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Factors influencing the adoption of modern beehives in Sikonge district, Tabora - Tanzania

Mohamed Musa Wawa[1*], Neema M Kitasho[2]
[1] Ministry of Natural Resources and Tourism, Beekeeping Training Institute, Tabora, Tanzania
[2] Department of Forest Economics, Sokoine University of Agriculture, Morogoro, Tanzania

Abstract
Choices made by a beekeeper to use modern beehives depend on various factors. This study assessed the factors influencing adoption of modern beehives in Sikonge District. Data was collected by semi-structured questionnaire, key informants interview and focus group discussion. This study was done in four wards; Chabutwa, Tutuo, Kipanga and Kiloleli, which were randomly selected out of the 15 wards of Sikonge District. Descriptive statistics and binary logistic regression were used as analytical tools. Binary logistic regression model revealed that factors which statistically affect the adoption of modern beehives are gender of the household head ($p < 0.05$), affiliation of a beekeeper to beekeeping group ($p < 0.001$) and experience in beekeeping ($p < 0.001$). It is recommended that beekeepers in the study area be encouraged to develop and join beekeeping groups so as to improve the adoption.

Keywords: beekeeping, beehives, adoption, Sikonge district, binary logistic regression

Introduction

Beekeeping is the practice and management of honeybees for man's economic benefits by production of valuable materials such as honey, beeswax, propolis, bee pollen, bee venom and royal jelly [19]. Beekeeping is one of the widespread activities practiced in the world while honey and beeswax being the major products in many parts [30]. Recently, in many parts of the world beekeeping has been promoted so as to tackle unemployment and improve the living standards of people [1].

Historically and in some places in the world today, honeybee products are obtained through hunting, as a way to diversify food supply and increase income [17]. Besides honey hunting, traditional forms of beekeeping have also been developed over the centuries [17]. More advanced forms of beekeeping involve using purposely made hives which not only allows for ownership of the bee colony and its products, but also makes it easier to harvest honeybee products [20]. The beehives provide far more reliable sources of honeybee products, on a regular basis and enables beekeepers to manage and control the bee colony [17].

Beekeeping in Tanzania is carried out using both traditional (but highly discouraged) and modern methods [10]. Approximately 95% of all beehives in Tanzania are traditional beehives including log and bark hives and only 5% are the modern beehives including the top bar hives and the langstroth hives [10, 18]. The traditional methods accounts for 99% of the total honey and beeswax production in the country (18, 20). In Tanzania, the use of traditional beehives (especially bark hives) is being discouraged due to its low productivity and negative effects to the forests [27]. The adoption rate of the modern beehives which are being promoted is very low making a total of barely 5% of all beehives in the country [29].

However, inspite of Sikonge District leading the potential and production of honey and beeswax in the country of 6000 tonnes and 2000 tonnes respectively [25, 29] its enormous potential remains unused fully, the factors for adoption of modern beehives which are highly encouraged by the government to use due to its high productivity, are not known and therefore this study aimed to provide an understanding of factors influencing the adoption of modern beehives in Sikonge.

Literature review

1. Modern beehives

The modern beehives which in Tanzania are synonymously called appropriate beehives are those with proper measurements based on research findings to suit bees [8]. This category is one promoted by the government of Tanzania through the Ministry of Natural Resources and Tourism (MNRT) to be used by beekeepers all over the country because of its major stated benefits: improved yield (quality and quantity) and environmental conservation [27] and a category includes the top bar hives (Tanzanian and Kenyan top bar hives) and the langstroth (Tanzanian commercial hives). These beehives are usually constructed by carpenters using timbers extracted from mature trees and the advantage is that from one tree several beehives can be obtained after timber extract and are usually durable and easy management of bee colonies [27].

2. Theory of innovation diffusion (adoption)

The innovation diffusion process consists of four key elements [16]: (i) *innovation creation* – which is an idea, practice or object that is perceived to be new by a person or adopting entity (23); (ii) *communication channels* – which are the means by which information about an innovation is transmitted to the social system [16]; (iii) *social system* – which refers to the boundary within which innovations diffuse; and (iv) *time*.

Innovation

Robertson [22] classifies innovations into three categories: *discontinuous* (e.g. supplanting transparencies with power point as the medium of visual communication); *dynamically continuous* (e.g. moving from a traditional chalkboard to transparencies); and *continuous* (e.g. using coloured chalk to supplement white chalk). Some innovations diffuse relatively slower and others diffuse relatively faster [26]. Rogers [23] suggests five major attributes of innovations that influence the rate of their adoption:

- **Relative advantage:** This factor is defined as a degree to which the innovation is perceived as being better than that which precedes it [6]. To be considered superior to its predecessor, the innovation must be perceived by target group as providing benefits (technological, economic, physical improvement) that are truly advantageous.
- **Complexity:** This attribute represents the extent to which an innovation is difficult to understand or use [22, 23]. If an innovation is complex, individuals will have inadequate knowledge, skills and experience to use it. These circumstances will likely impede the innovation adoption rate. To deal with innovation that is complex, potential adopters need to be educated about it, thus acquiring new knowledge about it [9].
- **Compatibility:** Compatibility is defined as a degree to which innovation is consistent with existing values, past experience and current audience needs [23]. When an innovation seems to complement individual's present situation, they possess less uncertainty about the successor, when it fits in with their present circumstances and may require little new learning or behavioural change, then adoption of innovation can be facilitated.
- **Observability:** This factor is defined as a degree to which an operation and results of an innovation are observable, visible or readily communicated to others [6]. An innovation that is manifested to others gains rapid awareness and recognition among the targeted group, and even ultimate acceptance. Current adopters legitimise the innovation through adopting it, thus providing endorsement of the innovation, and consequently fostering faster adoption. Essentially, because the innovation can be clearly seen by others, information about the innovation is revealed and it makes the adoption rate higher.
- **Trialability:** It is a degree to which an innovation can be tried on a limited scale [22, 23]. Those innovations that can be used on trial basis with minimum investment of time, money, or effort have advantage over their counterparts that do not possess this attribute. Trial ability allows individuals to 'try and buy'. If trying out the idea, practice or product seems to satisfy individuals' needs, then they are likely to adopt it; if not, they will probably reject the innovation.

Communication channels

The nature of information delivery determines the conditions under which a source will or will not transmit the information to the receiver. There are two main communication channels: *mass-media* – external influence, most efficient way to create awareness of an innovation; and *interpersonal channels* – internal influence, more effective in persuading an individual's acceptance of a new idea. Members of the social system have different propensities for relying on mass media or interpersonal channels when seeking information about innovation. Most individuals evaluate an innovation not on the basis of scientific research or expert opinion, but through the subjective evaluation of peers who have already adopted the innovation. Interpersonal communication, including non-verbal observation, is an important influence in determining the speed and shape of the innovation diffusion process in a social system [26].

Social system: The members or units of a social system may be individuals, informal groups or organisations [26]. Rogers [23] has classified members of the social system on the basis of their innovativeness: *innovators* (pioneers), *early adopters* (visionaries), *early majority* (pragmatics), *late majority* (conservatives), and *laggards* (sceptics). The innovators play an important role in the diffusion process, launching the new idea in the social system by importing the innovation from outside the system's boundaries. As for the *early adopters (visionaries),* members of this group are more integrated in the local system than innovators. Early adopters have the greatest degree of opinion leadership. This category is as a local missionary for speeding the diffusion process.

Early majority (pragmatics): the unique position between the early and late adoption, makes this category an important link in the diffusion process. The early majority is one of the two most numerous adopter groups, making up one-third of the members in a social system.

Late majority (conservatives): this group adopts innovation relatively late. They adopt more for economic or peer pressure reasons, not for usefulness. Because of scarce resources, late adopters try to avoid uncertainty and secure from the possible failure.

Laggards (sceptics): They possess almost no opinion leadership. Laggards are the most locative in their outlook and decisions are often made in terms of what has been done previously. Their resources are limited and they must be certain that a new idea will not fail before they can adopt.

The time before a new product attains major sales is divided in three main stages: *product development time, incubation time* and *mass diffusion time* of the new product. The diffusion time stage is the time through which an individual or other unit passes from first knowledge of an innovation, to forming an attitude towards the innovation, to a decision to adopt or to reject, to implementation of new idea and to confirmation of this decision [26].

Methodology

1. Description of the study area

1.1 Location

This study was conducted in Sikonge District in Tabora Region (Fig. 1). A District lies between 5° 38' 0" South and 32° 46' 0" East. It is 71 km from the headquarters of Tabora Region in the Southern part. The District has fifteen wards which are: Chabutwa, Kikungu, Ipole, Kiloleli, Kiloli, Kipili, Kitunda, Misheni, Mpombwe, Mtakuja, Ngoywa, Nyanhua, Pangale, Sikonge, Tutuo and Usunga. The total area of the District is 27 873 km² of which 26 834 km² are in forest and game reserves which is suitable for beekeeping activities and the remaining 1039 km² is for settlements and other economic activities [25]. Sikonge District is leading in honey and beeswax production (2000 tonnes annually) with the highest potential of honey and beeswax production in the country [29].

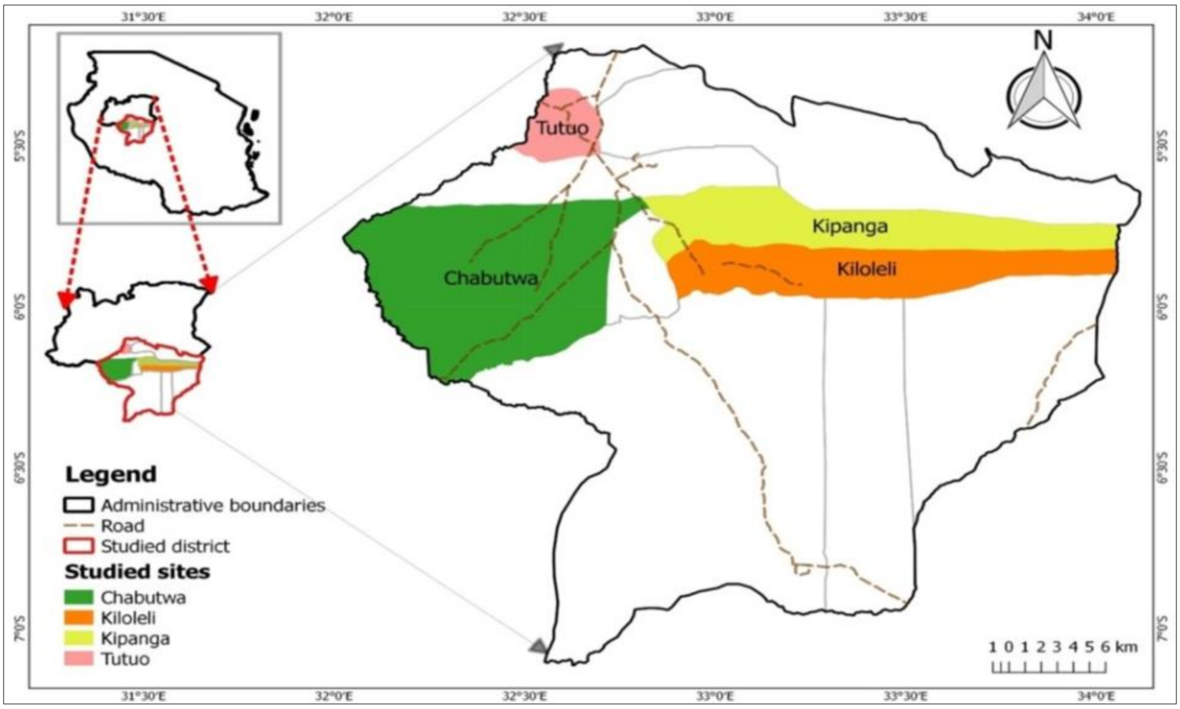

Fig 1

1.2 Climate and vegetation

Sikonge District has rainfall ranges from 600 mm to 900 mm annually and temperatures from 22˚C to 32˚C with the highest temperatures experienced in August, September and October and low temperatures in May. The daily mean temperature is around 23˚C. There is a slightly cooler period from May to July, marked by onset of dry winds which continue until October. Rainfall is seasonal, falling almost from June to October. In the West the rainfall totals over 1000 mm, while in the East it drops to 700 mm or less [28].

Vegetation of Tabora Region includes woodland, bushland thicket, grassland; lowland or wetland vegetation consisting of wooded grassland and swamps which favours beekeeping. Woodland is the natural vegetation over most of the region and can be divided into two groups: (a) Miombo woodland and Acacia (b) Cambretum and Albizia species [28]. Climate and the nature of vegetation covering Sikonge District (*largely Miombo woodland*) provide suitable environment condition for beekeeping activities rendering it with the high potential of beekeeping in the country.

1.3 Economic activities

The main economic activities of Tabora Region are agricultural production and livestock keeping. About 90% of the population is engaged in agriculture and livestock keeping apart from other activities like beekeeping, fishing and lumbering [28]. The region is estimated to have 2.4 million hectare of potentially cultivable land but only less than 20 percent is under cultivation [28]. Subsistence farming is the main form of farming while tobacco and cotton are the major cash crops. Livestock keeping is the second predominant economic activity [28]. The natural forests which provide high quality hardwood for timber and fuel wood are also a source of beekeeping for honey, beeswax production and also harbours wildlife.

1.2.1 Sampling procedure and sample size determination

Sampling procedure

A sampling unit was the household. For the purpose of this study, existing fifteen wards of Sikonge District were stratified into three strata based on levels of honey and beeswax production; low production, medium production and high production. Thereafter, four wards were randomly selected proportionately to the total number of wards in each strata using random numbers developed from excel computer program. The four wards selected include; Chabutwa (*low production*), Tutuo and Kipanga (*Medium production*) and Kiloleli (*High production*). The three strata allowed the capture of information in all levels of beekeeping production in the District. From each ward, one village was randomly selected using random numbers technique. The selected villages and their wards in brackets include: Chabutwa (*Chabutwa*), Muungano (*Tutuo*), Imalampaka (*Kipanga*) and Kiloleli (*Kiloleli*). Households from each village using modern and traditional beehives were identified and randomly selected for survey.

After selecting the household to take part in the survey, either the *husband* or *wife* of the respective household (*for a married couple*) was responsible for answering the questionnaire which is consistent with approach used by Lusambo [20]. In the event both (husband and wife) were present at the time of interview, then a *random sampling technique* (using playing cards) was used to determine who should be the respondent. Otherwise, for those beekeepers households whose heads were single or at the time of the visit there was only one of the couple present, the questionnaire was administered to either single household heads or the available couple member (for the latter case). District Beekeeping Assistant (DBA) and District Forest Officer (DFO) were key informants for the study and a checklist was administered. On the other hand, two experienced beekeepers for each type of beehives used in the area formed a focus group discussion and a checklist was administered.

1.2.2 Sample size determination

The total sample size for the study was 206 beekeepers households (50 households using modern beehives and 156 households using traditional beehives). The total Sample size of the District beekeepers households was obtained using the formula developed by Bartlett *et al.* (4):

$$n = \left(\frac{n_0}{1 + \frac{n_0}{N}} \right) \quad (1)$$

Where: n is the required (adjusted) sample size, N is the population size; n_0 is the sample size as calculated by Cochran's (7) formula:

$$n_0 = \left(\frac{t^2 \times pq}{d^2} \right) \quad (2)$$

Where: p is the proportion of respondent that give information of interest (the proportion *confirming*), q viz (1-p) is the proportion not giving information of interest (proportion *defective)*, and $p^* q$ is the estimate of variance (*which is maximum when p = 0.50 and q=0.50).* The maximum population variance of 0.25 will gave the maximum sample size.

Krejcie and Morgan (11) suggest the following values for survey studies: the appropriate *margin of error* is 0.05 (i.e 5 percent), and *alpha* is 0.05 (i.e 95% confidence level); and p and q should be 0.5 and 0.5 respectively. Based on the information above, Lusambo (15) modified the sample size formula as:

$$n = \frac{384}{1 + \frac{384}{N}} \quad (3)$$

Where, n is the sample size for finite population, and N is the population size. Table 1provides a summary of sample size in respective study villages.

Table 1: Summary of respondents in the respective study sites

Village	Total beekeepers (N)		Sampled beekeepers (n)	
	Using modern beehives	Using tradition beehives	Using modern beehives	Using tradition beehives
Chabutwa	27	35	25	32
Muungano	15	63	14	54
Imalampaka	4	52	4	46
Kiloleli	7	26	7	24

Data collection

Data used for this study consisted both primary and secondary data. Primary data was obtained through questionnaire survey, focus group discussion and direct field observation while secondary data were obtained through publications.

1.1.1 Questionnaire survey

Prior to actual data collection, questionnaire was pilot tested for a number of reasons as were suggested by Lusambo [15]: (i) to gauge whether questions, as set in the questionnaire, are understood by the respondents, (ii) to check whether the questions elicit the intended information, (iii) to find out the sensitive questions contained in the questionnaire, (iv) to determine the respondents' *interest, attention* and *cooperation* towards the survey, (v) to test the competency of assistant data collector, (vii) to estimate the time it takes to complete one questionnaire. The questionnaire used in the survey was semi-structured and were administered through personal interviews in order to encourage interviewees to participate and also allow probing and clarification by interviewer. Open and closed ended questions with a series of choices were used for respondents to choose the proper answer. The questionnaire was used to collect information on socio-economic variables of beekeepers households and factors for adoption of modern beehives.

Checklist for key informants was also prepared. Additionally, preliminary survey was conducted in the study area to understand the practicability of the research methodologies and understanding driving factors to data collection.

1.1.2 Focus group discussion

The group sizes ranging from 6 to 10 (11) were sampled (*at least two beekeepers from each type of beehives used*) in each village. A summary of the numbers of representative members for each village on FGDs is shown in Table 2.

Table 2: Number of FGD attendants in each selected village

S/no.	Village	Group size
1	Muungano	10
2	Imalampaka	6
3	Chabutwa	11
4	Kiloleli	8
Total		35

Data analysis

Binary logistic regression model was used to determine how the factors affecting the choices (*by households*) of type of beehives used by beekeepers affects the adoption of modern beehives in the study area. The adoption decision of modern beehives is a discrete outcome where the beekeepers face a dichotomous decision to adopt or not to adopt modern beehives. In this context, modern beehive adopters were those beekeepers using modern beehives (TTBH, TCH or KTBH) during the data collection while those using tradition beehives were considered as non-adopters. The binary logistic regression model is expressed as:

$$Logit\ (Y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + \varepsilon_i \quad (4)$$

Where: logit = $\ln \left(\frac{p}{1-p} \right)$ and p is the probability of an event of owning modern beehives; Y is the dependent variable i.e. adopted =1 and not adopted = 0; α is the Y intercept, β_s are regression coefficients, ε_i is an error term and X_s are a set of predictors for owning or not owning modern beehives and include factors such as the social economic characteristics: sex, income, experience in beekeeping activities (age involved in beekeeping), family size and whether a beekeeper has received training or not [5]. The factors included in the binary logistic regression for this study were; Age of a household head(*Number of years*), Sex (*1= Male, 0=Female*), education level (*1= Attended formal education, 0= Not attended*), family size (*Number of family members*), number of able adults, beekeeping as main economic activity (*1=Yes, 0=No*), attended beekeeping training(*1=Yes, 0=No*), Membership to beekeeping groups (*1=Yes, 0=No*) and experience in beekeeping (*Number of years*).

Results and discussions

The candidate variables and the estimate coefficients of the modern beehives adoption model are presented in Table 3 and Table 4 respectively

Table 3: Description of variables used in Linear Regression Model

Variable	***Description***
Y	Household beehive use choice (1 = Modern, 0 = Traditional)
X_1	Age of the household head
X_2	Sex of the household head (1 = Male, 0 = Female)
X_3	Education level of household head (1= Educated, 0 = Illiterate)
X_4	Family size
X_5	Number of able adults
X_6	Beekeeping Economic activity (1 = Main activity, 0 = Sideline activity)
X_7	Received beekeeping training (1 = Received, 0 = Not received)
X_8	Membership in beekeeping groups (1 = Affiliated to beekeeping group, 0 = Not affiliated to any beekeeping group)
X_9	Experience in beekeeping (years)

Table 4: Binary Logistic Regression Model results for modern beehive use choice

Predictor	***β***	**S.E.*β***	**Wald's**	**D .f**	***P***	**Exp (*β*)**	**95.0% C.I. for EXP(*β*)**	
			χ^2				Lower	Upper
X_1	-0.032	0.023	1.94	1	0.164	1.032	0.987	1.079
X_2	1.507	0.597	6.374	1	0.012*	4.515	1.401	14.553
X_3	0.133	0.662	0.04	1	0.841	0.876	0.239	3.206
X_4	-0.057	0.115	0.241	1	0.624	0.945	0.754	1.185
X_5	0.218	0.202	1.16	1	0.281	1.243	0.836	1.848
X_6	0.151	0.807	0.035	1	0.852	1.163	0.239	5.656
X_7	0.116	0.653	0.032	1	0.859	1.123	0.312	4.04
X_8	3.771	0.651	33.571	1	0.0001***	0.023	0.006	0.082
X_9	-0.145	0.038	14.722	1	0.0001***	0.865	0.803	0.932
Constant	-0.435	1.756	0.061	1	0.804	0.647		
Tests:			χ^2	D f	*P*			
Model Evaluation (Overall)								
Likelihood ratio test			112.70	7	0.001			
Goodness-of-fit test								
H-L statistic			4.004	8	0.857			
* Statistically Significant at α = 0.05								
*** Statistically Significant at α = 0.001								
Notes: PAC: Null model = 76.2; Model with descriptors = 88.8; Cox & Snell R^2: 0.423; Nagelkerke R^2 =0.632; Sample size used in the analysis (n) = 206								

The findings indicate that the model with descriptors (PAC: 88.8) performs better than the null model (PAC: 76.2). The goodness of fit test of predictors (*Omnibus test of model coefficients*) shown to be significant where $p < 0.001$, the results show further that the model performance is statistically significant (χ^2 (9 d.f) = 113.3). The model is further supported to be worthwhile by the inferential test for goodness-of-fit, the Hosmer and Lemeshow (H-L) statistic, indicates that the model fits the data well (χ^2 (8 d.f) = 4.004, p value of 0.857 ($P > 0.05$). Descriptive measures of goodness-of-fit also supports that the model fits the data well (Cox & Snell R^2 and Nagelkerke R^2 are 0.423 and 0.635 respectively) suggesting that between 42.3 % and 63.5 % of variability are explained by this set of variables. The regression results show that out of the nine predictors which were considered to influence the adoption of modern beehives in the study area, three factors were statistically significant influencing beekeepers' decision to adopt modern beehives; *Sex of the household head* ($p < 0.05$), *Experience in beekeeping activities* ($p < 0.001$) and *Affiliation to beekeeping group* ($p < 0.001$).

1. Sex of household head

The results show that gender of the household head (*whether the head is male or female*) has a significant influence to adoption of modern beehives ($p < 0.05$). The result in Table 4 shows that male headed households are more likely to adopt modern beehives 4.5 times a female headed household. This could be due to culture and norms of Sikonge, just like in many other societies in the country and other countries that women have less access to resources like capital [2, 14]. Also, in the study on adoption of improved maize and common bean varieties found that the rate of adoption for female headed household is low because women have less access to external inputs, services, and information due to socio-cultural values [14].

2. Affiliation to beekeeping groups

The empirical evidence from this study as presented in Table 4 show that beekeeper's affiliation to beekeeping groups significantly influenced adoption decisions to use modern beehives ($p < 0.001$). A beekeeper affiliated to beekeeping group had slightly higher chance of 0.02 times of adopting modern beehives to a beekeeper not affiliated to any beekeeping group. This could be due to the fact that affiliation to any group or an organization is a social capital. Also group membership is an indication of the beekeeper's level of networking and contacts with organised groups and informal groups. In Sikonge District, groups seem to enable beekeepers to learn about beekeeping technologies as are exposed to more contacts to extension, share experiences and exchange ideas about beekeeping technologies with others. This was also said by key informant (*District Beekeeping Assistant*) that "*we conduct beekeeping trainings and consulted mainly by members of beekeeping groups because is easy to get them and monitor their activities and are considered therefore to be more committed in beekeeping activities*". Networking enables beekeepers to assess and understand the risks and benefit associated with the use of an innovation thus high probability of adopting. These results are consistent with observations by other researchers [24].

3. Experience in beekeeping activities

The results of this study indicated that number of years of experience in beekeeping has a significant effect to adoption of modern beehives ($p < 0.001$). Experience has a negative effect with the decision to adopt modern beehives ($\beta = -0.145$) (Table 4). This implies that less experienced beekeepers (*recently joined beekeeping activities*) are more willing to adopt modern beehives varieties (*early majority*) than older beekeepers (*late majority/conservatives*). People with higher experience in beekeeping are highly *used to* traditional approaches and that they are risk averse to change to modern beehives than those with less experience who are more receptive towards newly introduced technologies. These findings are similar to those found by other researchers [21, 3, 13, 31]. The marginal effects show that the probability of adopting modern beehives varieties for elder beekeepers is lower by about 0.86 times to that of younger beekeepers.

Conclusions and recommendations

The study findings revealed that sex of the household head, affiliation to beekeeping groups and experience in beekeeping activities had statistically significant effect to the decision to use modern beehives in Sikonge District. Based on findings of this study there is a need for motivating young people to engage in modern beekeeping as a study has shown young beekeepers adopt modern beehives easily (early majority) than the old, therefore for the sake of increasing the number of adopters, motivating and encouraging this group could improve the rate of adoption and thereafter improve yield quality and quantity.

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