption of modern box hives at P<0.01 (Table 3).

Technology adoption requires capital investment in order to acquire the necessary inputs. As noted by Adesina and Zinnah (1993) the asymmetric distribution patterns of endowments are the major determinants of adoption behavior. Thus, acquisition of capital through credit was expected to influence technology adoption. Only 30% (28.2% adopters and 1.8% non-adopters) had accessed credit within two years prior to the study while the remaining 70% had not. Chi-square analysis revealed a statistically significant relation between credit access and the adoption (Table 3). The findings were in agreement with Feder *et al.* (1985) who noted that credit programs enable farmers acquire physical capital needed for technology adoption.

Training is an important prerequisite for effective technology adoption as it develops the beekeeper's confidence in the technology. Some 53.6% of the respondents had training on modern apiculture while the remaining 46.4% had not. The association was significant at P<0.01 (Table 3). This implies that developing the skill of beekeepers through training enhanced adoption of modern box hives. Workneh (2007) also found that training enhanced adoption of improved box hives in Atsibi Wemberta District of Ethiopia.

Table 2: T-test results for continuous variables

Variable	**Adopter (n=42)**	**Non-adopter (n=68)**	**Combined (n=110)**	**t-value (df=108)**
Age (years)	48.21	58.63	53.42	-3.849*
Education level (years)	11.38	5.07	8.23	-8.881**
Beekeeping experience (years)	13.45	21.43	17.44	4.855**
Bee colony holding	10.09	12.13	11.11	1.164
Knowledge on modern apiculture	4.24	1.93	3.09	17.999**
Beekeeper's perception	1.714	1.941	1.83	0.386

*, **, significant at P<0.05, P<0.01

Table 3: Chi-square results for categorical variables

Variable	**Response**	**Adopter (n=42)**	**Non-adopter (n=68)**	**Combined (n=110)**	**X^2 (df=1)**
Off-farm employment	Yes	30 (32.7)	22 (20.0)	58 (52.7)	29.660**
	No	6 (5.5)	46 (41.8)	52 (47.3)	
Apiary visit	Yes	38 (34.5)	37 (33.6)	75 (68.2)	15.566**
	No	4 (3.6)	31 (28.2)	35 (31.8)	
Extension contact	Yes	39 (35.5)	30 (27.3)	69 (62.7)	26.380**
	No	3 (2.7)	38 (34.5)	41 (37.3)	
Credit access	Yes	31 (28.2)	2 (1.8)	33 (30.0)	62.094**
	No	11 (10.0)	66 (60.0)	77 (70.0)	
Training	Yes	41 (37.3)	18 (16.4)	59 (53.6)	52.852**
	No	1 (0.9)	50 (45.5)	51 (46.4)	

**, significant at P<0.01; (), percentage

Regression model outcome on socio-economic and institutional factors

In the preceding section, chi-square and t-test statistical tools were used to test for significance in association between different variables and adoption of modern box hives with each variable being tested individually. In this section, logistic regression model based on maximum likelihood estimation procedure was applied to analyze the combined effect of the independent variables between adopters and non-adopters on probability to adopt. The model outcome did not contradict results of chi-square and t-test tools but gave more details about association of the tested variables with the adoption behavior, such as the odds ratios. To measure how much the model fits the data Cox and Snell R^2 was reported. The R^2 value of 0.566 indicates that 56.6% variation in the adoption behavior was explained by the 11 independent variables fitted in the model. The analysis results indicate that education level, off-farm employment, apiary visit, age, knowledge, credit access, training and extension contact were found significant. The significant variables are discussed below. The other predicted variables; bee colony holding, experience in beekeeping, and perception were found insignificant (Table 4).

Table 4: Logistic regression results

Variable	B	S. E	Wald	Sig.	Exp(B)
AGE	-0.589	0.226	5.463	0.009	0.555
EDUC	1.035	0.283	13.408	0.000	2.815
EXPR	-0.050	0.098	0.261	0.609	0.951
KNOW	1.001	0.429	5.439	0.020	2.720
PERC	0.031	0.134	0.53	0.818	1.031
COLN	0.091	0.056	2.638	0.104	1.095
TRAN	0.712	0.364	3.835	0.047	2.030
APVST	-0.710	0.465	2.850	0.091	0.490
OFF	0.948	0.370	6.571	0.010	2.581
CRED	2.544	0.968	7.251	0.006	12.730
EXTC	0.33	0.057	6.630	0.01	1.390
Constant	2.279	0.823	4.867	0.027	9.766

-2log likelihood 39.033, Wald chi (10df): 66.817 (0.000) significant at $p< 0.05$, Cox & Snell R^2: 0.566.

A person's education increases access to information and their ability to understand the technology more. The variable was significant at $p<0.01$ and took a positive sign. The odds ratio, 2.815 implies that one unit increase in years of schooling of the beekeeper increases the odds of adopting modern box hives by 2.8 times, keeping other variables in the model constant. The findings were in consistence with those of, Adgaba *et al.* (2014). Modern beekeeping training registered an odds ratio of 2.030. This implies that trained beekeepers are 2.0 times more likely to adopt modern box hives than the untrained. Gebiso (2015) also noted that training improves farmers' chances of adopting new farm technologies. Apiary visits was significant with a positive sign as hypothesized with an odds ratio value of 0.490. Similar findings were made by Affognon *et al.* (2015) who reported that exposure through apiary visits increases chances of farm technology adoption.

Beekeepers with off-farm employment earn higher incomes enabling them afford the box hives and the other necessary equipment required in modern beekeeping. The odds ratio was at 2.581 and indicates that beekeepers with off-farm employment are 2.6 times better placed to adopt modern box hives than those without. The findings were consistent with those of Yehuala *et al.* (2013). Credit access had 12.730 odds ratio value meaning that beekeepers with credit access are 12.7 times better placed to adopt modern box hives than those without. Since lack of credit is a challenge to

farm technology adoption, its availability would enhance the adoption (Adgaba *et al.*, 2014). The odds ratio on extension contact was at 1.390 implying that beekeepers who contact extension officers are 1.4 times more likely to adopt modern box hives than those who don't. The findings concur with those of Agwu *et al.* (2008). On knowledge, the model reported an odds ratio value of 2.720 implying that one unit increase in the knowledge score increases the odds of adopting the modern box hive by 2.7 times. The findings were in congruence with those of Workneh (2007) who found that having technical knowledge about modern box hives positively influenced the adoption. Age had a negative influence on the adoption. The model reported an odds ratio of -0.555 which implies that one unit increase in age decreases the odds of adopting the modern box hives by 0.6 times. Propensity to adopt the new technology decreased with increase in age of the beekeepers. Such findings were also reported by Adgaba *et al.* (2014).

4.0 CONCLUSION AND RECOMMENDATIONS

From the study low adoption rate of the modern box hives is evident. Adoption is low despite most of the beekeepers being aware of the modern box hives benefits. Data analysis proved existence of a number of socio-economic and institutional factors influencing adoption of modern box hives. Action should therefore be taken in relation to the findings. Modern beekeeping training and apiary visits should be facilitated to increase the adoption rate. Off-farm employment and credit access ought to be enhanced through job creation and availing cheap credit facilities. Deployment of more extension officers is likely to increase the rate of adoption since they assist beekeepers with the necessary technical skills in handling of modern box hives. In a nut shell is that, there is need to maximize the adoption by acting in line with the outcomes of this study.

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