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Behavioral Response of Bee Farmers to Climate Change in South East, Nigeria

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Abstract**—**The enigma climate change is no longer an illusion but a reality. In the recent years, the Nigeria climate has changed and the changes are shown by the changing patterns of rainfall, the sunshine, increasing level carbon and nitrous emission as well as deforestation. This study analyzed the behavioural response of bee keepers to variations in the climate and the adaptation techniques developed in response to the climate variation. Beekeeping is a viable economic activity for the alleviation of poverty as the products include honey, wax, pollen, propolis, royal jelly, venom, queens, bees and their larvae and are all marketable. The study adopted the multistage sampling technique to select 120 beekeepers from the five states of Southeast Nigeria. Well-structured questionnaires and focus group discussions were adopted to collect the required data. Statistical tools like the Principal component analysis, data envelopment models, graphs, and charts were used for the data analysis. Changing patterns of rainfall and sunshine with the increasing rate of deforestation had a negative effect on the habitat of the bees. The bee keepers have adopted the Kenya Top bar and Langstroth hives and they establish the bee hives on fallow farmland close to the cultivated communal farms with more flowering crops.

Keywords**—**Climate, smart, smallholder, farmer, socioeconomic, response.

I. INTRODUCTION

BEEKEEPING is an act of rearing bees for the aim of harnessing its numerous potentials for income and livelihood activity. These potentials include honey, wax, propolis, royal jelly, venom and a very crucial aspect of crop pollination [1]. About 10% of the bee products in the region are gotten from the modern beekeeping, 30% from traditional beekeepers and the 60% are from the wild [2]. Local hives made from clay are hung on trees with baiting to draw swarms from wild honeybees, as practiced in some villages such as Nsukka, Obudu, Ijabu, Tiv. The indigenous regarded bee in Nigeria as tropical African honeybee is *Apis mellifera adansonii* [2].

Beekeeping has been described as competitive for on-farm integration because of its low startup cost, less labour requirement, user friendly technology and large scale dependency on tradition beekeeping technology. The dependency on traditional beekeeping techniques implies the huge impact of weather conditions on the beehives with the attendant consequences of climate change. Changing patterns of rainfall and increasing lengths of draught has left the South East geopolitical zone bee farmers vulnerable to the challenges of flooding and increasing temperature in some parts of the region. The dangers of climate change are worsened by the increasing level of deforestation, as most honey products are gotten from the wild and the bees need trees and plants for honey production [6].

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II. METHODOLOGY

South East, Nigeria comprises of five states, namely; Abia, Anambra, Ebonyi, Enugu and Imo States [10]. Southeast Nigeria is located within latitudes 6° 27' 10" (6.4528°) north, and longitude 7° 30' 37" (7.5103°) east [8]. Southeast Nigeria is a region of Nigeria that has borders with Cameroon in the East and the Atlantic Ocean to the south [12], [13].

The region is made of five states, namely Abia, Anambra, Ebonyi, Enugu and Imo. Two states were randomly selected for the study. A multi-stage sampling technique was used in the selection of sample. The respondents compose of beekeepers in the state. In the first stage, two agricultural zones were chosen from each of the selected states. The second stage involved the random selection of two Local Government Areas (LGAs) from each of the selected agricultural zones. In the third stage, two communities from each of the selected LGAs were randomly selected. In the fourth stage, two villages known for beekeeping were purposively selected from each of the selected communities. However, in order to ensure representative sample selection, a pre-survey sampling frame was determined by compiling lists of beekeepers in the selected 32 villages. The lists were collected from the selected LGAs, village heads and the related associations in beekeeping in the area. From these lists, four producers (2 males and 2 females) were purposively selected, making a total of 128 beekeepers. But, eight of the beekeepers selected were not willing to respond to the survey or discuss with field officers. Well, structured questionnaires and focus group discussions were adopted to collect the required data.

A. Method of Data Analysis

Data were analysed using Principal Component Analysis, Multinomial Logit, graphs, and charts were used for the data analysis.

In order to estimate the determinants of the beekeepers choice of beekeeping technique the following multinomial logit model was adopted:

$$\text{Pij} = \frac{e\,B_j X_i}{1+\sum_{k=0}^{j} X^{B} k X_i}$$

The model is explicitly stated as

$$\text{Pij} = b_0+b_1x_1+b_2x_2+b_3x_3+b_4x_4+b_5x_5+b_6x_6+b_7x_7+b_8X_8+\ldots+b_nx_n+ei$$

where i = 1, 2 …..n and j = 0, 1,.. j categories; Y = Kenya Top bar = 3, Langstroth hives = 2; *Yref* = traditional beekeeping = 1; X_1 = level of education of the beekeeper measured in years; X_2 = gender (male = 1 and female = 0); X_3 = experience of the beekeeper measured in years; X_4 = household size of the beekeeper measured in numbers; X_5 = size of the beekeeper labor force; X_6 = source of capital (formal = 1, informal = 0); X_7 = type of capital structure required (Equity = 1, debt = 0); X_8 = perception of rainfall level (very low = 1, low = 2, average = 3, high = 4, very high = 5); X_9 = perception of sunshine level (very low = 1, low = 2, average = 3, high = 4, very high = 5); X_9 = income in naira; B_i = coefficient; E_i = the error term.

The multinomial logit model was applied based on the following studies [3]-[5], [7], [14]. The principal component analysis model is specified as follows

$$y = L_{11}X_1 + L_{12}X_2 + L_{13}X_3 + L_{14}X_4 + L_{15}X_5$$

y = number of behavioural responses; X_1= modern beekeeping (yes = 1, no = 0); X_2 = forestation (yes = 1, no = 0); X_3 = change of hive location (yes = 1, no = 0); X_4 = increase in the number of hives (yes = 1, no = 0); X_5 = change of management practices (yes = 1, no = 0); L = factor loading

The principal component analysis model was applied based on [15].

III. Results and Discussion

A. The Perception of the Beekeepers on Climate Change

This section reveals the beekeepers' perception to rainfall from the previous planting seasons as presented in Fig. 1, 42% of the beekeepers perceived that rainfall was high while 34% perceived that the rainfall was very high. This observation is similar to the report of [11] forecasting a very high amount of rainfall for the 2016 planting season.

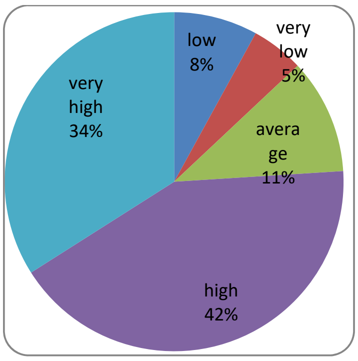

Fig. 1 Beekeeper perceptions to rainfall

The beekeepers that perceived that sunshine was very high were 40%; those that perceived the sunshine to be high were 38% while those that perceived sunshine to be at the average were 12%, as illustrated in Fig. 2.

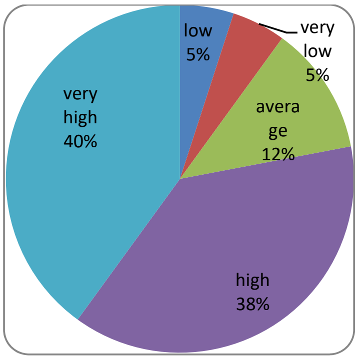

Fig. 2 Beekeeper perceptions to sunshine

The beekeepers' perceptions on the effects of climate change were presented in Fig. 3, deforestation was perceived to be very high by 65% of the beekeepers, as the natural habitats of the bees are declining very fast. Flooding was perceived to have serious effect on climate change by 30% of the beekeepers this may be attributed to rising sea level and excessive rainfalls. Erosion was perceived as an effect of climate change by 38% of the beekeepers. This is due to the excessive rainfalls recorded in the region. These changes in the climatic variables could be attributed to have affected the bee habitat in the area.

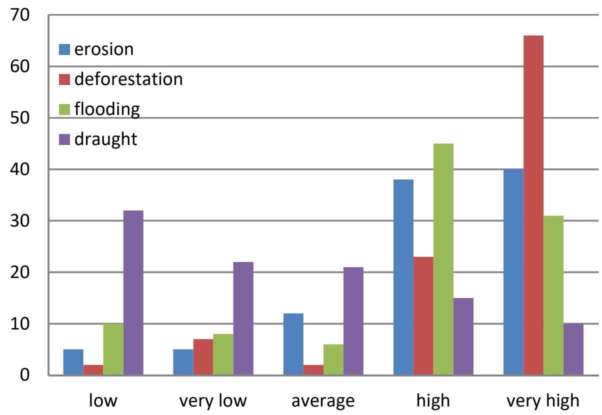

Fig. 2 Beekeepers' perceived effect of climate change

B. Determinants of the Beekeepers' Choice of Beekeeping Technique

The determinants of the beekeepers' choice of beekeeping technique are presented in Table I. The distribution of the multinomial logit model for the beekeeping techniques used by the beekeepers reveals that the probability of the model chi-square (78.44) was statistical significant at 1%. The null hypothesis that the independent variables in the model have no significant effect is rejected. Hence, we accept the alternative hypothesis that the included independent variables have a significant effect on the dependent variable.

The (Pseudo R-square) cox and Snell, Mcfadden and the Nagelkerke R square values, which provide the information on the strength of the model, were 0.55, 0.63 and 0.56 respectively. This suggests that between 55, 63 and 56% of the variability in the dependent variable is explained by the set of variables used in the model.

The Wald test, for the langstroth and Kenya top hive beekeeping techniques, indicates that the difference in probability with the reference group (tradition beekeeping practice) for education, experience, capital, rainfall, sunshine and income was statistically significant. Education was statistically significant at 5% and 1% for langstroth and Kenya top bar hive techniques respectively. Education was positively influencing the beekeepers to adopt the langstroth and Kenya top bar beekeeping techniques instead of the traditional technique. This implies that education enlightens the beekeepers to adopt langstroth or Kenya top hives instead of the tradition beehives.

Experience of the beekeepers was statistically significant at 1% and 10% for langstroth and Kenya top bar hives techniques respectively. Experience was positively influencing the beekeepers to choose the langstroth and Kenya top bar techniques instead of the traditional technique. The experience of the beekeepers over the years influences the beekeepers to adopt the modern beekeeping techniques.

Capital of the beekeepers was statistically significant at 1% and 10% for langstroth and Kenya top bar hives techniques respectively. Capital negatively influenced the beekeepers to maintain the traditional beekeeping techniques instead of the modern beekeeping techiniques.

The beekeepers' perception of climate change such as rainfall and sunshine which are very crucial in locating the hives and survival of the bees was significant and positively influenced the beekeepers' choice of modern beekeeping techniques instead of the traditional techniques which are more vulnerable to climate change.

Income generated for the langstroth and Kenya top bar beekeeping techniques was significant and positively influenced the beekeepers to adopt the techniques instead of the traditional beekeeping technique.

TABLE I
MULTINOMIAL LOGIT (MNL) FOR THE DETERMINANTS OF BEEKEEPING TECHNIQUES

Beekeeping techniques	Langstroth hive	Kenya Top hive	Traditional Beekeeping (reference category)
Intercept	-4.794 (1.948)*	-5.383 (7.068)***	-0.0021
Education	0.008 (2.893)**	19.087 (7.889)***	1.5023
Gender	1.317 -0.708	0.042 -1.175	-0.0024
Experience	9.639 (4.359)***	1.658 (2.348)*	-0.0025
Household size	-0.242 (-0.221)	0.089 (0.003)	0.0002
Labour force	-0.004 (-0.009)	0.184 (0.294)	1.0021
Capital source	0.647 (1.481)	0.872 (1.674)	0.0121
Capital	-2.122 (-1.960)*	-0.754 (-8.289)***	1.2031
Rainfall	0.006 (1.805)*	0.076 (2.144)*	0.2124
Sunshine	0.104 (6.526)***	0.129 (3.919)***	0.1120
income	1.157 (3.16)**	2.592 (8.078)***	0.1332
		Pseudo R-Square	
Cox and Snell	**McFadden**	**Nagelkerke**	
0.55	0.56	0.63	
chi square		74.44***	

Note: the values in parenthesis are Wald-statistics.
***,** *and** statistically significant at 1%, 5% *and*10% respectively

C. Principal Component Analysis on the Climate Change Behavioural Responses

The climate change behavioural response and strategies were analysed using principal component and the result is presented in Table II.

TABLE II
PRINCIPAL COMPONENT ANALYSIS ON THE CLIMATE CHANGE BEHAVIOURAL RESPONSES

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1. modern beekeeping	1.899	31.647	31.647	1.899	31.647	31.647
2. forestation	1.244	20.741	52.388	1.244	20.741	52.388
3. change of hive location	1.053	17.558	69.946	1.053	17.558	69.946
4. increase in the number of hives	0.675	11.248	81.194			
5. change of practices	0.589	9.820	100			
KMO and Bartlett's Test						
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.600					
Bartlett's Test of Sphericity — Approx. Chi-Square	29.616***					

From Table II, the Berlett's Test value of 29.616 shows that PCA model was significant at 1% while the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value of 0.600 clearly indicates that 60% of the variables were adequate.

The modern beekeeping had the total eigenvalues of 1.899 which was the highest, this indicates that the adoption of modern beekeeping technique is the major behavioural response and adaptation strategy to check the consequences of climate change.

Forestation practices with an eigenvalue of 1.224 are the second behavioural response and adaptation strategy to climate change by the beekeepers. Forests are the natural habitat of bees; the practice of tree planting is a behavioural response and an adaptation strategy of the beekeepers to climate change [9].

Change of hive location with an eigenvalue of 1.053 is the third behavioural response and adaptation strategy to climate change by the beekeepers. Beekeepers tend to change their hives to locations close to farms and garden for the bees to have enough flowers to forage and for the pollination of plants.

Increase in the number of hives with an eigenvalue of 0.675 is the fourth behavioural response and adaptation strategy. The beekeepers tend to increase the number of bee hives in order reduce the hive density and increase the level of swarming.

Change of practices with an eigenvalue of 0.589 is the fifth behavioural response and adaptation strategy to climate change by the beekeepers. The beekeepers tend to either reduce or increase the hives densities.

IV. Conclusion

The beekeepers perceived that there was a high level of rainfall and sunshine which resulted in high level of flooding and erosion affecting the natural and artificial habitat of the bees. Climatic change as a result of deforestation also poses severe consequences to the habitat of the bees. The adoption of modern bee techniques were significantly affected by the level of education of the beekeepers, experience of the beekeepers, capital available to the beekeepers, experience of the beekeepers, perceived rainfall and sunshine as well as the income of the beekeepers. The behavioural response of the beekeepers to climate change includes forestation practices, change in hive location, increase in the number of hives etc. Based on the findings of this study we recommend the following:

1. The continuous forestation practice by all relevant stakeholders
2. Continuous education and enlightenment of the beekeepers on the consequence of climate change and the need to adopt modern beekeeping techniques
3. Provision of capital at an affordable rate to motivate the beekeepers adopts the modern beekeeping practices.

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