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Adoption of Improved Technologies and Management Practices Among Bee Farmers in North Central and North Western Nigeriatowards Sustainable Development Goals

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ABSTRACT

The total honey produced in Nigeria is usually inadequate, not documented and the country augments 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. This paper assesses adoption of improved technologies and management practices nexus efficiency gaps among bee farmers in Nigeria that optimize the use of available inputs to maximize honey output. A field survey through stratified random sampling, with questionnaire administration, farm visits and experiments were conducted in 148 honey bee farms comprising 102 traditional and 46 modern honey bee farms inKwara and Kebbi States Nigeria. The tools of analysis were net margin, double difference estimators and dichotomous regression models. Modern bee farmers were younger, had more formal education, but less adjusted household size which manifested inenhanced decisions and level of adoption results, increased output per hive and invariably increased net margin. The constraints to indigenous apicultural development were not limited only to technologies adoptions and improved management practices in nature, but also related to socio-economic and rural development. Empirical result indicates that the decision to adopt and level of adoption of improved techniques and practices had slight variations and where it does, not either by the same coefficients, direction, magnitude orstructure. Honey bee farmers' and relevant government agencies should collaborate to ensure gradual adoption of improvedmanagement practices and environmentally adaptable techniques capable of increasing the output and make efficient use of the abundant apicultural resources. This could be an impetus to achieving sustainable honey production, and possible transition of this sector from subsistence to commercial and export production to support globally, the new Sustainable Development Goals (SDGs).

Keywords: Sustainability, honey, double hurdle, rural development, Nigeria

INTRODUCTION

Overview of Nigeria Agriculture and Formal Sectors

Agriculturehas thepotential to compete favorably with and possibly displace petroleum oil which has dominated Nigerian economy over half a century if its resources are used more effectively, and efficiently. The country is endowed with rich vegetation and abundant water resource, about 214 billion m^2 of surface water and 87 km^3 of ground water both of which are capable of supporting a large population of livestock and crop irrigation as well as to produce enough honey and its products not only for domestic consumption but also for export (Food and Agricultural Organization, 2013, Oladimeji*et al.*, 2014).Achieving this feat of enhanced productivity may continue to be a mirage if improved management practices and environmental compatible techniques and technologies are not adopted and applied in agricultural production sustainably. Although, increasing population pressures and consequent increase in food demand have necessitated the intensification of better management practices and improved adaptable technologies or innovations to increase agricultural productivity.

Even before now and of recent, it has becomeclear that Arthur Lewis theoretical model of economic development model has contradicted Nigeria and some developing countriesagricultural and economic development (Charmes, 1998; Ali, 2013; Oladimeji*et al.*,2016a).In the mid-1950s, W. Arthur Lewis developed a theoretical model of economic development with unlimited supplies of labor in developing countries which envisages the capital accumulation in the modern industrial sector (formal sector) so as to draw *perceived excess*labor from the subsistence agricultural sector or informal sector (Fig. 1).

Although, the theory assumed a dual economic structure with manufacturing sector (including petroleum and service sub-sectors) taken over excess labor in rural agriculture sector, however, the formal sector in Nigeria was not able to absorb the remnants from informal sector largely due to the shortcoming of inequality in income distribution. Instead and ironically, agricultural sector otherwise referred to as informal sector of the Nigerian economy's increasingly becoming an alternative or main source of employment and livelihood for the growing urban labor force. This confirmed the importance of the sector in terms of absorbing employment and income generation for both active but unemployed rural and urban households as well as numerous lay off workers in many service and manufacturing sectors in the country, owing to the weakness of the formal sector in creating additional job opportunities in defiance of Lewis postulation.Therefore, concerted effort must gear towards harnessing Nigeria's agricultural potential of which apicultural resources is one of the vital components to cater for the large, active, productive but unemployed youths in the State.

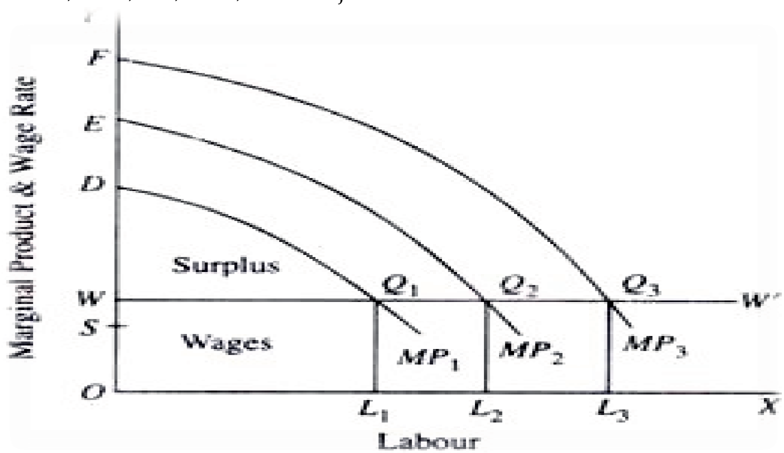

Figure1: Capital expansion and growth in labor employment (Extrapolated by Oladimeji*et al.*, 2016a from Jhingan edition)

Problem Statement

The honeybee, Apismellifera depends mostly on plants for food. Honeybee workers possess a modified hind-leg which bears the pollen basket and pollen brushes, an adaptation for efficiency in pollen and nectar collection and transportation to the queen and drones(Ajao*et al.*, 2013b). While doingthis they pollinate these flowers, thereby helping to increase fruit and seed-setting bothin wild and cultivated plants. The implication of this is that honeybees contribute immensely to the sustainable maintenance of ecosystems and agricultural production while they produce important products such as honey (Dukku, 2013). Honey, the major apiculture product is produced in nearly all countries of the world. Total world production in 2003 was estimated at 1.2 million MT. Yet, only about 400 000 MT of the honey is traded in the export market annually, implying a dominance of domestic markets within the producing countries. The combined production of honey by the top 20 producer-countries for 2011 was estimated at 1.30 million metric tons valued at US $4.62 billion(UEPB, 2005, Dukku, 2013).

However, 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. Bee farming in Nigeria is an important seasonal activity that predominantly remains rudimentary and unexploited, but it has tremendous potential for widening Nigeria export base (Ajao and Oladimeji, 2013). There is a growing consumption of honey and other bee products because of its high values in maintaining good health and in treatment of various diseases (Ajao*et al*., 2014). With the current growth in domestic consumption of honey in Nigeria coupled with mechanized agriculture springing up in most part of Nigeria, resulting in large bee pollinators' crop acreage, the future of bee farming is very bright as the demand for honey is bound to increase. It could provide food, nutritional, and livelihood security to the rural work force on an ecologically sustainable basis. Apiculture is the art of rearing, breeding and managing honeybee colonies in artificial hives for economic gains (Ikediobi*et al*., 1985; Morse, 1989; Ajao, 2012).

Apart from honey and other by-products such aspropolis, beeswax, bee pollen, bee venom and royal jelly derivedfrom honey bee, estimates suggest that between 35 percent and 73 percent of the world's cultivated crops are pollinated by some varieties of bees indicating that most of the plant species rely on bee insects for pollination (Klein *et al*., 2007; Harshwardhan*et al*., 2012). Estimates also place the annual global value of pollination services, including those of wild and managed bees, at $216 billion or about ₦64 trillion per year, or 9.5% of the worldwide annual crop value (Gallai*et al*., 2009). Yet, Harshwardhan*et al*. (2012) opined estimated that approximately 73 percent of the world's cultivated crops dependent on natural pollination by some varieties of bees, 19 percent by files, 6.5 percent by bats, 5 percent by wasps, 5 percent by beetles, 4 percent by birds and 4 percent by butterflies, indicating that most of the plat species rely on insects for pollination.

In spite of the favorable climatic and socio-economic environment, low-cost and sufficient availability of flowering plants and manpower in tropical countries, most developing countries including Nigeria have not tapped the available apicultural potential optimally. These could be attributed to shortage of appropriate technical assistance for bee farming, lack of trained manpower and appropriate technical knowledge, limitations in resources, especially in the case of endemic diseases affecting bee colonies, lack of information on suitable internal/external markets, inappropriate processing technology for product diversification, lack of financial resources for sustainable apiculture development (Dukku, 2001) and poor management practices which are decimating honey bee and productivity.

Therefore, the promotion for adoption of modern environmental compatible technology and improved management practices that is aimed at conserving the apicultural resources and enhance its sustainability could be a panacea towards increasing honey yield and enhancing cropproduction and productivity through bee pollination as well as revolutionizing apiculture as export potentials in the sub-region. This study was proposed in North-central and North-western regions of Nigeria to find answers to the following research questions:

(i) What are the socio-economic characteristics of the bee farmers in the study area?
(ii) What is the level of awareness of the bee farmers on improved technologies and management practices?
(iii) What is the difference between the gross margins of users and non – users of apicultural technologies,
(iv) What are the factors that influenced the decision to and level of adoption of these practices?

The findings of this study would elucidate some problems and suggests solution to the objectives of this study.

Theoretical Framework

A simplified conceptual model that leads to our empirical specification premised on the spirit of the theoretical models such as adoption-diffusion, knowledge gap and human ecology theories.Briefly, adoption-diffusion theory describes the patterns of adoption, explains the mechanism and assists in predicting whether and how a new invention could be adopted. Several studies (Munyuli, 2011, Kasina*et al*., 2009, Oladimeji *et al*., 2016b) shows that highly educated household heads of the social system and social status tend to receive information more quickly and adopt faster due to different forms of contact with extension education, training and agents. Conversely, less educated and lower socio-economic status members tend to receive information late and are usually skeptical and traditional in their attitude towards new technology (Roger, 1995).

In line with adoption-diffusion theory, Knowledge Gap Theory identified socio economic factors as the factors that largely determine the extent of knowledge acquisition and its rate in any given social system thereby creating knowledge gap in the society. It stressed that households that are of high socio-economic status will have greater access to information and uses it better and faster than their counterparts who are of low socio-economic status (Oladimeji*et al*., 2016b). However, Human Ecology Theory borders on how environmental resources are used sustainably. Hauser, (1990) opined that the essence of agricultural conservation practices isto improve the ways in which soil and water resources are used sustainably to achieve higherproductivity and ensure sustainability for future uses.

Conceptual and Analytical Framework

The study was based on the level of adoption of improved technology and agricultural practices among bee farmers. This is premised on the fact that increase in food production cannot be achieved if the bee farmers are not conversant with the improved practices and adopt the practices sustainably. As Nigerian population is fast growing, foodproduction must increase at geometric rate and this can easily be achieved by adopting improved management practices and technologies. It is assumed that a farmer has some knowledge on the use of a technology upon an objective of utility maximization such as maximum yield, income and environmental sustainability. In other words, farmers adopt new technology if the utility obtained from the new technology and management practices exceeds that of the old one. The gain of farmerfrom using the new technology can be expressed as:

$$Y = f(X_i;\beta) + \mu_i \quad \text{..} \quad (1)$$

Where:

Y represent gain reap from using new technology, x_i is vector of technology and management practices farmers' specific characteristics, β is a vector of the parameters, i_s an independently and identically distributed farm specific *ex ante shock*. If *U*represents expected utility a bee farmer could gain by adopting new technology/management practices and U_{i0} represents the utilities from the honey bee production using the traditional practices then, utility function of a given bee farmer*f*or adopting improved honey bee production technology*j*could be written as:

$$U_{ij} = x_{ib}b_{ij} + \delta_{ij} \qquad j = 1{,}0 \qquad x = 1 \dots n \quad \text{.................................} \quad (2)$$

Where

x_{ib}= is a set of socio-economic variables and a set of technology and management practices, $b_{ij}$is a vector of parameters, δ_{ij} is a disturbance term with zero mean and a constant variance. Utilities are random, the ith farmer adopts improved technology and management practices of honey bee management and production system that is, j= 1; if U_{i1}>Ui_o otherwise, the farmer will not adopt the new technology and management practice which was presented as shown below:

$$p_i = F(x_j b) = \frac{1}{1+Exp(-x_j b)} \quad \text{...} \quad (3)$$

$$prob(p_x = 1) = F(b'x) \quad \text{...} \quad (4)$$

$$prob(p_x = 0) = F(b'x) \quad \text{...} \quad (5)$$

p_x = 1 for an adopter, and p_x =0 for a non-adopter, and x isa set of explanatory variables such as age, level of education, types of hives, and bee farm size which determine the probability of adoption or not and b is a vector of parameters. Explanatory variables were transformed into vectors of first derivative by

$$\frac{p_i}{x_j} = P(y_i = 1, x_j = 1) - (y_i = 1, x_j = 0) \quad \text{..................................} \quad (6)$$

Since variables are discrete, the first derivative does not exist and change in probability is accomplished by evaluating p_i at alternative values of x_j (Godwin and Koudele, 1990, Agada and Philiph, 1997,Balogun and Balogun, 2008) that is

$$\frac{p_i}{x_j} = \frac{b_i exp(-x_j b)}{1+exp(-x_j b)^2} \quad \text{..} \quad (7)$$

The improved technology and management practices which were the focus of this study include the following Kenya top bar hive, Langstroth, Thermometer, supplemental feed, inoculations, ecological farming, bee pollination services, brooding and honey sampling.

Model Specification

Both Descriptive and inferential analysis were employed to analyze the data collected. Research questions 1 and 3 were achieved with the aid of descriptive statistics while research question 2 was achieved by adoptingand modifying Bagheri (2010) and Bagheri*et al.* (2008) perception analysis used byGido*et al.* (2013), to determinethe level of awareness of adoption of improved management practices which include supplemental feed, pest and disease control, inoculations, honey sampling, brood sampling, pollen collection, bee pollination service and new innovations such asmounting of Kenya top bar, Langstroth, thermometer, hygrometer, bait materials and modern processing methods and equipment,and other modern bee farming accessories that sustain effective honey production and productivity. To determine bee farmers' awareness towards new innovations and improved practices,5-point Likert-type continuum scale ofvery highlyaware (VH_{aw}), highly aware (HG_{aw}), moderately aware (MO_{aw}), low aware (LO_{aw}), and least/notaware (LE_{aw}) with assigning a weight of 5, 4, 3, 2, and 1 respectively for each statement. For each indicator a weighted mean was obtained as follows:

$$WM = (fVH_{aw}*5) + (fHG_{aw}*4) + (fMO_{aw}*3) + (fLO_{aw}*2) + (fLE_{aw}*1) / n \quad \text{.........} \quad (8)$$

Where: WM = weighted mean; f = frequency; Values 5, 4,3,2,1.

The means for all indicators followed application by Gido*et al.* (2013) categorized as follows; the means4.50-5.00 = very highly aware (VH_{aw}),3.50-4.49 = highly aware (HG_{aw}) 2.50-3.49 = moderately aware

(MO_{aw}),1.50-2.49 = low aware (LO_{aw}), and1.00-1.49 = least/not aware (LE_{aw}).

Research question 4 was achieved through double hurdle regression model. The determinant of adoption of improved management practices and new technological innovations by the individual bee farm household was a two-stage decision process: viz. decision to adopt, and level of adoption. There are two main reasons for separating these decisions. First, due to social-demographic-institutional or psychological drives, some bee farming households may not adopt new innovation and management practices as a result of the prevailing socio-economic and institutional factors and many other possible factors. Secondly, a household head may see the needs to adopt an innovation (adoption or participation strategies) to increase honey production and productivity but for certain levels of relevant variables, decide not to respond. The former represents abstention, the latter a corner solution.

Damisa*et al.* (2011) observed that the application of either multiple regression or one step tobitregression analysis for a cross sectional data of this nature can be misleading, for most of cross-sectional adoption data, zero adoption/participation is one problem for any modelling effort to address. In addition, two disadvantages of using one step to bit model are that all zero observations on level of decision to adopt new innovation (adoption strategies) are interpreted as corner solutions, that is, the household head is assumed to perceive the need for adoption of new innovation (participation) but chooses not to respond at the current level of exogenous variables. A further restriction of the uses oftobit model is that both decision to adopt and level of adoption are determined by the same variables but with varying degree and extent, that is, a variable that influences the decision to adopt also influences the level of adoption (adoption/participation strategies) undertaken.

Several studies have used binary choice models in determining adoption and the response decisions where the adoption andthe responses resulting from it were viewed as a single step process. However, the study employed double-hurdle model in determining decision to adopt and adoption strategies where the decision and the level of adoption resulting from the decision were viewed as a two-step processes. In other words, decisions to participate and its level are viewed as separate hurdle that needed to be crossed.

The double-hurdle model was originally proposed by Cragg (1971) adopted in agricultural technology adoption studies byShiferaw*et al.*,2008, Oladimeji et *al.,* 2016b, also adopted in consumer demand and market participation studies by (Weersink, 1992; Matshe and Young, 2004; Serra *et al.*,2005; Damisa and Hassan, 2009; Idowu*et al.,* 2013, Oladimeji and Abdulsalam, 2016).Therefore, the decision to adopt or not to, was addressed by fitting a logit model while its extent or level of adoption was addressed by fitting Tobit regression model.

The relevant logistic expressions were given by the underlying response variable y* in the case of binary choice was specified (explicitly) by the multivariate logit regression relation below:

$y* = \beta_0 + \beta_i X_i + \cdots \dots \dots \dots \dots \dots \dots \dots \dots + \beta_n X_n + u_i$(9)

Where: y* = the probability that a household will adopt the technology and ranges from 0 to 1.

It suffices to note that theory provides no guidance as to which explanatory variables are included in the first and second equations, thus exclusive restrictions were imposed (Matthews *et al*., 2003; Oladimeji*et al.,* 2015a; Oladimeji and Abdusalam, 2016). Therefore, continuous variables either with correlations due to the spurious effect or detected to exhibit multicollinearity were dropped from the second equation.This was achieved through both farrarglauber test and method of Variance Inflation Factor (VIF) to check the correlation matrix and find a matrix of pairwise coefficient of all independent variables. Themethod of contingency coefficients was also employed to checking the presence of associationbetween dummy variables.

Table 1: Measurement of variables and *a priori* expectations

Variables	Description and *a priori* expectations
Decision to participate	1 = If a respondent adopt improve technologies and management practices and 0, otherwise
Level of adoption	The value =5 if bee farmers adopt between 75-100% improved practices and innovations; =4, if adopt <75% &≥50%; =3, ifadopt<50% &≥ 25%; =2, if adopt <25% &≥ 1%&>1 if non-adopter.
Age (years)	Age of the household head in years; *negative*
Education (years)	Years spent in a formal education by the household head; *positive*
Adjusted Household size (no)	Number of dependents per household head; *negative*
Bee farming income (₦)	Total bee income of the household (₦/season); *positive*
ee farming experience (yrs)	Experience gathered in bee farming activities; positive
Extension contact (no)	Total number of visits per season; (positive)
Cooperative membership. (yr)	Years of membership of bee farming cooperative society; positive
Access to credit (₦)	Amount of credit accessed during the production season; positive
Cost of innovation (₦)	Amount of investment committed to bee farming; negative
Occupation	Dummy, main=1 and 0, otherwise; positive
No of hives	Total number of hives mount in bee farm; positive
Bee farm area (ha)	Portion of land area invested in bee farm; positive
Training in bee farm	Number of years months/years; positive
GAs (Dummy)	Jrban or peri-urban/rural; LGAs; yes = 1 and 0, otherwise (positive)

The second hurdle (adoption/participation level) involved the use of Tobit model, thus:

$Y_i^* = \sum X_i\beta + \mu_i$(10)

Where: $Y_i^*$is the vector of variables indicating the level of adoption, β is a vector of unknown co-efficient and μi is an independently distributed error term. Xi is a vector of explanatory variables. The model was estimated using maximum likelihood estimation procedures. Table 1 shows the description and measurement of variables employed in the double-hurdle model estimation.

The empirical models were used to draw inferences on the probability of and the determinants of adoption of new innovation by bee farm households. Following a tobit decomposition framework suggested by McDonald and Moffit (1980) and adopted by Bogale and Korf, (2009); Gazi*et al.* (2010); Oladimeji*et al.* (2015a), the effect of changes in adoption variables (X_i) on the probability and level of the adoptions were obtained. For all observation if the expected value of the dependent variable is given as $E(s_i)$ and the expected value of adoption (Litres), si for those households that participated in adoption as $E(s_i^*)$ and F is the cumulative normal distribution function at z, that is F(z), where z is the X′β/ϭ. The relationship between the variables is given as

$$E(s_i) = F(z).E(s^*) \quad (11)$$

For a change in the level of the adoption variable, the effect on bee farmer household output could be decomposed into two parts by differentiating equation (11) with respect to the specific output (X_{is}) as follows:

$$\frac{\delta E(si^*)}{\delta X} = \frac{F(z)[\delta E(si^*)]}{\delta X_i} + \frac{E(si^*)\delta F(z)}{\delta X_i} \quad (12)$$

Multiplying equation 11 through by $X_i/E(s_i)$, equation 12 was converted to elasticity forms as follows:

$$\frac{\delta E(s_i)X_i}{\delta X_i E(s_i)} = F(z).\frac{\delta E(s_i)X_i}{\delta X_i E(s_i)} + E(s_i).\frac{\delta F(z)}{\delta X_i}.\frac{X_i}{E(s_i)} \quad (13)$$

Substituting equation (11) into (12) we have

$$\frac{\delta E(s_i)X_i}{\delta X_i E(s_i)} = \frac{\delta E(si^*)X_i}{\delta X_i E(si^*)} + \frac{\delta F(z)}{\delta X_i}.\frac{X_i}{F(z)} \quad (14)$$

This shows that the total elasticity of a change in output has two effects:

(i) The change in elasticity of output intensity for the households that adopt new innovation.

(ii) The change in the elasticity of the effects on the probability of the observation that will fall in that part of the distribution.

MATERIAL AND METHODS

An overview of Nigeria's Apicultural Resources

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 km² and 139 million in 2006 (NPC, 2006) with average population and agricultural densities of 150-person km^{-2}andabout 3.3 farm families' km^{-2} respectively. The latest United Nation estimate at growth rate of 2.48% put the country at about 190 million with 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. Nigeria is blessed with a vast expanse of inland freshwater and brackish ecosystems. Their full extent cannot be accurately stated as it varies with season depending on rainfall.

Suffice it to note that the country has rich vegetation consisting largely of a great expanse of arable land, rich fertile soil and abundant water resource, with about 214 billion m³ of surface water and 87 km³ 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. Economic trees and crop flowering plants include:*Amaranthusspp, Abelmoschusesculentus, Capsicum annum,Solanummelongena,Lycopersicumesculentum,*Citrullulslanatus, Corchorusolitorus, *Arachis hypogeal,Glycine max*, *Citrus sinensi,Parkiabiglobosa, Butyrospermumparkii, Azadiractaindica, Mangiferaindica,, Acacia species,Delonixregia andAnacardiumoccidentale.*

Despite high variability and insufficient rainfall, high incidence of droughts and of recent occasional torrential rainfall leading to flooding, food production in Nigeria is virtually rained.

The Study Area

The study site 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 ranges from 787mm to 1500mm and 29.5°C - 35°Crespectively (See details of Kwara State in Oladimeji*et al.,* 2016b& c). However, In addition, KebbiStatelies in Sudan savanna area with scattered trees, numerous herbs and grasses, and relatively abundant surface water resources in the form of rivers, such as the Niger, Rima and Ka. These rivers are sources of water for irrigation, domestic use, fish and bee farming. The State has a total land area of approximately 36,229 sq. km. of which an estimated 13,209sq. km is currently being used for cultivation, while 293 sq. km is the built up area thus far, leaving a large proportion of land still under-utilized. More than200,000 ha of fertile land is fadama land, mainly situated along the flood plain land(NPC, 2006).The State was purposefully chosen later as the study area along with Kwara State, for this remarkable factor.

Data Collection and Sampling size

Primary data were obtained using a structured questionnaires and interview. A multi-stage random sampling procedure was employed for selecting the representative of bee farmers inNigeria. The first stage involved the purposive selection of 2 States:

Kwara and Kebbi States from the list of the 14 States in the two regions including Abuja Federal Capital Territory (See details of purposeful chosen of Kwara State in Oladimeji*et al*., 2016c). In addition, largely due to ecological factors enumerated above in the study area, Kebbi State was also chosen. 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 thebee 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 the traditional and modern bee farms. The size of minimum respondents that could be sampled was determined using:

$$n = \frac{N}{1+N(\propto)^2} \quad (15)$$

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

Where: n is the required sample size; N is the sample frame which implies the number of bee farmers in target population (234) and α is the precision level at 5%. The minimum sample size that we could select from statistical analysis was approximated to 148 which amount to about 63% of the sample frame. The sample frame (234) was stratified into 188 traditional bee farms and 46 modern bee farms.Thereafter, aproportionate random sampling of 55% of traditional bee farms and 100% of modern bee farm result in 102 traditional and 46 modern honey bee farms in both States. The villages were randomly sampled and not stratified because they are largely homogenous.

It is sufficient to note that institutional based bee farmswereincluded in modern bee farms statistics.The selected villages inKebbi State: Lolo, Bagudo, Koko, Besse, Ulaira, Warrah, Ngaski,Dolekaina, Yauri andSamanagewhile selected villages in Kwara State wereLantanna,Amberi,Buhari, Erinle, Lafiagi, Patigi,Ngurumi-Gwanara, Shia,Afon and Kaima.The institutional base farms include University of Ilorin Apiary, Kwara State University Apiary, Malete, Beekeeping Training and Research Centre (BTRC) at Amberi and Buhari, Kwara state, Nigeria.

RESULTS AND DISCUSSION

Socio-economic and production data

Several studies reveal that socio-economic characteristics of householdheads play great role in adoption of improved practices and influences adoption levels. The results in Table 2 indicate that majority of traditional bee farmers were male (95.1), married (92.2), farming as major occupation (76.5) and arable crop as ancillary occupation (82.3) in in line with studies of Adesope*et al*. (2012) and Oladimeji*et al*. (2015). However, the results in modern bee farmers also indicate that majority of respondents were male(78.3), married (73.9), farming as major occupation (58.7) and arable crop as ancillary occupation (47.8) consistence with studies of Adesope*et al*. (2012) andOladimeji*et al*. (2016b).

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

	Traditional bee farmers		Modern bee farmers	
Variable	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Gender				
Male	97	95.1	36	78.3
Female	05	4.9	10	21.7
Total	**102**	**100**	**46**	**100**
Marital status				
Married	94	92.2	34	73.9
Single	08	7.8	12	28.1
Total	**102**	**100**	**46**	**100**
Major occupation				
Farming	78	76.5	27	58.7
Non-farming	24	23.5	19	41.3
Total	**102**	**100**	**46**	**100**
Ancillary occupation				
Arable cropping	84	82.3	22	47.8
Other cropping	18	17.6	24	52.2
Total	**102**	**100**	**46**	**100**

Source: *Field survey, 2014/2015*

Table 3 reveal 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 line with studies of Adesope*et al*. (2012), Oladimeji*et al*. (2015a), Oladimeji*et al*. (2016b). In addition, low level of investment and devoted less area for bee farming (0.6 ha) which corroborates the findings ofMunyuli, (2011); Moussaa*et al*. (2012) and Oladimeji*et al*. (2016b). These might have result in their inability to embrace improved technologies and practices, notably supplement feed and water, inoculations, honey and brood sampling among others.

Table 3: Differential Bee farmers' socio-economic and production data in Nigeria

Description	Traditional farmers] (n= 102)	Mean	Modern farmers (n=46)	Mean
Age (years)	67% above 50 years	55	52% below 50 years	43
Level of education (years)	73% had no primary sch.	1.4	68% had secondary sch.	9.1
Bee F. 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 labor	na
Hired labour/season	30% used hired labour	na	78% used hired labor	41
Type of hive used	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 method	na
Inoculations	< 10% inoculates	na	58% inoculates	na
Honey & brooding samp.	< 10% practice sampling	na	53% practice sampling	na
Climate studies	≈10% improvised	na	63% had instruments	na
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/years (₦)	61% had>₦100,000/years	142th	71% had>₦100,000/years	138th
Honey B. output/hive (L)	69% had < 5-6 L/hive	3.4	72% had >5-6 L/hive	7.9
Honey bee/colony (L)	51% had ≈ < 60, 000	na	49% had ≈ >60, 000	na

Source: *Field survey, 2014/2015,₦167 = 1US$ in 2014; th denote thousand; na not available,*19[&]denote varieties of local hives such as clay pots, cylindrical log hives, bark hives, grasses woven and log hives.

However, the modern bee farmers possessed higher education index (9.1 years), higher exposure to extension service, technology driven information and training, had improve and durable hives, possessed honey extractor and higher output per hive. These also result in better and improved management practices with attendance improvement in bee production, productivity and higher honey output per hive. Therefore, the constraints to indigenous apicultural development were not limited to only technologies adoption and improve management practices in nature, but also related to socio-economic and rural development such as production credit, level of education, access to extension, low level of investment, agriculture advisory services and land resources.

Level of awareness of improved bee farming techniques and practices

The results of level of awareness, knowledge and usage of improved bee farming techniques and practices presented in Table 4 indicate that the pooled bee farmers were not only aware of improved practices (mean score = 3.7) but had moderate positive attitude, knowledge and willing to imbibe improved practices (2.8). This was motivated from the result of their positive perception statements such as willingness to planting bee pollinating crops around apiary farm which enhance honey bee production & honey yield with mean score of 4.0. Also, farmers had believe that these technology and practices enhance improve honey bee/honey production and productivity (3.4) andcould bring about residual increase in their bee income (3.1). However, to have access to improved technology and practices, extension service (3.5) and social organization (3.8) were rated most appropriate channels by sampled bee farmers. The willingness to imbibe improved practices and technology (2.8) could be enhanced if farmers strengthen their cooperatives and liaise with extension agents and resource personnel for training on new innovation and improved practices.

The result also revealed that the uses of most improved techniques and technologies such as uses of thermometer, hygrometer, and laboratory activities were rated low (Table 4) expect ecological farming (3.3) and supplemental feed (2.8). Therefore, based on Bagheri*et al.* (2008) and Bagheri (2010) adoption index, the result indicates that the bulk of bee farmers had mean adoption score range of less than 2.50 for sampled technologies and practices which implies virtually low or no adopters. This result is consistent with findings of Munyuli (2011) andOladimeji*et al.* (2016b) on farmers' perception and adoption of bee pollinators in coffee production in Uganda and adoption of improved fisheries technology in Nigeria respectively.

Table 4: Level of awareness of improved bee farming techniques and practices

practices (pooled data) n=148	Weighted scores of level of awareness of bee farmers					Mean score
	VH	HG	**MO**	**LO**	**LE**	
Level of perception of improved practices						
Aware of improved bee farming practices and tech.	215	208	72	36	11	3.7
Willingness to adopt improved tech. &practices	95	128	117	38	40	2.8
Improve techniques & tech enhance honey yield	195	172	93	38	16	3.4
Improve techniques and technology could bring about residual increase in your bee income	175	108	123	36	17	3.1
Access to bee farming techniques and technology through extension contact is more realistic	195	208	51	42	19	3.5
Access to bee farming techniques and technology through cooperative enhance adoption	240	224	42	38	11	3.8
Planting of bee pollinating crops around apiary farm enhance honey bee production & honey yield	280	244	33	26	7	4.0
Uses of improved bee farming accessories & tech.						
Thermometer	30	20	30	06	124	1.4
Hygrometer	10	16	9	08	135	1.2
Bore hole &dug well	125	148	174	24	16	3.2
Assorted bait materials	30	20	60	62	86	1.7
Ecological (organic) farming	205	132	93	54	16	3.3
Possession of Kenya top bar or Langstroth hives	50	48	60	62	75	2.0
Engages in laboratory activities (inoculation, honey and brood sampling, pest and disease control)	20	24	36	40	106	1.5
Provision of supplemental feed	155	108	45	66	42	2.8
Engages in bee pollin. Services & pollen collection	15	16	21	18	125	1.3

***Source**: Field survey, 2014/2015; very high (VH), high (HG), moderate (MD), Low (LO) and Least (LE), bee farming accessories include thermometer, hygrometer, processing equipment & type of baits used*

Level of Adoption of Improved Technologies and Practices

The level of usage of new innovations and improved bee farming practices is depicted in Table 5. The result reveals that generally, the levels of usage of improved techniques and practices in traditional bee farms were low. However, low levels of usage of Kenya top bar and Lang troth (45%) as well as provision of water in form of either boreholes or dug well (58%) were recorded in traditional unit. Result further reveals that all modern bee farmers used either Kenya top bar or Lang troth, assorted bait materials (63%), supplement feed (59%), control pests and disease (78%). Furthermore, modern bee farmers made use of experimental. The findings are comparable to the studies ofSharma, (2004).

Table 5: Degree of usage of new innovations and improved bee farming practices

Items	Traditional (n=102)			Modern (n=46)			Pooled bee farms n=148		
	F	%	Rating	F	%	Rating	F	%	Rating
Production items									
Kenya top bar hive	29+			31+			70		
Lang troth hive	17+	45.1	Low	15+	100	V. High	32	68.9	High
Thermometer	-	-	-	23	50.0	Average	23	15.5	Low
Hygrometer	-	-	-	17	37.0	Low	17	11.5	Low
Bore hole &dug well	59	57.9	Average	21	45.7	Low	80	54.1	Average
Assorted bait materials	28	27.5	Low	29	63.0	High	57	38.5	Low
Supplemental feed	41	40.2	Low	27	58.7	Average	88	59.5	Average
Disease & pest control	29	28.4	Low	36	78.3	V.high	65	43.9	Low
Experimental items									
Inoculations	-	-	-	19	41.3	Low	19	12.8	Low
Honey sampling	19	18.6	Low	23	50.0	Average	42	28.4	Low
Brood sampling	13	12.8	Low	31	67.4	High	44	29.7	Low
Bee pollination crops	32	31.4	Low	37	80.4	High	79	53.4	Average
Bee pollination services	-			8	17.4	Low	8	5.4	low
Pollen collection	32	31.4	Low	13	28.3	Low	45	30.4	Low
Ecological farming	19	18.6	Low	29	63.0	High	48	32.4	Low
Colony sub-division	23	22.6	Low	31	67.4	High	54	36.5	Low
Research & teaching	-	-	-	17	37.0	Low	17	11.5	Low
Processing equipment									
Honey press	13	12.8	Low	23	50.0	Average	36	24.3	Low
Honey extractor	17	16.7	Low	24	52.2	Average	41	27.7	Low

Source: Field survey, 2014/2015, *Note:VeryHigh (70% & above), High (69-60%), Average (59%-50%) & Low (<50%), + indicate addition of Kenya top bar &Langstroth*

Statistic comparison of Gross Output between Adopters and Non-adopters

The analysis of the mean net output as presented in Table 6 reveals that there was statistical significant difference between the mean honey output of bee farming technology of adopters and non-adopters at 1% level of probability. As canvassed by Munyuli(2011) in adapting bee pollination for coffee in Uganda or Moussaa*et al.* (2012) in adapting PICS bags in storing improved cowpea in West and Central Africa, such new technology provides an attractive opportunity for making better economic gains in terms of income generation, increased standard of living and ensuring food security.

Table 6: Difference in Gross output of Adopter and Non – adopters per colony

Items	Adopters	Non- adopters
Mean output per hive	7.9	4.1
Unit price per litre (₦)	1,300	1,350.00
Mean honey value per hive (₦)	10,270.0	5,535.00
Variance	3,012.984	2,089.092
Total observation	148	
Observations	46	102
Pooled Variance	9,119.82	
Df	146	
t - Stat	5.98***	

Source: Data Analysis, 2014/2015; *** denote Significant at 1% level of probability

Determinants of adoption of improved bee farming technologies and practices

Table 7showsthe estimates of factors that influence the bee farm household decision to adopt improved practices which had variation from those influencing level of adoption of bee farm technology and where it does, not by the same magnitude and direction. In the first hurdle, adjusted household size ($p<0.01$), cooperative membership ($p<0.05$) and marginally, bee farming experience ($p<0.10$) were found to have positive andsignificant influence on the bee farmer's decision to adopt a new technology and practices. The coefficient of education ($p<0.05$), was negative which implies that this variable had negative impact on adoption of new innovations and management practices. This was consistence with *a priori* expectations as the bulk of the traditional bee farmers neither had formal education or training in honey bee production which could propel them to adopt improve practices.

The results with respect to second hurdle also shows that the following variables: level of education ($p<0.01$), amount of credit ($p<0.01$), Training in bee farm ($p<0.01$), Area devoted to bee farm ($p<0.05$), number of hives ($p<0.01$), and marginally per capita income ($p<0.1$) were positive and statistically influencing the level of adoption significantly. It could also be observed that not only more variables were statistically significant in the second hurdle; the variables significant level seems to be higher in second hurdle with six variables than the first hurdle with four variables. The finding is comparable with studies of Adesope*et al.* (2012) on adoption of organic practices in River State, Nigeria, Moussaa*et al.* (2012) on adoption of improved cowpea in West and Central Africa and, Oladimeji*et al.* (2016b) on adoption of improved fisheries technology in Nigeria respectively.

Table 7: Determinants of decision and extent of adoption (Double Hurdle Model)

Variables	First Hurdle equation (Decision) n = 148			Second hurdle equation (Adoption) no = 46		
	β	SE	t-value	**β**	SE	t-value
Age (X_1)	-0.306	0.215	-1.42	-0.098	0.073	-1.34
Level of education (X_2)	-0.076	0.032	-2.36**	0.328	0.087	3.79***
Adj. household size (X_3)	0.251	0.050	4.98***	0.217	0.381	0.57
Bee farming experience(X_4)	0.006	0.003	1.74*	-0.063	0.042	-1.49
Extension contacts (X_5)	-0.438	0.340	-1.29	-0.279	0.206	-1.35
Cooperative societies (X_6)	0.074	0.035	2.09**	0.342	0.332	1.03
Access to credit (X_7)	-0.458	0.432	-1.06	0.642	0.072	8.93***
Per Capita bee income(X_8)	0.053	0.077	0.69	0.076	0.051	1.48
Per Capita bee income^2	0.062	0.048	1.29	0.347	0.196	1.77*
Training in bee farm (X_9)	-		-	0.025	0.008	2.95***
Area devoted to bee farm (X_{10})	0.009	0.007	1.33	0.789	0.373	2.09**
OccupationMain=1(X_{11})	-		-	-0.621	0.514	-1.21
No of hives (X_{12})	0.003	0.045	0.067	0.234	0.080	2.94***
Constant	0.056	0.028	2.00**	0.762	0.249	3.06***
Log likelihood function	**-26.54**			**-35.08**		
LR Chi^2	**39.04**			**42.98**		

Source: Data analysis, 2014/2015,

CONCLUSION AND RECOMMENDATIONS

The study reveals that factors that influence decision to adopt new innovations and management practices were in variance with those that affect level of adoption of such improved practices. The result also reveals that the extent of adoption of improved techniques and practices in traditional bee farms were low. Based on the empirical results, it was recommended that bee farmers should form a social organisation to access loans from formal and informal credit institutions, and extension agents should provide basictraining within the bee farming communities because education and training enhances adoption of technology and improved methods which are vital means of achieving honey bee productivity and invariably honey production.Research funding should also be made available to relevant government and non-government agencies towards all aspect of apicultural development in Nigeria.

Honey bee farmers' and relevant government agencies should collaborate to ensure gradual adoption of improved management practices and technology that are compatible and environmental friendly at affordable price capable of increasing the output and making efficient use of the abundant apicultural resources. This could be an impetus to achieving sustainable honey production and ecological intensification, and possible transition of this sector from subsistence to commercial and export production to support globally, the new Sustainability Development Goals (SDGs).

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