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Indigenous Climate Change Adaptation Strategies Used by Honey Producers in Rural Communities of Enugu State, Nigeria

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Dimelu Mabel, Ukamaka
Department of Agricultural Extension,
University of Nigeria, Nsukka
Email: mabel.dimelu@unn.edu.ng
Phone : +2348185631828

Nwuba Loveth Eberechukwu
Department of Agricultural Extension,
University of Nigeria, Nsukka.
Email:nwubaloveth@yahoo.com
Phone: +2347031532245

Abstract

The study examined the effectiveness and challenges in the use of indigenous climate change adaptation measures by bee farmers in Enugu State. Sixty households' heads involved in honey production were used. Structured interview schedule, focus group discussion and observation were used for data collection and the analysis was carried out using descriptive statistics. Production of honey across the years (2000 to 2015) showed a downward trend, while the number of hives installed increased significantly. The respondents effectively adapted to climate change through change of sites of hives ($\bar{x}$= 4.00), tree planting ($\bar{x}$= 3.33), amendment of the periods of beekeeping operations ($\bar{x}$= 3.00) among others. However, they experienced challenges caused by indiscriminate cutting of trees ($\bar{x}$=3.42), inadequate information on adaptation measures ($\bar{x}$= 3.30), pesticide threat ($\bar{x}$=3.07) among others. Extension workers should intensify tailored training and visit to beekeepers to update producers' knowledge on bee farming (modern techniques), climate change implications of some farm practices (indiscriminate cutting of tree) and provide information on innovative adaptation options. Educational outreach on climate change to rural communities to stimulate community involvement in promoting environmentally sound practices should be advocated and funded by development agencies. Also, linking farmers to relevant actors, equipment dealers, financial institution; and enacting policy that will create and foster collaborative interaction for effective adaptation to climate change should be championed by public and non - governmental organizations.

Key words: Climate change, honey, producers, adaptation, bee, hives

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Introduction

The world has witnessed distinctive change in climate parameters such as rising temperature, shifting in rainfall patterns, melting of glaciers and snow, rising in global mean sea level among others. It is expected that these changes will continue and that extreme weather events resulting in hazards such as floods and droughts will become more frequent and intense across the globe. Generally, the impacts of climate change may be physical, ecological, social or economic and evident in areas such as agriculture/agroforestry and fisheries, energy, water, human health, food security, biodiversity and ecosystem services, industry and human settlements (Fischlin, et al. 2007). Many of the predicted consequences of climate change, such as increasing temperatures, changes in rainfall patterns, and more erratic or extreme weather events, have impacts on honey bee/ pollinator populations (United Nation Environment Programme (UNEP), 2010). According to Allsopp et al., (2014), climate change will very likely affect the interaction between pollinators and their sources of food, (flowering plants) by inter alia changing the dates and patterns of flowering. Aneni et al., (2017), reiterate that the recent advent of environmental change (Climate change) globally and in Nigeria suggests that our bees are now more vulnerable and stressed than was previously the case.

Beekeeping is an environment friendly activity that can be integrated with agricultural practices like crop production, animal husbandry, horticultural crops, conservation of natural resources; and a non-farm business activity that has immense contribution to the economies of a segment of the society and to the national economy as a whole (Beyene & Davide, 2007). However, the adverse effects of global climatic change evidenced in the form of drought, temperature variations, rainfall fluctuations and wind speed affect flowering (Seo & Mendelsohn, 2008), which further affect the quantity and quality of bee-forage and honey yield. Conte & Navajas, (2008) noted that as the observed variation in honeybee abundance and honey yields along climatic gradients suggests, climate change is among the environmental factors that impact on the production of honeybees. According to the authors, at low latitudes, honeybees remain active throughout the year, whereas at high latitudes they pass through a period of complete inactivity. Elevated colony losses in much of Europe and Canada are attributed to V. destructor and its associated pathogens, as well as known environmental and managerial challenges such as weather events and starvation (Aston 2010; Chauzat et al., 2010; Gajger, et al., 2010; Mutinelli et al., 2010; Neumann and Carreck 2010; Potts et al., 2010a). Similarly, the majority of losses in the U.S. have been attributed to one or more known causes such as weather events, starvation, queen failure, and mites by beekeepers. (van Engelsdorp et al., 2010; van Engelsdorp et al., 2011, van Engelsdorp et al., 2012). Being ectothermic, the temperature of their surroundings determines the activity of bees and hence climate change, characterized by elevated temperatures could drastically impact the biology, behavior and distribution.

Furthermore, climate change can indirectly influence honeybees through its effects on their resource base, including flowering plants, pathogens and predators, thereby leading to low production of honey. It influences flower development, nectar and

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pollen production, which are directly linked with colonies' foraging activity and development. Stockstad (2007) states that an excessively dry climate, which reduces pollen production and impoverishes its nutritional quality, would adversely affect bees of that habitat. In another hand, cases of excessive rain and water decreases the quality and quantity of honey and leads to the production of maggot by the bees. Also, increased intensity of sunlight weakens the bees'

immune system thereby predisposing them to diseases, tse-tse fly infestation; and also reduces the bees' activities which can lead to low productivity. Consequently, benefit from yield of honey and beeswax remain unsatisfactory (Beyene and Davide, 2007) due to the effects of climate change.

The Food and Agricultural Organization (FAO), 2008) notes that adaptation is critical in protecting livelihoods and food security in many developing countries. According to Soussain *et al* (2003), the fundamental goal of adaptation strategies is the reduction of the vulnerabilities to climate-induced change in order to protect and enhance the livelihoods of poor people. Literature is replete of measures used by honey producers to adapt to the impacts of climate change in honeybee production (Gbetibou, 2009, Berhe et al., 2013; Malisa and Yanda, 2015,) but the extent to which these measures are effective in adapting production to climate change is not certain. Incidentally, while many farm households are diversifying into beekeeping, in response to the need for income in diverse ways, perhaps to caution shocks/failure from conventional crop and animal production which often are the only source of income (Olarinde, *et al*, 2008); productivity has continued to decline. As revealed from personal observation, famers continue to experience varying dimensions of unanswered challenges evidenced in low production, loss of colony, infections and diseases. Assessing the effectiveness of adaptation measures, particularly the indigenous adaptation strategies is apt to policy and interventions in the sector. Therefore, the study aimed to;

1. explore production trend of honey between 2000 and 2015;
2. ascertain effectiveness of indigenous climate change adaptation measures used by farmers;
3. determine challenges encountered in adapting to climate change by farmers; and
4. identify information needs of farmers for adaptation to climate change.

Methodology

The study was carried out in Enugu State. The state has a land mass is 8,022.95Km^3 and population of 3,267,837 (National Population Commission, 2006). The state is made up of three senatorial zones namely; Enugu North, Enugu West and Enugu East. Enugu North was purposively selected because of its popularity in honey production. The senatorial zone comprised Nsukka, Udenu, Igbo Eze North, Igbo Eze South, Uzo Uwani, Igbo Etiti and Isi Uzo Local Government Areas (LGAs). The population comprised households involved in honey production in the zone. Enugu North senatorial zone is popularly known as the major honey producing area in Enugu State. A multistage sampling technique was adopted. The first stage

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comprised the purposive selection of three local governments that are highly involved in honey production namely Nsukka, Uzo-uwani and Igbo-etiti. Second stage comprised purposive selection of three town communities (one from each local government) based on their level of involvement in honey production. Finally, twenty honey producing households were selected from each town community using snowball sampling techniques. The heads of households were interviewed. A total of 60 respondents constituted the sample size for the study.

Data were collected on trends in honey production from 2000-2015. The respondents were asked to indicate the number of hives, colonized hives, quantity of honey produced and income from honey production over a period of 15 years. Also, the respondents were presented with a list of possible adaptation measures to indicate on a four point Likert type scale measures that were perceived effective in adapting to climate change. The scales and the weighting values were very effective (4), effective (3), not very effective 2 and not effective (1); with mean value of 2.5. Measures with mean of ≥ 2.5 were considered effective and < 2.5 were regarded not effective. Some of the adaptation strategies were change of sites of the hives, increase in the number of hives, use of a particular type of hive, and changing of apicultural techniques and others. Respondents were asked to indicated the challenges experienced in adapting to climate change (example inadequate fund, inadequate information, poor contact with agricultural extension agents, etc.,) on a four point Likert-type scale of 'very great extent'(4), an extent (3) little extent (2) and no extent (1)' and this gave a mean value of 2.5. Measures with mean scores ≥ 2.5 were considered major challenges, while < 2.5 were regarded as minor ones. Furthermore, the respondents provided information on their climate change information needs. Data were presented in percentage and analysed with mean score and standard deviation.

Results and Discussion

Average Honey Production Between 2000 and 2015

Table 1 shows that from 2000-2003 the majority (75%) of the respondents had between 6 and 10 hives. The average number of hives colonized was 6 compared to average of 10 installed by the farmers. In other words, a significant proportion (40%) of the hives were not colonized. A more threatening picture appeared in 2004-2007. Out of an average of 12 hives used by farmers, about 6 hives were colonized accounting for only 50%. In 2008 - 2011, 10 hives were colonized out of 18 hived installed by the farmers. This means that about 56% of the hives were colonized, showing a slight change in the proportion of hived colonized, though the number of installed hives were on the increase. Relatively, there was significant increase in the average number of hives to 21 in 2012-2015, compared to number installed previous years. Also the average colonized was 12 hives, accounting for about 57% of installed hives. While the number of installed hives are increasing, the number colonized are fluctuating downwards. Personal interview with the farmers showed that the production records have continued to dwindle over time.

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Table 1: Trends on honey production between 2000 and 2015

Production season	Percentage (n=60)	Mean
2000-2003 years		
Number of hives		
1-5	8.3	
6-10	75.0	10.2
>10		
Number colonized		
1-10	91.7	6.0
11-20	8.3	
Quantity in 25liter gallon		
1-5	91.7	4.0
>5	8.3	
Income	-	70,454.55
2004-2007 years		
Number of hives		
1-5	18.2	
6-10	45.3	12.3
>10	36.4	
Number colonized		
1-5	54.5	5.9
6-10	45.5	
Quantity(25 litres Gallons)		
1-5	81.8	4.0
6-10	18.2	
Income (naira)		66000
2008-2011 years		
Number of hives		
1-10	59.3	
11-20	25.9	17.5
>20	14.8	
Number of colonized hives		
1-5	14.8	
6-10	70.4	10.3
>10	14.8	
Quantity (25liter gallons)		
1-5	55.6	
6-10	33.3	7.56
>10	11.1	
Income		139,259.26
2012-2015 years		
Number of hives		
1-20	78.3	
21-40	10.9	21.09
41-60	4.3	
>60	8.7	
Number colonized		
1-10	76.1	
11-20	10.9	12.2
21-30	4.3	
>30	8.7	
Quantity in gallons		
1-5	50	
6-10	30.4	8.26
11-15	8.7	
>15	10.9	
Income		158,673.91

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This could be attributed to several factors such as technical, economic, edaphic and more importantly, environmental/climate related factors. The adverse effects of global climatic change evidenced in the form of drought, temperature variations, rainfall fluctuations and wind speed affect flowering vegetation including crops, which further affect the quantity and quality of bee-forage and honey yield (Seo and Mendelsohn, 2008). Malisa and Yanda (2015) reported that it causes colony starvation, physical damage of hives and retard bee forage activities. Overall, climate change can influence the honey bee development cycle; flower development, nectar and pollen production, which are directly linked with colonies' foraging activity and development.

Similarly, the volume of honey harvested within the period showed a declining trends. The quantity harvested between 2000 and 2007 was the same, and a slight increase to less than I gallon from 2008-2015 was recorded. Invariably, while the number of hives steadily increase, there is no corresponding steady increase both in the number of colonized hives and the quantity of honey produced by bees. This confirms the findings of Oyerinde, et al., (2014) which reported reduction in the volume of honey harvested from respective hives between 2010 and 2011 beekeeping seasons. On the contrary, income from production increased across the years, and decreased only in 2004-2007. The Dwindling production could explain the gaps in supply and demand and subsequently, the increasing price of the product observed in the market. This has a serious implication on the availability, access and use of honey in the nation. It could also promote greater adulteration of honey product not minding, the health implication.

Effectiveness of Adaptation Strategies Used by Honey Producers

The effective climate change adaptation measures employed by the honey producers are similar. Modern beekeepers indicated that effective climate change adaptation measures used were change of sites of hives ($\bar{x}$= 4.00), tree planting around bee yards ($\bar{x}$= 3.33), protection of beehive areas ($\bar{x}$= 3.00), amendment of the periods of beekeeping operations ($\bar{x}$= 3.00), avoiding vegetation that restrict bees' free movement and harbour pests ($\bar{x} - 3.00$), increase in the number of hives ($\bar{x}$= 2.67) and keeping bee hives under tree shades ($\bar{x}$= 2.67)). Similarly, traditional beekeepers employed protection of beehive areas ($\bar{x}$= 3.64), keeping of bee hives under shading of big trees ($\bar{x}$= 3.61), amendment of the periods of beekeeping operations ($\bar{x}$=2.68), increase in the number of hives ($\bar{x}$= 2.67) and change of sites of hives ($\bar{x}$= 2.63) (Table 2). The results agree with Gbetibou, (2009) and Malisa and Yanda (2015) who reported that strategies such as use of other species (diversification of bees species), the change of sites of hives, the reduction or increase in the number of hives, the use of a particular type of hive (modern or traditional), the changing of apicultural techniques and the amendment of the periods of operations, the shift from beekeeping to honey hunting activity were used for adaptation to climate change by beekeepers.

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In addition to these strategies, Berhe, et al., (2013) also reported the use of supplementary feeding, stone bund, trench and hive areas closure. Some strategies adopted such as keeping bee hives under shades and protection of hives are common traditional measures used in honey production. Measures like planting of trees, change of period of operation or apiary site are climate related responses due to deforestation, flooding, drought and changing climatic parameters associated with climate change. While tree planting ensures adequate vegetation, flower and pollination, provision

Table 2: Climate change adaptation strategies used by honey producers

	Modern techniques		Traditional techniques	
Strategies	Mean	Standard dev. (SD)	Mean	SD
	4.00*	0.00	2.63*	1.16
Change of the sites of the hives				
Increase in the number of hives	2.67*	1.16	2.31	1.17
Use of a particular type of hive	2.33	1.15	1.67	0.84
Changing of apicultural techniques	2.33	0.57	2.49	0.88
Amendment of the periods of beekeeping operations	3.00*	1.00	2.68*	1.03
Keeping of beehives under shading of big trees	2.67*	1.15	3.61*	0.69
Tree plantation around the bee yards	3.33*	1.15	2.29	1.22
Avoiding vegetations that restrict bees' free movement and harbor pests	3.00*	1.00	1.94	0.94
Supplementary feeding to bee colonies with solutions of sugar and grain powder	2.33	1.52	1.43	0.75
Keeping bees close to irrigated areas	2.33	1.52	2.25	1.197
Protection of beehive areas	3.00*	1.00	3.64*	0.74
The amendment of the periods of hunting	2.33	1.52	1.76	0.72
Change of the hunting grounds	2.33	1.52	2.27	1.01
Reduction or increase in the frequency of hunting	1.33	0.57	1.90	1.04
Change of hunting techniques	2.33	1.52	2.27	1.01
Change of farm activities and practices	2.67*	0.577	2.51*	0.967
Cluster hives for easy access	2.67*	1.155	1.59	0.762
Establish water dams or water reserves	2.33	1.528	1.96	1.117

*Effective adaptation strategies

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of shade; change in period of operation targets provision of favorable environment, humidity and temperature for optimal bee activities. This is in consonant with the elements of viable apiary site as stated by Segeren 1997 in Oyerinde., et al., (2014).

Challenges in Adapting Production to Climate Change

The major challenges to climate change adaptation in modern and traditional bee farms were inadequate fund ($\bar{x}$ = 4.00, $\bar{x}$ =2.90), pesticides threat ($\bar{x}$= 3.37, $\bar{x}$ =3.08), indiscriminate cutting of trees ($\bar{x}$=3.33, $\bar{x}$ =3.41), time spent on conservation/ labour intensive ($\bar{x}$=3.36), inadequate information on adaptation measures ($\bar{x}$ = 3.33 $\bar{x}$ =3.33) and degradation of natural resources (=$\bar{x}$3.33, $\bar{x}$ = 3.14). Other challenges included unavailability of modern harvesting techniques ($\bar{x}$=3.00,$\bar{x}$ = 3.04), increase pest and diseases ($\bar{x}$=3.33, =$\bar{x}$ 2.69), inefficient beekeeping methods ($\bar{x}$=2.67, $\bar{x}$=3.41) and others (Table 3). Generally, the challenges identified are economic, technical, institutional, environmental; directly and indirectly related to climate change. Some of these factors such as diseases and predators cause a serious devastating damage on honey bee colonies within short period of time and even overnight.

Table 3: **Challenge to climate change adaptation by honey producers**

	Modern technique		Traditional technique	
Challenges	**Mean**	**Standard dev. (SD)**	**Mean**	**S.D**
Inadequate fund for establishment of hives	4.00*	0.00	2.90*	1.15
Poor knowledge of tree planting practices	3.00*	1.00	2.29	1.06
Pesticide threat	3.67*	0.57	3.08*	1.09
Shortage of skilled man power	3.00*	1.00	2.86*	0.69
Increased cost of production	3.00*	1.00	2.80*	0.87
Inadequate information on adaptation measures/lack of research extension	3.33*	0.57	3.33*	0.71
Unavailability of modern harvesting techniques	3.00*	1.73	2.88*	0.91
Increased pest and disease pathogens	3.33*	1.15	2.69*	1.06
Poor access to beehives materials and equipment	3.00*	1.00	3.04*	0.72
Poor infrastructure development	3.00*	1.00	3.00*	1.00
Time spent on conservation/ labour intensive	3.00*	1.00	3.31*	0.88
Indiscriminate cutting of trees for firewood	3.33*	0.57	3.41*	0.72
Inefficient beekeeping methods	2.67*	1.52	3.41*	0.80
Degradation of natural resources	3.33*	0.57	3.14*	0.80
Increasing challenges of theft	4.00*	1.00	2.53*	1.12

*Major challenges

Empirical studies attributed pollinator decline to effects of multiple environmental pressures, including pesticides, pests and diseases, and climate change (Potts et al, 2010b; Vanbergen, 2013). This corroborates with the report by Kerealem (2005), that ants, honey badger, bee-eater birds, wax moth, spider, and beetles were the

most harmful pests and predators. Indiscriminate cutting of trees results to elimination of good nectar and pollen producing tree species in many areas, making it difficult to maintain bee colonies without supplementary feeding (Kerealem, 2005), which subsequently, affect cost of production and profit of farmers.

Lack of finance hinders honey producers from getting the necessary resources and technologies that facilitate adaptation to climate change due to the relatively high cost (Deressa et al. 2008). Credit is one of the important inputs essential for adoption of modern beekeeping techniques and other practices useful for adaptation to climate change. Also, poor connectivity to information source could hinder access to innovative technology critical to enhancing farmers' capacity for effective climate change adaptation. Other related issues include absence or knowledge of location specific climate forecasts, poor reliability and failure of the climate forecasts, coupled with poor extension service on climate prediction. (Shankar et al., 2011 and Idrsi et al., 2012). According to Nuru, (2007) some of these factors make it very difficult for farmers to establish honey bee colonies and expand beekeeping, particularly in modern beekeeping.

Climate Change Information Needs of Honey Producers

The respondents indicated needs for information on linkage to equipment suppliers (96.7%), efficient beekeeping methods (93.3%), development and maintenance of sustainable bee colony (93.3%), harvesting techniques (91.7%), habitat conservation (88.3%), procurement of credit facilities (80%) and location of hives (78.3%). Others included water resource development (73.3%), tree diversity improvements (73.3%), efficient tree planting strategies (71.1%), reduction of contaminations in harvested honey products (70%), amendment of the periods of beekeeping operations (65%), and supplementary feeding of the honeybees (60%) (Table 4) Timely and relevant information on establishment and management of ecologically sound apiary site is crucial for effective climate change adaptive, to mitigating the risk climate change and take advantage of it. Highlighting on the importance of interaction among climate change actors for adaptation, Cherotich, Saidu and Bebe (2012) expressed that information sharing among climate change actors in Africa is limited and may be worse in semi-arid environments due to barriers like poverty, lack of infrastructure, illiteracy and socio-economic factors. Farmers, including honey producers are becoming increasingly conscious of local climate variability issues (Li et al., 2013). However, they have limited understanding of the importance of adaptation and adaptation options for sustained livelihoods. They also have limited knowledge of where and whom to contact for appropriate climate change adaptation information. Generally, access to adequate information equips farmers to deal with climate variability and hence increase agricultural production. It is an indispensable factor for a sustained honey production and a huge challenge to extension service.

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Table 4: Information needs for climate change adaptation by honey producers

	Percentage
Market information	98.3
Linkage to equipment suppliers	96.7
Efficient beekeeping methods	93.3
Development and maintenance of good bee colony	93.3
Environmental friendly harvesting techniques	91.7
Habitat conservation	88.3
Procurement of credit facilities	80
Water resource development	73.3
Tree diversity improvements	73.3
Efficient tree planting strategies	71.7
Timing or amendment of beekeeping operation	70
Reduction of contaminations in harvested honey products	70
Feeding of the honeybees	60

Conclusion and Recommendations

Honey production consistently declined over the years, along with decreasing trend in number of colonized hives. On the contrary, the number of installed hives considerably increased across the years. Effective indigenous strategies used for climate change adaptation by modern and traditional beekeepers include protection of beehive areas, keeping of bee hives under shading of big trees, amendment of the periods of beekeeping operations, increase in the number of hives among others. However, farmers have several economic, institutional, technical and environmental challenges in adapting honey production to climate change. The respondent needs information on different adaptation practices and related issues for effective adaptation to climate change

Extension workers should intensify tailored training and advisory services to beekeepers to update producers' knowledge on bee farming (modern techniques), climate change implications of some farm practices (indiscriminate cutting of tree) and provide information on innovative adaptation options. Educational outreach on climate change to rural communities to stimulate community involvement in promoting environmentally sound practices should be advocated and funded by development agencies. Also, linking farmers to relevant actors, equipment dealers, financial institution; and enacting policy that will create and foster collaborative interaction for effective adaptation to climate change should be championed by public and non -governmental organizations. Extension agents should encourage and mobilize honey producer for group formation to facilitate access to credit and greater synergy in addressing increasing challenges of climate change adaptation.

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