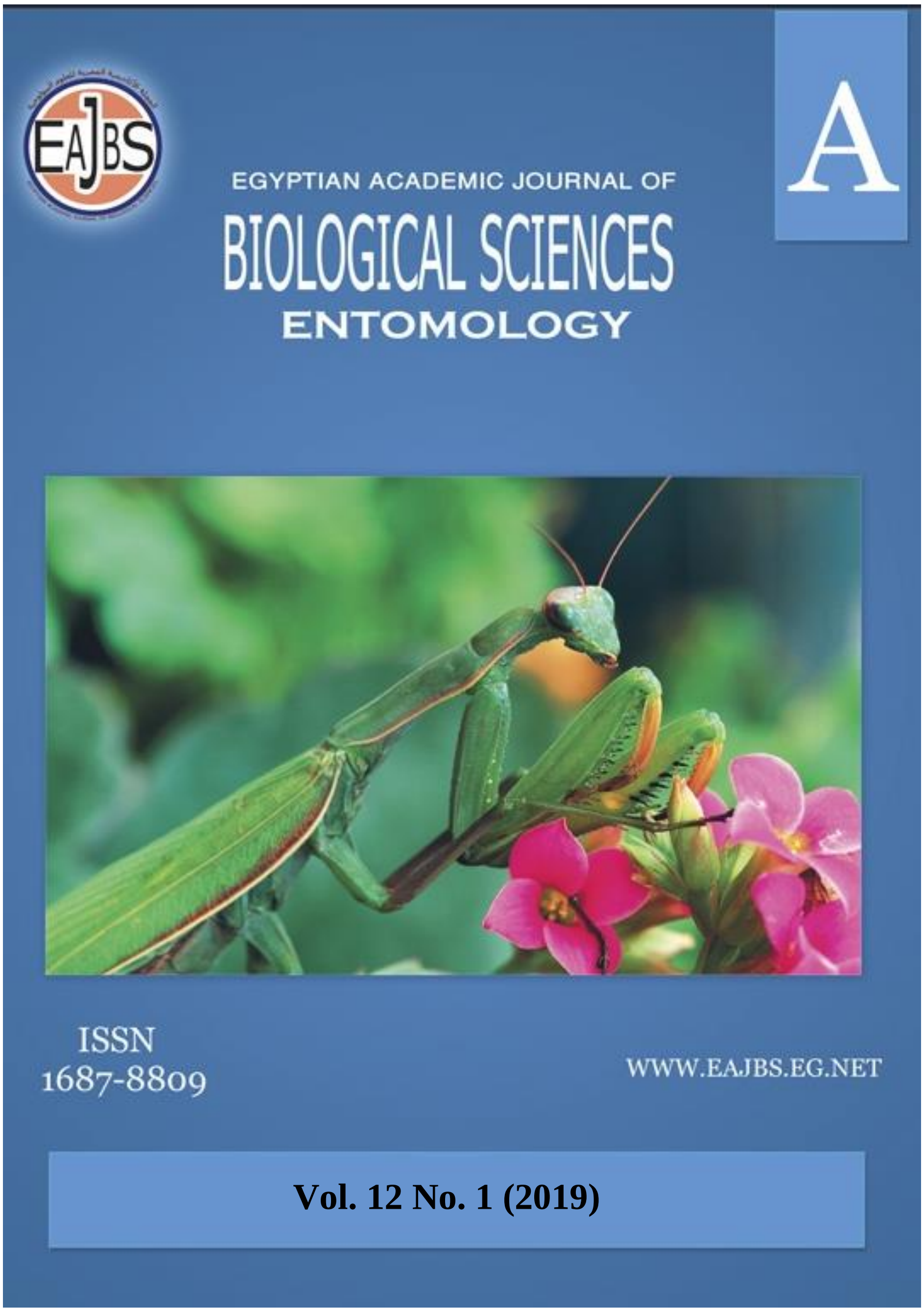

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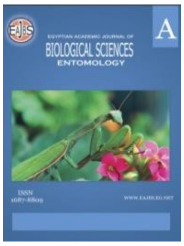

Analysis of Risks in Honeybee Production Farms in Nigeria: A Boost to Food Security

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ABSTRACT

This paper focuses on achieving sustainable food security through analysis of risk in honeybee production farms and determines the risk behaviour of bee farmers in kebbi and kwara states of Nigeria. Primary data were obtained using structured questionnaires and interview. A multi-stage random sampling procedure was employed for selecting 148 respondents comprising 102 traditional bee farmers and 46 modern bee farmers. Descriptive statistics: mean, percentage, standard deviation, the coefficient of variation and, safety model was used to determine the risk attitude coefficient of bee farmers. The conditional distribution of the honey harvest probabilities per ha for a food secure and insecure was plotted against the poverty index using normal kernel cumulative density. Result revealed that risks in apiculture are related to socio-economic and production characteristics. The bulk of traditional bee farmers (57.8%) is categorized as risk neutral while the majority of modern bee farmers (67.4%) belong to risk preferring (with an index of 1.52). The results revealed that the set of significant explanatory variables and their sign vary across the traditional and modern groups. The coefficient for marital status, bee farming experience and family labour were statistically significant for traditional bee farmers. While education, investment, family labour and hired labour were statistically significant for modern bee farmers. Bee farmers are encouraged to form cooperative society and if already existing should liaise with relevant agencies such as the ministry of agriculture and agricultural insurance companies for training, workshops and seminars on the capacity to handle risk-taking into cognizance their socioeconomic and institutional traits.

INTRODUCTION

The Honeybee, *Apis mellifera*, is social insects noted for providing their nests with large amounts of honey. A colony of honeybees is a highly complex cluster of individuals that functions virtually as a single organism (Ajao *et al.*, 2014a).

Honeybee (*Hymenoptera: Apidae*) is also known as the most economically valuable insect because of its honey production and pollinating activities. Several methods and structures including traditional, modern beekeeping, and age long honey hunting are employed to obtain honey from honeybee for its several uses.

Bee farming and apiculture is the art of rearing, breeding and managing honeybee colonies in artificial hives for economic gains (Morse, 1989). It refers to the practice and management of the bees in the hives, which leads to the production of valuable materials such as honey, beeswax, propolis, bee pollen, bee venom, bee brood and royal jelly among others. Apiculture offers unexploited succor capable of salvaging the people from food insecurity. Honeybee and its products are used in diverse ways and contribute to agricultural development through crop pollination and income to farmers (Ajao and Oladimeji, 2013 & 2015, Ojo *et al.*, 2017). The total honey produced in Nigeria is usually inadequate, not documented and the country meets the domestic consumption and industrial needs partly from the public based farms, array of diverse honey bee indigenous farmers and mostly import from other countries. However, bee farming in Nigeria is gradually becoming an important aspect of agriculture and has tremendous potential for widening Nigeria's export base. With the current increasing demand for honey products for domestic and industrial consumption coupled with mechanized agriculture in most part of Nigeria, resulting in large crop acreage, the future of apicultural enterprise is very bright as the demand for honey and perhaps pollinators is bound to increase (Oladimeji *et al.*, 2017).

Bee farming could provide food, nutritional, and livelihood security to the rural workforce on an ecologically sustainable basis. Globally, honeybee and its products such as honey, propolis and bee venom are found useful in the treatment of different diseases (Ajao *et al.*, 2014b). Honey has continued to play an important role in nutrition and medicine; it is an ingredient in many herbal remedies and a crucial component of the bride price for many tribes in Nigeria (Ajao and Oladimeji, 2015). Therefore investment in honey bee production system, *ab initio*, is one of the pathways for achieving Sustainable Development Goals (SDGs) of complete eradication of hunger, enhancing food security and improved nutrition, and promoting sustainable agriculture as proposed by post 2015 SDGs of the UN General Assembly for developing countries including Nigeria (Oladimeji *et al.*, 2016, Oladimeji and Ajao, 2018).

However, one of the most critical issues in honeybee production is a risk, that is; the production environment is hampering with imperfect knowledge and the vagaries of nature. The complex nature of weather and climate as well as other factors make bee farming more difficult to manage. The risk in bee farming is not only of production in nature, but also related to technical, financial, market and price, political, and of human (physical) induced risks. Figure 1 enumerates some of the most important risks in apiculture. It is pertinent to note that risk in honeybee production can be exogenously caused or endogenously induced. The exogenous risk may arise from extreme weather conditions, climate change, genetic weakness and threats of disease outbreaks, mostly independent of bee farmers' decisions. The endogenous risk is incurred solely by human-induced actions such as theft, bush burning, colony disturbance, poor nutrition, pollution, predators, parasites and pathogens, changes in forage quantity and quality due to land use, and other forms of environmental degradation.

There is a substantial body of evidence that supports risk response in agriculture and its relevance to economic decisions (Carl, 2005). Therefore, it is pertinent to note that bee farming production decisions are often made under the environment of risk and uncertainties. Jones (2002) defined risk as the uncertainty in farming endeavors whose negative event in terms of outcome could result in a significant economic cost. The risk attitude denotes their willingness (or reluctance) to accept risks. People's attitudes towards risks are very diverse, including risk-averse, risk-neutral and risk-seeking behavior.

It is a widely shared assumption that several of the risks mentioned in Figure 1 has become more relevant for bee farms and farmers in recent years (Frentrup *et al.*, 2010).

In most developing countries, our identification and understanding of why risk response occurs and how it motivates observed behavior is very limited (Just and Pope, 2003, Carl, 2005). Nevertheless, such knowledge is imperative. For example, in order to enhance food production and improve agricultural policy analyses, it becomes imperative to analyse risk in honeybee production in bee farms in north-central and western Nigeria. This will enable us to gather reliable data gearing towards averting the risk thereby improving honeybee production, crop pollination and productivity. This paper focuses on achieving sustainable food security through analysis of risk in honeybee production farms in Nigeria, specifically to describe the socio-economic characteristics of honeybee farmers and determine the risk behaviour of bee farmers.

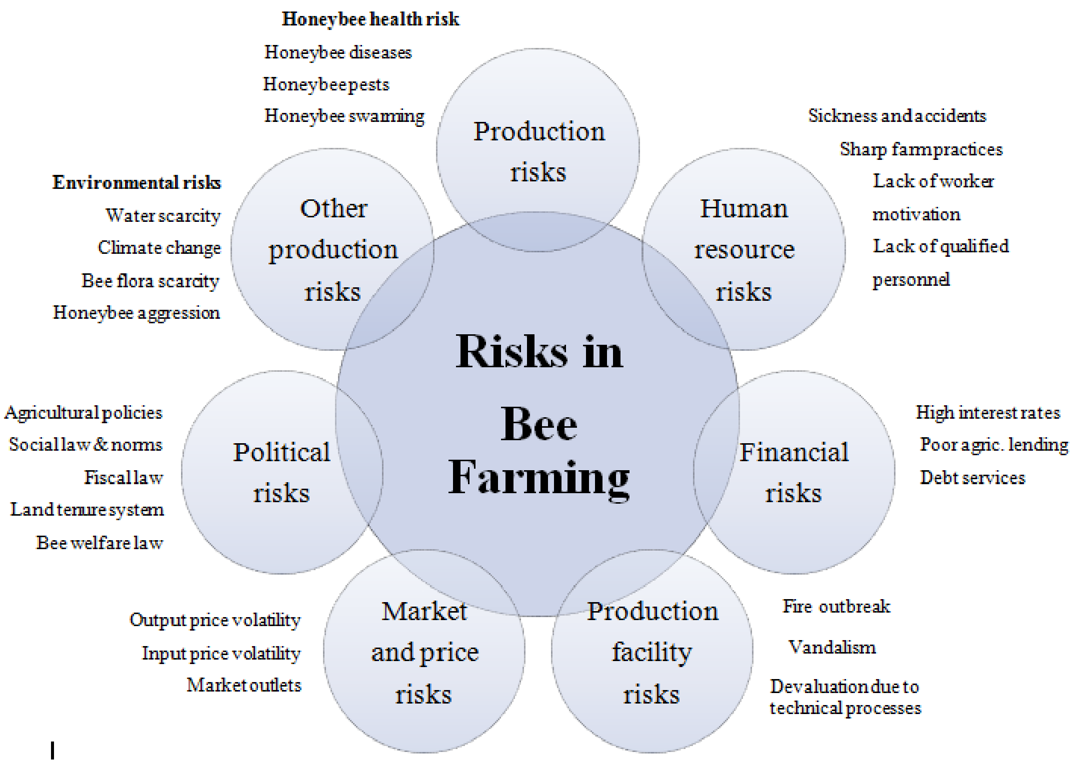

Fig. 1: Classification of risks in bee farming
(Adapted and modified from Theuvsen, 2012 and Oladimeji *et al.*, 2019)

MATERIALS AND METHODS

The Study Area:

Nigeria lies between longitudes 2° 49' E and 14° 37' E and latitudes 4° 16' N and 13° 52' north of the equator. The climate is tropical, characterized by high temperatures and humidity as well as marked wet and dry seasons, though there are variations between south and north. It has a total land area of 923,768.6 km^2 and 139 million in 2006 (NPC, 2006) with average population and agricultural densities of 150 people km^{-2} and about 3.3 million farm families. The latest United Nations estimate of 2017 at a growth rate of 2.48% put the country's population at about 190 million with an average human density of 204-person km^{-2}. Total rainfall decreases from the coast northwards. The south (below latitude 8°N) has an annual rainfall ranging between 1,500 and 4,000 mm and the extreme north between 500 and 1000 mm.

The country has rich vegetation consisting of a great expanse of arable land, rich fertile soil and abundant water resource, with about 214 billion m^3 of surface water and 87 km^3 of ground water both of which are capable of supporting a large population of forest trees, tall grasses, woodland and deciduous tree in savannah areas (Oladimeji *et al.*, 2017). Economic trees and crop flowering plants prominent in the study area include: *Amaranthus spp, Abelmoschus esculentus, Capsicum annum, Solanum melongena, Lycopersicum esculentum, Citrullus lanatus, Corchorus olitorus, Arachis hypogeal, Glycine max, Citrus sinensi, Parkia biglobosa, Butyrospermum parkii, Azadiracta indica, Mangifera indica,, Acacia species, Delonix regia and Anacardium occidentale* (Ajao *et al.*, 2014a).

The study was conducted in North-central and North- western Nigeria 40° 00' N and 75° 09' W. The two region falls within the tropical guinea and derived savannah zone of Nigeria with mean annual rainfall and temperature range from 787 mm to 1500 mm and 29.5 °C – 35 °C respectively.

Data Collection and Sampling Size:

Primary data were obtained using structured questionnaires and interview. A multi-stage random sampling procedure was employed for selecting the representative of bee farmers in Nigeria. The first stage involved the purposive selection of two States: Kwara and Kebbi states from the list of the 14 states in the two regions including Abuja Federal Capital Territory. Economic trees and crop flowering plants in addition to river Niger and its tributaries that provide enabling environment for bee farming characterize the two states. The second stage involved the random selection of bee farming villages in bee farming Local Government Areas (LGAs) in chosen States. Then, twenty villages were randomly selected from the bee farming LGAs with combined efforts of agricultural development project staff, state ministry of agriculture, bee farming or beekeeper associations and village heads. The total sample frame from the twenty villages was 235 bee farms comprising traditional and modern bee farms. The size of the minimum respondents that could be sampled was determined using:

$$n = \frac{N}{1-N(\alpha)^2} \tag{1}$$

$$\frac{234}{1-234(0.05)^2} = 147.63$$

Where: n is the required sample size; N is the sample frame, which implies the number of bee farmers in the target population (234) and α is the precision level at 5%. The minimum sample size that we could select from the statistical analysis was 148 respondents that amount to about 63% of the sample frame. The respondents were sieved into 102 traditional bee farmers and 46 modern bee farmers, The selected villages in Kebbi State were Lolo, Bagudo, Koko, Besse, Ulaira, Warrah, Ngaski, Dolekaina, Yauri and Samanage while the selected villages in Kwara State were Lantanna, Amberi, Buhari, Erinle, Lafiagi, Patigi, Ngurumi-Gwanara, Shia, Afon and Kaima.

Analytical Techniques:

Descriptive statistics: mean, percentage, standard deviation, a coefficient of variation and, safety model, which involve multiple regression analysis were used to determine the risk attitude coefficient of bee farmers. The safety-first model involves the estimating of the Cob-Douglas ordinary least square (OLS) regression analysis. The explicit form of the model is given as:

$$\ln Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + e_i \quad (2)$$

Y = The dependent variable was measured using Risk Behavioural Model (RBM) developed by Roy (1952) and modified in line with studies of Sekar and Ramasamy (2001), Salimonu and Falusi (2007) and Babalola, (2014).

$$\Phi_i = \frac{(\lambda_i^* - \mu_i)}{\theta_r} \quad (3)$$

Where: Φ_i = risk aversion Index; λ_i^*= attained level of average output/hive; μ_i = expected average output/hive from the farm; θ_r = standard deviation of output/hive; $i = 1\ to\ n$ while $n = 148$ bee farmers. The attained level of average output/hive (λ_i^*) represents the point below which the behavior of the decision maker must change markedly; the bee farmer must take a rational decision to remain in the business or opt out. This level of output/hive would also be determined by the situation of the decision-maker in a given production environment (Sekar and Ramasamy, 2001). That is, the respective respondent is a risk averter if $\Phi_i < 0$, if $\Phi_i = 0$, the farmer's attitude to risk is neutral and if $\Phi_i > 0$, the farmer is a risk seeker or preferred.

The model was constructed following the utility function. It is assumed that a bee farmer took a risk to invest in some technology and practices upon an objective of utility maximization such as maximum output, income and environmental sustainability. In other words, farmers imbibe a technology if the utility obtained from the technology used and management practices exceeds that of the old one (Oladimeji *et al.*, 2017).The exogenous variables fitted include:

X_1 = Age (years), X_2 = Marital status (dummy, married = 1, single = 0), X_3 = Educational level (years of formal schooling), X_4 = Fishery experience (years), X_5= Average investment in bee farm per ha, X_6 = Family labour (man-days), X_7 = Hired labour (man-days), α = constant, β_i = coefficient to be estimated and μ_i=error term associated with data collection from the i^{th} bee farm which was assumed to be normally distributed with zero mean and constant variance.

Evaluation of Food Security and Risk Status of Bee Farmers:

Bee farmers could be categorized to their risk status based on bee farm size. The rationale behind this classification is that the level of risk a farmer is willing to take is directly related to the size of farms he possesses. It is also well established in the literature that the sizes of farms a farmer possess also tends to define his farming objectives, which are subsistence farming, food security farming and profit-oriented farming. The mean bee farm size was determined (Table 1) and then was used to classify how food-secure each of them is as follows: 0.1- 4.0 ha: food insecure, 4.1-6.0 ha: neither food-secure nor insecure and > 6 ha: food-secure.

Thereafter, a non-parametric analysis that involves Kernel density estimation was used to explore how the food security status of bee farmers depends on farm size (Deaton, 1997). The aim of Kernel density estimation (KDE) is to find the Probability Density Function (PDF) for a given data set by smoothing the around values of PDF. The conditional distribution of the honey harvest probabilities per ha for a food secure and insecure was plotted against the poverty index using normal kernel cumulative density. The KDE is thus given as follows:

$$\hat{f}_h(x) = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{h}K\left(\frac{x-x_i}{h}\right) \quad (4)$$

Where: $H =$ is a band width, $n =$ number of data points, K(.) = kernel density and $X =$independent variable.

Table 1: Classification of farmers and their risk-taking attitude

Bee farm size (ha)	Types of hive	Investment (N)	Classification	Objective	Risk taking
0.1-2.0	Local	1,000- 100,000	Improvised	Food security	Aversion
2.1-4.0	Local	100,001-200,000	Traditional	Food security	Neutral
4.1-6.0	Assorted	200,001-300,000	Small scale	Mixed	Slight
6.1-8.0	Kenya top bar	300,001-400,000	Medium scale	Mixed	Slight
8.1-10.0	Modern	400,001-500,000	Large scale	Profit	High
> 10.0	Modern *	> 500,000	Commercial	Profit	Very high

Source: Field survey, 2014/2015, Note: medium scale, large scale and commercial farmers are risk seekers; * implies the bee farmers practice inoculations, honey & brood sampling & supplement feed. Naira, average ₦195 = 1US$ during a survey

RESULTS AND DISCUSSION

Socio-economic and production data

Table 2 reveals that traditional bee farmers had low average formal education (1.4 years), low extension contacts (0.8) and low access to credit (only 7% respondents). In addition, low level of investment and devoted less area for bee farming (0.6 ha) and rarely practice inoculations (10%), honey and brood sampling (10%) and majority (83%) used improvised hive and local baits. These might have resulted in less than 20,000 honeybees per colony (59%), low honey output per hive (5-6 liters) and low income per season (N43,000). Their inability to embrace improved technologies and practices, notably supplement feed and water, inoculations, honey and brood sampling among others implies this category of respondents are mostly risk aversive and risk neutral.

However, the modern bee farmers possessed higher education index (9.1 years), relatively higher exposure to extension service (2.9%), technology driven information and training, had improve and durable hives (5 years), possessed honey extractor and higher output per hive (8 liters). These also result in better and improved management practices as the majority of these respondents practices honeybee inoculations (58%), honey brooding and sampling (53%) and supplement feeding and water (74%), with attendance improvement in bee production, productivity and higher income per season per ha. Therefore, risk in both indigenous and modern apiculture is not only limited to technology adoption and improved management practices in nature, but is also related to socio-economic characteristics such as production credit, level of education, access to extension, low level of investment, agriculture advisory services and land resources.

Table 2: Bee farmers' socio-economic and production data in Nigeria

Description	Traditional farmers] (n= 102)	Mean	Modern farmers (n=46)	Mean
Sex	95% were male	-	89% were male	-
Marital status	93% were married	-	85% were married	-
Age (years)	67% above 50 years	55	52% below 50 years	43
Education (years)	73% had no primary sch.	1.4	68% had secondary sch.	9.1
Experience (years)	81% had up to 10 years	17	54% had < 15 years	10.5
Adj. household size	68% had 6-9 persons	7	53% had <6-9 persons	4.0
No. of extension contacts	85% had no contact at all	0.8	59% had no contact (s)	2.9
Family labour/season	87% used family labour	na	41% used family labour	na
Hired labour/season	30% used hired labour	na	78% used hiredlabour	41
Type of hive used/ha	83% used local materials	19[&]	84% used Kenya T. bar	41
Hive materials life span	78% had ≈3 years	1.6	61% had >3 years	4.8
Bait types	84% used local baits	na	74% used assorted baits	na
Supplement feed/water	<10% had S. feed & H2O	na	74% supplement both	na
Pest & disease control	45% used local methods	na	69% used varying mthd	na
Inoculations	< 10% inoculates	na	58% inoculates	na
Honey & brooding	< 10% practice sampling	Na	53% practice sampling	na
Crop flowering crops	19% attempted pollens	na	63% practice pollination	
Area devoted to bee farm	82% had < 1 ha	0.6	52% had > 1 ha	1.6
Access to credit (₦)	7% had access to credit	59 th	37% had access to credit	320th
Level of investment (₦)	84% invest<₦100, 000	65th.	75% invest<₦100, 000	219th
Bee income/season (₦)	73% earn <₦80th/season	43th	76% earn >₦100th/s.	137th
Off-bee income/yrs (₦)	61% had>₦100,000/yrs	142th	71% had>₦100,000/yr	138th
Honey output/hive (L)	69% had < 5-6 L/hive	3.4	72% had >5-6 L/hive	7.9
Honey bee/colony (No)	59% had ≈ < 20, 000	na	49% had ≈ >60, 000	na

Source: *Cited from Oladimeji et al. (2017), Note: ₦167 = 1US$ during the survey in year 2014/2015; th denote thousand; na not available*,19[&] denote varieties of local hives such as clay pots, cylindrical log hives, bark hives, grasses are woven and log hives

Figures 2 and 3 show the preference and willingness to accept risk respectively, among honeybee farmers in north-central and north-western Nigeria. The bulk of traditional bee farmers (57.8%) is categorized as risk neutral while the majority of modern bee farmers (67.4%) belong to risk preferring (with index of 1.52). Studies have shown that risk attitudes could only be explained by multifaceted factors including individual behavior, social, economic, cultural and psychological factors and it may be important to estimate individual risk preferences or identify factors that affect the individual's capacity to bear risk or consider their risk environment.

Figure 3 indicates bee farmers' risk attitudes by assessing their own willingness to accept risks from 0% (extremely risk averse) to 100% (extremely risk seeking). Similar results have also been obtained with regard to farmers' risk attitudes by Schaper *et al.*, 2012 and Theuvsen, 2012. From a risk management perspective, a bee farmer's risk attitudes are highly relevant since they will strongly influence his or her decision to implement risk management strategies. If a farmer is highly risk-averse, he or she will be reluctant to accept many risks and will try to reduce, transfer or even completely avoid as many risks as possible. Nevertheless, if a farmer is highly risk-seeking, he or she will deliberately accept major shares of the risks facing the farm and will largely refrain from actively implementing strategies aimed at reducing, avoiding or transferring risks. Therefore, the exposure of farms to risks can be very diverse, depending on farmers' risk attitudes (Faff *et al.*, 2008; Lucius 2009; Schaper *et al.*, 2012).

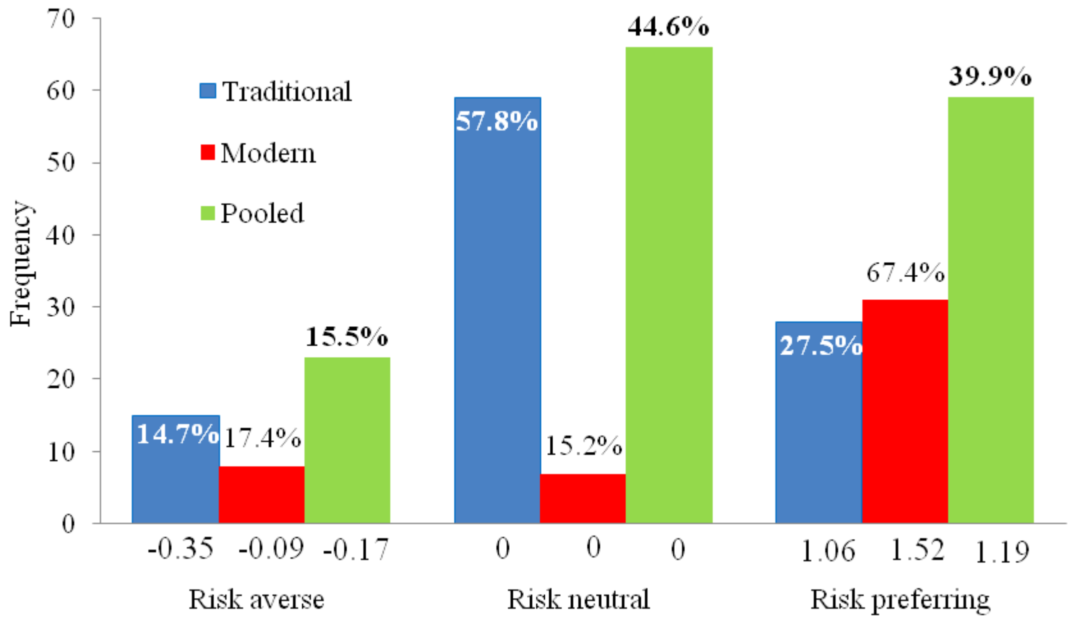

Fig. 2: Distribution of bee farmers by risk preference
Source: 2014/2015, note RAI denote risk aversion index

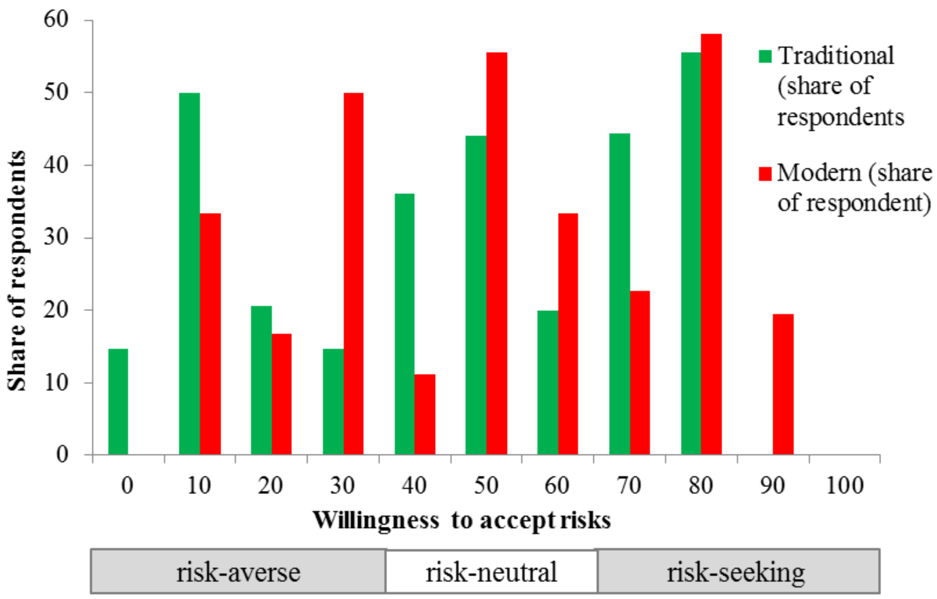

Fig. 3: Willingness to accept risks, Source: Field survey, 2014/2015

Table 3 shows the determinants of the risk behavior of bee farmers disaggregated into traditional and modern bee farmers as well as pooled data. The adjusted coefficient of determination (R^{-2}) for each regression signifies that the variables considered jointly explain significant influence on the risk status of the respondents. This is an indication that all or some of the slope coefficients are significantly different from zero. The F-tests result showed that the model was statistically significant at 1.0% level. It therefore means that the model is capable of showing and explaining the determinants of risk status of the bee farmers. This indication is also confirmed by the Durbin Watson statistic of 2.01 and 2.18 for traditional and modern bee farmers respectively which is similar to the quantity obtained by Ayinde *et al.* (2008) but quite higher than what Zepeda (1990) obtained. Conclusively, the risk-bearing capacity of the bee farmers can be explained by their socio-economic characteristics in respect of each group.

Table 3: Estimates of the variables determining bee farmers' risk status

Variables	Traditional β	SE	t-value	Modern β	SE	t-value	Pooled B	SE	t-value
Constant	-0.029	0.023	-1.25	0.101**	0.049	2.05	0.283*	0.162	1.75
Age	0.156	0.184	0.85	0.006	0.010	0.58	0.076	0.110	0.69
Marital status	-0.308**	0.149	-2.07	0.302	0.293	1.03	0.332*	0.194	1.71
Education	-0.024	0.031	-0.78	0.095***	0.023	4.08	0.004	0.004	1.06
Experience	0.115*	0.067	1.71	0.007	0.011	0.65	0.427	0.356	1.20
Investment	-0.017	0.013	-1.30	1.643***	0.208	3.09	0.221*	0.112	1.98
Family labour	-0.623***	0.202	-3.09	0.2e-6*	0.1e-6	1.81	0.465**	0.205	2.27
Hired labour	0.003	0.004	0.85	1.604*	0.308	1.96	0.009	0.006	1.42
Observation	102			46			148		
R^2	0.594			0.678			0.602		
R^{-2}	0.564			0.641			0.582		
F-value	11.83			24.05			16.22		
Durbin-Wat.	2.01			2.18			1.86		

Source: Field survey, 2014/2015; Note: ***P<0.01, **P<0.05, *P<0.10; β denote coefficient & SE, standard error.

The results of the estimates of the explanatory variables in Table 4 revealed that that the set of significant explanatory variables and their sign vary across the traditional and modern groups. The coefficient for marital status, bee farming experience and family labour were statistically significant for traditional bee farmers but with different signs and levels of significance. While education, investment, family labour, hired labour and sex were statistically significant for modern bee farmers but also with different signs and levels of significance.

In traditional bee farming, the coefficient of marital status (0.308) was statistically significant at 5% and had a negative effect on the risk capacity of the bee farmers. According to the results the bulk of the respondents were males (95%) and married (95%). Although studies have shown that male are usually risk seeking but this study tends to suggest that the probability of risk neutrality is increased by marital status as about 60% of respondents were risk neutral. This could be probably due to increased responsibility of having to take care of the their households in addition with the socio-economic and institutional constraints surrounding the respondents, such as using rudimentary and improvised bee production materials, the low level of education, virtual lack of extension contacts and reliance on family labour to manage their farm.

Table 4: Elasticity estimates (ε_i) of the variables determining bee farmers risk status

	Elasticity estimates (Cobb-Douglas function)		
Variables	Traditional	Modern	Pooled
Age	0.156	0.006	0.076
Marital status	0.308	0.302	0.332
Educational level	-0.024	-0.095	0.004
Fishing experience	0.115	0.007	0.427
Investment	-0.017	-1.643	0.221
Family labour	0.623	0.2E-06	0.465
Hired labour	0.003	-1.604	0.009

The coefficient of bee farm experience (0.115) was positive and statistically significant at 10%. This implication is that as bee farming experiences increase by a unit, the bee farmer tend to increase his risk seeking by 0.115 units. It is expected that with rising experience in bee farming the farmer may have more exposure to extension service, technology-driven information and training, better understand the production technology that could improve honey production and could bring about residual increase in their income (Oladimeji *et al.*, 2017), as well as associated bee farming challenges thereby forming models of how to deal with such challenges intuitively (Nmadu *et al.*, 2012). However, experience alone seems inadequate to curb risk hence the sample bee farmer tends to grow his risk status more towards risk neutral and aversion. Generally, in farming, it would appear that up to a certain number of years, the experience would have a positive effect. After that, the effect may become negative. The negative effects may be derived from aging or reluctance to change from old and familiar practices and techniques to those that are modern and improved (Ajao and Oladimeji, 2015, Oladimeji *et al.*, 2017).

In addition, family labour coefficient (-0.623) was statistically significant at 1% and reduce the probability of risk-seeking of the respondents contrary to *a priori* expectation. This may be due to the excessive uses of family labour resource in rural areas which tend to be a common occurrence due to a rather low opportunity cost for the input (Ladipo *et al.*, 1992, Oladimeji *et al.*, 2013). Family labour cannot sensibly be 'laid off'. For instance, in agricultural activities even when it is making a negative contribution, it still has to be catered for whether it is employed or not. Besides, the existence of disguised unemployment and under-employment of labour in rural areas of the country necessarily promote excess labour in agriculture and bee farming enterprises.

However, in modern bee farming, the coefficient of education (0.095) was statistically significant at 1% and positive which implies that the probability of risk of the respondents is increased when the respondents have attained secondary educational status. This is expected as more educated bee farmers would have acquired the knowledge base that is necessary to understand the nature of risk and the various technologies available to fight it which will of course encourage risk seeking. This tends to confirm why the probability of risk-seeking is increased by secondary educational status.

The coefficient of the amount invested in modern bee farming (1.643) increases the probability of risk seeking of the respondents and statistically significant at 1% in line with expectation. Modern bee production requires improving techniques and equipment to enhance honey yield. Hence, availability of credit facilities for the use of the bee farmers could also increase the likelihood of their adopting the use of modern and improved hives, baits, inoculations, sink boreholes, honey brooding and sampling as against the use of traditional hives materials and baits. Finally, both coefficients of family and hired labour were also statistically significant at 10%. The significant of hired labour in modern bee farming could be attributed to the fact that some household members were involved in production largely to supplement the hired labour in the enterprise.

The results of the Cob-Douglas elasticity in Table 5 of the explanatory variables showed that none of the variables is elastic with respect to risk status in traditional bee farming and both education and investment are negatively elastic. The amount invested in bee farming and hired labour is positively elastic with respect to the risk status trait of the respondents. Elasticity indicates that a one percent change in the explanatory variable leads to more than one percent change in the probability of risk status of the respondent.

Evaluation of Food Security and Risk Status of Bee Farmers:

Figure 4 shows the empirical cumulative distribution functions (CDFs) of farm size in hectare committed to bee farming systems using kernel density estimation. The result found higher variability in food security for modern bee farming system than for traditional bee farming system. The kernel CDFs show that honey yield per hectare in modern bee farming for first degree stochastic dominates the traditional system, since at every possible probability level the output per hectare from modern bee farming is greater than that from traditional bee farming enterprise. The finding is in line with studies of Kyaw and Routray, (2006), Flatten *et al.* (2008), Oladimeji *et al.* (2015).

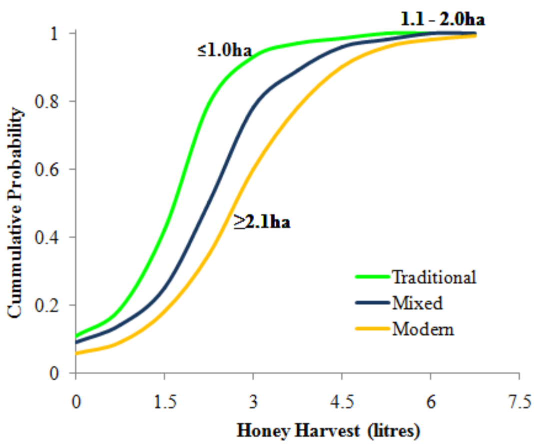

Fig. 4: CDFs of farm size in hectare committed to bee farming systems using KDE

Conclusion and Recommendations

This paper focuses on achieving sustainable food security through determining the risk behavior of the bee farmers. The results obtained herein showed that more than half of the traditional bee farmers are categorized as risk neutral while the majority of modern bee farmers belong to risk preferring. Socioeconomic and institutional characteristics were found to influence risk status of bee farmers. Nevertheless, the factors that influence the risk among traditional bee farmers showed variation from those influencing modern bee farmers and where it does, not by the same magnitude and direction. Hence, bee farmers are encouraged to form cooperative society and if already existing should liaise with relevant agencies such as the ministry of agriculture and agricultural insurance companies for training, workshops and seminars on the capacity to handle risk-taking into cognizance their socioeconomic and institutional traits. This could be an impetus to achieving sustainable food sufficient through pollination, honey food security and improving living standard among bee farming households, and possible transition of Nigeria bee farming from subsistence (traditional) to commercial production (modern). This will also support inclusive economic and human development of new sustainable development goals (SDGs) especially to end extreme poverty in all forms by the year 2030 (Goal 1); end hunger, achieve food security & improved nutrition & promote sustainable agriculture (Goal 2) and protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, and halt biodiversity loss (Goal 15) among others, in the country.

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