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EFFECT OF CLIMATE VARIABLES ON POULTRY PRODUCTION EFFICACY IN NIGERIA

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Supporting Information

ABSTRACT: The paper examined the effect of climate variables on poultry production efficacy in Nigeria with emphasis on broilers and layers. Multi-stage sampling was used to select 401 poultry farmers who provided useful information with the aid of a questionnaire. Data were analyzed using descriptive statistics, and logit regression model. Result shows that free range accounted for 22.7%, battery cage 11.2%, deep litter 54.6%, and semi-free range 11.5% were notable systems of poultry rearing in the state. Heat stress 75.1%, reduced egg 99.8% and meat production 88.5%, and reduction in quality of eggs 51.9% were some of the climate change effects on poultry production. Adaptation strategies of poultry farmers include; proper housing system 100%, proper feed formulation 99.8%, right stocking density 96.8% and adequate water and feed supply 82.8%. Age, education, off-farm activities, size of poultry pen and poultry farming experience were important adaptation determinants of poultry farmers to climate change. High price of feed 100%, lack of access to credit services 77.1%, disease outbreak and parasites 100% and high cost of poultry inputs 99.5% constrained poultry farming. The study concludes that climate variables affect poultry farming. Farmers were recommended to practice climate smart poultry production to mitigate adverse effects.

Keywords: Climate Change, Farm Efficacy, Poultry Farmers, Poultry Production

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INTRODUCTION

Poultry production is becoming the first priority in terms of protein sources and income opportunities for the involved poultry farmers. According to FAOSTAT (2023), poultry meat represents about 33% of the total global meat production in the world. This posits the relevance and importance of poultry production. However, poultry production across Africa and other world countries have been hit by climate change affecting production and supply of poultry products especially meat and eggs (Abioja and Abiona, 2021). The vulnerability of poultry production to climatic change in Nigeria in recent times has been overwhelming and worrisome to the poultry producers (Ahmad et al., 2022).

It should be noted that poultry birds can only tolerate mild atmospheric and weather conditions, and recent variations in climate and weather condition had caused enormous fatality and high mortality rate in poultry production (World Bank Group, 2023). Studies have shown that the level of performance of birds depends on environmental conditions; such as rainfall, temperature, relative humidity and sunshine prevailing at a given time. Also, housing systems, ventilation of poultry houses and other management procedures have in recent times impacted negatively on poultry farming (World Bank Group, 2023). High temperature and humidity for instance, increases body temperature of poultry birds, decreases feed consumption and feed efficiency, and reduction in body weight and size, while high mortality and decrease in productivity and quality of eggs are caused by high and variant rainfall patterns (Zhang, et al., 2023). There are recent concerns that the ongoing global warming and climate change in Africa will have more negative impacts on the future growth and wellbeing of poultry birds.

Thus, developing countries, in Africa, especially Nigeria is bound to face substantial risks in poultry production from climate change due to increased exposure and inadequate adaptive potentials (Attia et al., 2022). These outcomes created the gap in knowledge and induced the motivation for the study.

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MATERIALS AND METHODS

The study was conducted in Ebonyi State, Nigeria. The State has an estimated population of 3,242,500 persons. Multi-stage sampling technique was used to select the poultry farmers. In the first phase, four local government areas (LGA's) were picked from the agricultural zones (Ebonyi North, Ebonyi South, and Ebonyi Central), to make 12 LGA's. The second phase involved the random selection of four autonomous communities making a total of 48 communities. The third phase had two villages picked at random from the communities to make 96 villages. In the final phase, 5 poultry farmers were picked to sum 480 farmers. Primary data were collected using questionnaire and out of the selected 480 poultry farmers, only 401 provided useful information for data analysis. Data were analysed using descriptive statistics, and the logit regression model. The logit regression model is expressed as follows;

$Y_i = \log (p/1\text{-}p) = F (X_i,b) + e$ ———— equation. 1

i.e.,

The logit of a number p between 0 and 1 is given by;

$(p) = \log (p/1\text{-}p) = \log (p) = \log (1\text{-}p)$ ———— equation. 2

Where:

P, is the probability, while (1- p) is the corresponding odds, and the logit of the probability is the logarithm of the odds.

Y_i = Observable dummy variable that indexes adaptation to climate change (Adapted =1, otherwise =0)

F = Logistic cumulative distribution function

b = Vector of estimated parameter

X_i = Independent variables considered, which include;

X_1 = Age (Years)

X_2 = Education (No of years spent in school)

X_3 = Household size (No of persons)

X_4 = Off-farm activities (Engaged =1, otherwise=0)

X_5 = Size of poultry pen (Meters)

X_6 = Access to livestock extension services (No of visits)

X_7 = Poultry farming experience (No of years)

X_8 = Participation in climate change workshop (No of times participated)

X_9 = Access to climate change information (Accessed =1, otherwise=0)

X_{10} = Climatic events (Experienced =1, otherwise=0)

e = error term

RESULTS AND DISCUSSION

Socioeconomic characteristics of the poultry farmers

The socioeconomic characteristics of the poultry farmers are presented in Table 1. The result shows that majority of the farmers 51.6% were between age ranges of 41-50 years with a mean of 48 years. This implies that the poultry farmers were young and in their productive age (Adeyemo et al., 2019). Majority of the poultry farmers, 75.8% were married, implying the dominance of married poultry farmers. Educational level of the poultry farmers shows that the farmers had different levels of education with majority, 39.9% in primary cadre. This means that the farmers attempted formal education, which could help in understanding of poultry management principles (Brown and Vivian, 2018). Household size shows that majority, 51.1% the poultry farmers had household size of 5-8 persons. This implies that the farmers had relatively large household size that could aid their poultry production in terms of family labour provisions. Majority of the poultry farmers 51.4% reared broilers, 40.1% reared layers, while 8.5% reared both broilers and layers. This implies the preference of broilers over layers among the poultry farmers (Castro et al., 2023). Majority of the poultry farmers, 94.8% belongs to cooperative societies. The poultry farmers recorded various levels of poultry farming experience with the majority 72.3% having between 21-30 year's experiences.

Methods of poultry rearing adopted by the farmers

The methods of poultry rearing adopted by the farmers are presented in Table 2. The table shows that 22.7% practiced free range of poultry management, 11.2% battery cage system, 54.6% deep litter method, while 11.5% engaged in semi–free range method of poultry rearing. This implies that the most prominent method of rearing poultry in the state was the deep litter system, which does not require huge capital investment compared to battery cage (Cheng et al., 2022). In this system, birds are kept in large pens up to 250 birds in a house and the floor of the house covered with dry materials such as chopped straw, saw-dust, dried leaves, etc., which could be easily be replaced with new ones to enhance healthy management of the poultry birds (Evans et al., 2021).

Table 1 - Socio-economic characteristics of poultry farmers

Variables		Frequency	Percentage
Age	20-30	20	4.9
	31-40	159	39.7
	41-50	207	51.6
	51-60	15	3.7
	Mean	48	
Sex	Male	94	23.4
	Female	307	76.6
Marital status	Single	71	17.7
	Married	304	75.8
	Divorced	07	1.7
	Widowed	19	4.7
Level of education	Primary	160	39.9
	Secondary	139	34.7
	Tertiary	12	2.9
	Non formal	90	22.4
Household size	1-4	177	44.1
	5-8	205	51.1
	9-12	11	2.7
	13-16	08	1.9
	Mean	6.2	
Poultry reared	Broilers	206	51.4
	Layers	161	40.1
	Both	34	8.5
Cooperative membership	Yes	380	94.8
	No	21	5.2
Poultry experience	1-10	21	5.2
	11-20	78	19.5
	21-30	290	72.3
	31-40	12	2.9
	Mean	26	–

*Multiple responses

Table 2 - Methods of poultry rearing adopted by the farmers

Methods of poultry rearing	Frequency	Percentage
Free range	91	22.7
Battery cage	45	11.2
Deep litter	219	54.6
Semi-free range	46	11.5
Total	401	100

* Multiple responses

Effects of climate change on poultry production

The effects of climate change on poultry production are presented in Table 3. About 75.1% of the poultry farmers indicated heat stress (exceeding 41 °C) in poultry birds. This means that as temperature rises, chickens spend more time drinking water than consuming feed (Cheng et al., 2022). A high number of the poultry farmers 99.8% indicated drastic reduction (60%) in eggs produced. Empirical studies have revealed that high temperatures, intense sunrays, heat stress causes reduction in egg production (Castro et al., 2023). About 88.5% of the poultry farmers indicated reduced meat production (55%); rising temperatures causes poultry birds to consume less feed and concentrate in more water intake, this causes the birds to drop in weight and size (Evans et al., 2021). Furthermore, the table shows that the poultry farmers indicated 85% decline in income and profitability when compared to previous earnings (De-Sousa et al., 2023). Again 100% of the poultry farmers indicated a higher morbidity and mortality rate in poultry birds. Changes in temperature, relative humidity and rainfall patterns cause the outbreak of poultry diseases (coccidiosis) causing high death rate in poultry birds (Zhang et al., 2023). Increased in appetite of birds was indicated by 85.8%, while 51.1% of the poultry farmers indicated decreased in feed intake. This means that changes in precipitation such as increased rainfall causes poultry birds to consume more feed and drink less water and thus necessitating the provision of more poultry feed (Wasti et al., 2020). About 94.0% of the poultry farmers indicated high usage of drugs and vaccinations, this brings rising cost in farmers purchase of drugs and vaccinations administered to poultry birds (Sesay, 2022). Loss in body weight was indicated by 75.6%, rising temperatures causes poultry birds to consume less feed which leads to loss in body weight. Decrease in fodder/grain production was indicated by 51.6%, this result from unavailability of rainfall which hinders the optimal growth of fodder/grain used in poultry feed formulations (Wasti et al., 2020). About 90.0% of the poultry farmers reported increase in feed cost, which invariably resulted from a decrease in fodder/grain production causing a rise in cost of available poultry feeds (Shikwambana et al., 2021). Loss of strength and energy was observed by 76.1%. Invariably inability of the poultry birds to consume feed during high temperatures causes loss in strength and energy leading to body weaknesses and loss in feathers (Sesay, 2022). Sleepiness was indicated by 74.6%. Frequent rains result in extreme cold conditions in poultry environments which causes sleepiness. Also feather moult, mite infestation or worms can place an extra strain on their immune systems and induces sleepiness. Supply of poor quality chicks was indicated by 95.0%, changes in climate causes newly hatch pullets to shrink in body weight and size leading to sale and supply of poor quality chicks (Saeed et al., 2019). Change in taste of poultry meat and egg was indicated by 52.1%, implying that changes in climate and weather conditions cause a change in taste of poultry meat and eggs.

Table 3 - Effects of climate change on poultry production

Effects	Frequency	Percentage
Heat stress in both house and outdoor flocks	301	75.1
Reduced egg production	400	99.8
Reduced meat production	355	88.5
Reduction in quality of eggs	208	51.9
Reduced income and profitability	401	100.0
Higher morbidity and mortality rate	401	100.0
Increased in appetite of birds	344	85.8
Decreased in feed intake	205	51.1
High usage of drugs and vaccinations	377	94.0
Loss in body weight	303	75.6
Decrease in fodder/grain production	207	51.6
Rise in feed costs	361	90.0
Cold proneness leading to shivering	187	46.6
Loss of strength and energy (body weakness)	305	76.1
Sleepiness	299	74.6
Supply of poor quality chicks	381	95.0
Change in taste of poultry meat and egg	209	52.1

*Multiple responses

Climate change adaptation strategies adopted by poultry farmers

The climate change adaptation strategies adopted by poultry farmers is presented in Table 4. In Table 3, note that climate change negatively affected poultry production in the study area and this necessitated the adaptation strategies

and/ or measures deployed by the poultry farmers in mitigating these adverse effects on poultry birds. The table shows that all the poultry farmers adopted proper housing system. Proper housing allows for ventilation, cleaning, spacing and prevention of outbreak of disease in the pens (Salem et al., 2022). About 99.8% of the poultry farmers practiced proper feed formulation which includes essential nutrients required for optimal growth (Sabry et al., 2023). Right stocking density was adopted by 96.8%, this prevents transference of outbreak of diseases occasioned by climate change. About 82.8% adopted adequate water and feed supply; this involves the provision of adequate water and feed during the dry season to cushion heat stress (Osuji, 2019). Similarly, result shows that the poultry farmers practiced prompt vaccination of their birds as a strategic way of combating the effects of climate change (Pepper and Dunlop, 2021). About 51.9% of the poultry farmers adopted the use of resistant and improved varieties of pullets. Ensuring adequate ventilation was adopted, this ensures that the poultry pens and houses are well ventilated enough to prevent heat stress (Olutumise, 2023). The use of efficient energy bulbs was adopted by 64.1%. Use of energy bulbs emit less heat and promote healthy poultry environment. Raise of broods and sell was practiced by 77.6% of the poultry farmers; this involves the rearing and sale of early broods to avert the incidence of changing climate. Tree planting around poultry house was adopted by 92.0%, this involves the intentional planting of trees around poultry houses to provide shade thereby reducing heat stress (Olutumise, 2023). Similarly, the table reveals that 97.8% of the poultry farmers adopted prompt routine management services (FAOSTAT, 2023). Keeping of birds and other livestock was adopted by 77.8% of the poultry farmers; this involves a diversification method of averting the negative effects of climate change on poultry enterprise. Consultation of veterinary services was adopted by 74.8%, this involves the use of veterinary services in responding to the changing climate. Interestingly, these adaptation practices mitigated adverse effects of climate change on poultry birds and further enhanced poultry production in the area.

Table 4 - Climate change adaptation strategies adopted by poultry farmers

Adaptation strategies	Frequency	Percentage
Proper housing system	401	100.0
Proper feed formulation	400	99.8
Right stocking density	388	96.8
Adequate water and feed supply	332	82.8
Outright sale of early maturing birds	390	97.3
Prompt vaccination	376	93.8
Rearing of poultry varieties	208	51.9
Ensuring adequate ventilation	401	100.0
Use energy efficient bulb	257	64.1
Raising of broods and sell	311	77.6
Tree planting around poultry house	369	92.0
Prompt routine management	392	97.8
Keeping of birds and other livestock's	312	77.8
Consultation of veterinary services	300	74.8

* Multiple responses

Adaptation determinants of poultry farmers to climate change

The adaptation determinants of poultry farmers to climate change are presented in Table 5. The logit regression model was used in preference of other models because of its simplicity in handling binary values such as (1, 0). The table shows that age is positive and significant at 1% level. This implies that increasing age of the farmers increases likelihood capacity in adapting to climate change (Abioja and Abiona, 2021). Education is positive and significant at 1% level. This implies that the adaptation strategy to climate change is greater for those that have higher educational attainment compared to less-educated or illiterate farmers (Adeyemo et al., 2019). Off-farm activities were positive and significant at 5% level. This implies that farmers who engage in off-farm activities are more likely to adapt to climate change (Ahmad et al., 2022). Size of poultry pen was positive and significant at 10% level. This implies that as poultry pen size increases, adaptation to climate change increases too. Poultry farming experience was found positive and significant at 1% level. Experienced poultry farmers adapt more easily to climate change than inexperienced ones (Attia et al., 2022). Participation in climate change workshops was positive and significant at 5% level. This implies that increased participation in climate change workshops increases the likelihood of poultry farmers to adapt to changing climate (Aroyehun, 2023). Climatic events were positive and significant at 5% level. This means that the devastating effects of climate change on poultry enterprise increases the likelihood of the poultry farmers to adapt to climate change.

Table 5 - Adaptation determinants of poultry farmers to climate change

Variables	Coefficients	t-values	Std. Error
Constant	0.7019	1.6001*	0.4387
Age	19.0058	4.1043***	4.6307
Education	0.0889	3.8300***	0.0232
Household size	-10.0255	-0.3051	32.859
Off-farm activities	24.9602	4.1131***	6.0684
Size of poultry pen	0.6909	1.8901*	0.3655
Access of livestock extension services	-0.7803	-0.0650	12.005
Poultry farming experience	7.0501	3.0195***	2.3349
Participation in climate change workshops	15.4350	2.0017**	7.7109
Access to climate change information	-0.6784	-1.2194	0.5563
Climatic events	20.0008	2.5011**	7.9968
R^2	0.8699		
F-value	170.305***		

***p < 0.001; **p < 0.01; *p < 0.05

Constraints encountered in poultry production

The constraints encountered in poultry production are presented in Table 6. According to the table, high price of feed was indicated by all the poultry farmers (Brown and Vivian, 2018). About 77.1% of the poultry farmers indicated lack of access to credit services, this implies that the poultry farmers were unable to access credit facilities to purchase more poultry inputs (Castro et al., 2023). Disease outbreak and parasites was indicated by all the poultry farmers, this implies that the farmers experienced outbreak of disease and parasites that affected their poultry enterprise negatively. High cost of poultry inputs was indicated by 99.5% (Cheng et al., 2022). About 96.5% indicated inadequate extension services; this implies that the farmers had poor information dissemination. High cost of poultry drugs and vaccines was indicated by 85.8% (Evans et al., 2021). Other constraints faced includes, weather and climate change issues 97.0%, lack of government incentives 97.5%, high cost of improved bird varieties, 94.8% and unfavorable price fluctuations, 88.5%. This generally implies that these identified factors negatively affected poultry production and severely reduced both output and farm income of the poultry farmers (Wasti et al., 2020).

Table 6 - Constraints of poultry farming

Constraints	Frequency	Percentage
High price of feed	401	100.0
Lack of access to credit services	309	77.1
Disease outbreak and parasites	401	100.0
High cost of poultry inputs	399	99.5
Inadequate extension services	387	96.5
High cost of poultry drugs and vaccines	344	85.8
Weather and climate change issues	389	97.0
Lack of government incentives	391	97.5
High cost of improved bird varieties	380	94.8
Unfavorable price fluctuations	355	88.5

* Multiple responses

CONCLUSION

The findings of the study reveal that climate change had adverse effects on poultry production and its manifestations include; rising feed cost 90.0%, cold proneness 46.6%, body weakness 76.1%, and sleepiness 74.6%, and poor-quality

chicks 95.0%. Age, education, off-farm activities, size of poultry pen and poultry farming experience were important significant adaptation determinants of poultry farmers to climate change. Weather and climate change issues 97.0%, lack of government incentives 97.5%, high cost of improved bird varieties 94.8% and unfavorable price fluctuations 88.5% were identified poultry constraints. The study concludes that climate variable affects poultry farming. Farmers were recommended to practice climate smart poultry production to mitigate its adverse effects and boost poultry production in the state.

DECLARATIONS

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Authors' contribution

E. Osuji, B. Ahamefule, M. Osuji = Conceptualization, model design, data analysis, section writing and proof-read.

G.Ben-Chendo, R. Nwose, A. Tim-Ashama = Data analysis, results editing, proof-reading and grammar checking.

H. Opaluwa, E. Nwachukwu, A, Eleazar, I. Ukoha = Conceptualization, result design, section writing, reference sorting and editing.

E.Offor, U. Anyanwu, Y. Ajibade = Questionnaire design, methodology design, section writing, editing and proof-read.

D. Iwezor-Magnus, G. Opeyemi, K. Anyiam, I. Nwaiwu, O. Ibeagwa = Data collection, data processing, data curation, data sorting, and data coding.

Ethical consideration

There is no direct contact with animals.

Consent to publish

All authors consented to publish the article.

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Conflict of interest

The authors declare that no conflict of interest exists.

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