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Effect of climate change on pig production and choice of adaptation strategies by farmers in southeast, Nigeria

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Abstract

Information from 120 pig farmers was collected using a structured questionnaire. Percentage, regression and multi nominal regression model were used to address the objectives of the study. The major results were that use of heat resistant breeds, heat resistant roofing materials and use of cross ventilation were the adaptation strategies adopted by the respondents. The variability of temperature, rainfall and pressure affected pig prosduction Also, age of the farmers, farm size, educational level, and access to climatic information affected households' choice of climate change adaptation strategies. The result of the challenges to adaption to climate changes in the study area were Poor access to credit, technology and extension services were the major limitations to the adaptation of the climate change strategies. The need to enhance farmers' access to credit, educational programmes and extension services were recommended.

Keywords: climate change, pig production, adaptation strategies, farmers

Introduction

Agriculture is the engine of the economy of most countries in sub-Saharan Africa and the role of small holder farmers in accomplishment of this noble art is well acknowledged [4, 7, 15]. The smallholder farmers as asserted by FAO [24, 34] constitute a significant portion of the world farming population with an estimated 450 - 500 million representing 85% of the world's farmers. One of the characteristic features of this farming class is its vulnerability to climate change, which are occasioned by poor financial resources, low institutional and technological adoption capability [1, 71]. Climate change is long term continuing fluctuation of weather variables [39, 48] caused by release of green house gases created by human events (IPCC, 2001) [45]. Furthermore, to [47; 55], it is a continuing variation in rainfall patterns and shifting temperature zones which is capable of being unfavorable to the food security and economic growth of the affected locality.

In livestock industry, pig production precisely, the influence of climate change differ slightly (depending on the breed types, locality etc), but the commonly reported problems are lack of portable water for the animal's use, incidence of diseases and pests, exitnction of the animal at extreme heat stress condition, alteration in grazing behavior [44, 52] decrease in feed intake and feed digestibility and efficiency of feed utilization (which can be measured in terms of growth, pork and milk production of feed available) [37, 64]. Other affects widely reported by scholars [27, 45, 64] are low pork carcass quality, increase in frequency of parasite and decline in the storage and handling of animal products.

Studies reveal the need to develop adaptation strategies or strengthen the available local ones to mitigate the influence of climate change on the likely extinction of the most accessible and affordable animal – protein origin by the resource poor household in most rural areas of developing countries [28, 33].

Adaptation according to [46, 54, 63] refers to modifications in human–environmental systems in response to observed or anticipated variation in climatic stimuli. In the same vein, adaptation is the process of improving individual or society's capability to deal with changes in climatic conditions across time scales [60, 67]. In addition, according to [56], adaptation entails the use of risk minimizing strategies and adoption of innovative low-input practices that can acclimatize to the environmental adjust.

In Africa, smallholder farmers have over the years developed adaptation methods to climatic changes and this is through proper comprehension of farming systems and ability, and more predominantly the utilization of traditional knowledge and their income [6, 60]. These adaptation strategies are usually location and farmer specifics. However, it becomes necessary to identify the adaptation strategies used by the farmers and factors sway such choice, since there is paucity of such information in the study area. The specific objectives are to:

1. describe the pig farmers' socioeconomic characteristics;
2. identify the adaptation strategies adopted by the farmers
3. determine the effects of variability on pig production
4. determine the factors affecting households choice of climate change adaptation strategies; and

5. Identify the factors limiting farmers' adaptation to climate change.

Fig 1: Map of southeast, Nigeria

Climate change and pig production; Impacts, adaptation and mitigation

There are glaring evidence that protein deficiency is accountable for prevalent under-nutrition and malnutrition among all ages in most rural areas of the countries in sub – Saharan Africa [7; 12]. Such nutrient lack is capable of causing weight loss, weakness, fatigue, poor appetite and anaemia among the vulnerable usually children under five years old [15; 37]. In addition, [45] reported that deficiency of protein is capable of undermining the efficiency and effectiveness of the labour population, hence dwarfing the nation's production and productivity particularly in the developing countries where farming is nearly zero mechanized. In recent time, there is a growing demand for livestock production and its products and this scenario, which is occasioned by varied policies and programmes by governments in the region, which is deemed by various literatures as "livestock revolution" [28, 58]. Apart from nutrition, livestock sector is source of employment for over1.1 billion people globally; income source through the marketing of the animal and it's by - product, source of manure for crop production, source of foreign exchange and among others [32, 65].

In livestock sector industry, pig production is gradually gaining prominence in non Muslim areas in most developing countries and this may not unconnected with inherent traits of the animal. The pig genetic traits as reported by [3, 5] are high fertility [20-30] piglets from 2-3 litres per year), high survival rate especially under scarcity of inputs and good convert of agro-industrial waste products to meat cheaply and more rapidly than any other domestic animal and high carcass dressing percentage. However, nowadays, piggery industry production and productivity has been hampered significantly, and chiefly among such factors is by climate change [13, 17, 21, 35]. Intergovernmental Panel on Climate Change (48) defined climate change as statistically significant variations in climate that endured for a extended period, usually decades or longer. The affects of climate change in livestock industry is detrimental and centrally among them are reduction in the quality of feed crop and forage, water availability, milk production, reproduction, biodiversity and increase in disease infestation [14, 16, 17, 25]. Climate change, apart being a threat to pig industry, it is probably the most important environmental concern and characteristics of being harsh and extensive destructive impacts, menacing ecological systems through heating up of the planet, peoples' source of living, and species continued existence [6, 13].

Global climate change is primarily rooted to Green House Gas (GHG) emissions as caused by human activities that results in warming of the atmosphere [53, 69]. The livestock sector contributes 14.5% of global GHG emissions [32], of which hog industry constituted about 7% [50]. For instance, the Green House Gas generated by livestock are, methane (44%) generated during enteric fermentation (eructation in ruminants) and from manure decomposition, carbon dioxide (CO_2) (27%) released during the production and transport of animal products and feed and Nitroxide (N_2O) (29%) emitted from manure and fertilizer [35]. The affects of the GHG are increasingly land degradation, air and water pollution, and declines in biodiversity [36, 23], which although has global dimensions but Africa, particularly the Southern part is most vulnerable [36, 62]. This could be linked to poverty, low adoption of technology and poverty links characteristics associated within the region [14, 24]. Therefore, there is need to understand the interaction between climate change and pig production

Impact of Climate change on pig production

The impacts of climate change on pig, just like other livestock are as result of an increase in temperature and atmospheric carbon dioxide (CO2) concentration, precipitation variation, and a combination of these factors [12, 16, 43, 69]. Among the above factors, it is of paramount importance to state that temperature is a critical factors that thwarts most pig production through its water availability, production, reproduction and health [14].

Forage quantity and quality

The **quantity and quality of forage** are affected by a combination of increases in temperature, CO_2 and precipitation variation [32, 69]. Furthermore, carbon dioxide (Co_2) affects on C_3 species and less on grain yields, partial closure of stomata, reducing transpiration, and improving some plants' water-use efficiency [20]

The varied effects of changes on quantity and quality of forage depend on the location, production system used, and plant species [23].

Water Availability

Water is vital in pig metabolism and in wallowing under severe high temperature [19, 30]. Salination as result of sea rise is capable of affecting animal metabolism, fertility, and digestion in generals [68]. Studies show that salination adds to chemical and biological contaminants and high concentrations of heavy metals could impair cardiovascular, excretory, skeletal, nervous and respiratory systems, and impair hygienic quality of production [74, 65].

Disease and Pest Infestation

The increase in temperature is capable of causing growth of pathogens and parasites that live outside of their host, resulting in poor performances of livestock [3, 4]. Global warming and changes in precipitation affect the quantity and spread of vector-borne pests such as flies, ticks, and mosquitoes especially under warmer condition [20, 29]. In addition, under warmer atmospheric temperature, there is higher disease transmission between hosts.

Heat Stress: Heat stress is one of the major concerns in pork production, since pigs do not have functional sweat glands like other livestock species in order to assist them in efficiently discharging of body heat. Pigs have, a range of ambient environmental temperatures (a thermal comfort zone) that are important for physiological functions. Heat stress on pig is dependent on temperature, humidity, species, genetic potential, life stage, and nutritional status [4, 36]. In pig, the thermal comfort zone varies depending on the stage of growth of the animal. For instance for;

Boar: Heat stress affects the reproduction efficiency of the animal through impairment of the oocyte growth and quality in boar, lower sperm concentration and quality in boar [14] Prolonged high temperature alter the metabolic rate, endocrine status, oxidative status [13]. In a related studies, [6, 42, 48] reported that increased temperature is capable of causing alteration of glucose, protein and lipid metabolism, liver functionality (reduced cholesterol and albumin), non-esterified fatty acids, saliva production, and salivary HCO_3^- content, boar fitness and longevity.

Sow: Studies [64, 68; 74] revealed that piglets born to sows that underwent heat stress during pregnancy will have increased core body temperature making them more vulnerable to heat stress after birth, metabolism of these offspring is also modified resulting in less skeletal muscle and more fat tissue being deposited during the growth stage. Heat stress as asserted by [41, 65] predisposes sows to decrease in farrowing rates, lower total born per litter, decrease in number of live piglets per litter; reduced number of litters farrowed per sow, higher embryonic death during early gestation and higher stillborns at late gestation and lower piglet body weight.

Finishing pigs: Heat stress on growing-finishing pigs has the potentials of causing decreased feed intake, reduced body weight achieved, unintelligible market weights [14, 74] decreased feed efficiency, higher carcass fat deposits, reduced carcass quality and malfunction to retain pregnancy [17].

Biodiversity: Biodiversity refers to a variety of genes and organisms within a specific environment, which is able to boosting human well – being [24, 73]. Studies show that climate is one of the direct divers of biodiversity loss. For instance, at temperature increase of 2 – 3^{o}C and above pre – industrial level as reported by [48, 62] results in potential loss of 20 – 30% of bioversity loss of plant and animal, loss of species reproduction, migration, mortality and distribution.

Food Security: Food security is a situation “when people, at all times, have physical and economic access, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [32]. Pig just like any other livestock contributes greatly to food security because: (i) suppliers of global calories, proteins, and essential micronutrients, (ii) thrives in areas not suitable for crop production (iii) most of the livestock feeds not suitable for human use, and (iv) boost sil fertility for plant growth through its manure [9, 31, 32]. However, the rivalry between pig and man for grains could negatively affect food security [64].

However, because of the effects of climate change, the needs for adaptation strategies become necessary. Adaptation as highlighted by [53, 62] is the process of improving society’s aptitude to manage the variations in climatic environment across time scales, from short term such as seasonal to annual to the long term like decades to centuries). These adaptation strategies could be in micro and macro levels, and the choice of the adaptation is affected by resource constraint (credit problem and poor access to market) and poor infrastructure [60, 61]. The appraisal of farm-level adoption of adaptation strategies is significant in supplying information that can be used to formulate policies that could enhance adaptation as a tool for managing a variety of risks associated with climate change in agriculture [73, 75]. The adaptation strategies as suggested by [38, 40] are to improve insulation of buildings to control internal temperature more effectively and reduce energy wastage, design ventilation control systems to manage changing climatic conditions and use enclosed creep boxes in farrowing houses to better regulate the environment for piglets and sows. The use of improve design and management of wallows and shaded areas, invest in water storage facilities, use less intensive rearing techniques and use of less fatty food in the animal feed [10, 31, 75]

For pig and other livestock-based livelihood, adaptation choice is influenced by climatic risks, agro-ecological zones, livestock production method and the socioeconomic characteristics of the household [2, 56]. The ability to adapt to climate change and the associated risks is functions of the economic resources, geographic location, existing technologies and information, infrastructures, institutions and networks [43, 61]. However, chiefly among the limitations to pig farmers in most developing countries to adaptation to climate change impacts are poor access to landfor farming, high cost of farmland, land ownership by inheritance, communal system of land ownership, poor access to source of information, poor access to credit facilities and poor availability of farm inputs of which vaccines and drugs stand tall [1, 3 6, 59]. The others barriers are insufficient knowledge of how to survive, high cost of improved pig breeds, lack of access to weather forecast, technologies, government irresponsiveness, climate risk management, poor agricultural extension service, lack of capacity of extension personnel to build resilience ability of farmers on climate change and poor information on early warning [4, 9, 12].

Mitigation and adaptation strategies are especially important in piggery for three main reasons, include enhancing poverty-reducing impacts, improved livelihoods and the nutrition of adults and children, improved pig farming for attainment in the levels of self-reliance; overflow of extended interest through increased investments in infrastructure and the import of pure bred pig. It could include technical and management options that encourage; reduction of greenhouse gas (GHG) emissions from livestock; efficient livestock feeding systems, balanced feed rations and efficient manure management [23, 63]. For instance, the foremost ways of reducing GHG, could be through feeding pigs with concentrated diets in a finely ground or pelleted ration, use of β-adrenergic agonists (βAAs) and recombinant bovine somatotrophin (rbST) as growth improved technology [66], use of feed additives such as nitric, fumarate and sulfate [38], genetic selection aimed at enhancing pig productive through greater feed intake with aim of sustaining the energy supplies associated with growth [8, 9, 13].

Materials and Methods

The study was conducted in South East Nigeria and located between latitude $5^0$9' and $7^0$75'N of equator and longitude $6^0$85' and $8^0$46' East of Greenwich Meridian. It has a total land mass of 10,952.400ha with population of 16,381.729 people (54). The zone comprises of of Abia, Anambra, Ebonyi, Enugu and Imo. South East Nigeria is bordered in the North by Benue and Kogi States, in the West by Delta and Rivers States, in the South by Akwa Ibom State and in the East by Cross River State. South east states comprises of rainy season (April – October) and the dry season (November to March). The zone has temperature range between 18^0C – 34^0C and relative humidity of 60 – 70%. The inhabitant of the zone are agrarians and engaged in other non agricultural activities such as civil service, pottery, vulcanizer and tailoring.

Purposive and multi-stage random sampling technique was used to select states, Local Government Area (LGA), communities, village and respondents. In the stage I, three states (Imo, Anambra and Enugu) were purposively selected because of their nearest to breweries (3- 3 Dubic and Ama Breweries respectively for the states), as sources of spent grain use in pig production. In stage II, one LGA each were the breweries are located were chosen. The LGAs were Awomama for Imo State, Ogbaru and Udi for Anambra and Enugu States respectively. In the third stage, two towns each were randomly selected from each of the LGAs. This brought to a total of six towns. In the third stage, two villages were randomly selected from each of the six towns. Finally, with help of local leader and Agricultural Development Programmed (ADP) extension agents, the lists of pig farmers in the selected villages were made available. From the list, ten farmers were randomly selected from the twelve villages. This brought to a total of one hundred and twenty pig farmers for detailed studies

A Structured questionnaire was used to collect information on primary data in respect to farmer's socio-economic characteristic (age, educational level, household size, farming experience, membership of organization), farmer's adaptation strategies and limitation to farmers' adaptation strategies such as credit, labour and poor extension outreach. Secondary data was obtained from literatures, journals, proceedings, textbooks and other periodicals.

Descriptive statistic such as percentages and frequency distributions was used to address objectives I, iii. and v. Objective ii was accessed using Multiple Regression Model (MRM) while objectives iv was addressed using Multi Nominal Logit Model (MNLM)

Model Specification

Multiple Regression Model

The model is implicitly represented below as

$$Y=f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8,\ldots X_n)\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Four functional form of the models: linear, semi-log. Exponential were tried and the one that gave the best fit were chosen.

Linear function:

$$Y=b_{0+} + b_1x_1+ b_2x_2+ b_3x_3+ b_4x_4+ b_5x_5+ b_6x_6+ b_7x_7+ei\ldots (10)$$

Semi logarithmic form:

$$Y=b0+b_1log+b_2logX_2+b_3logX_3+b4logX4.......+ei\ldots\ldots (11)$$

Double logarithmic form:

$$Log\ Y=b_0+b_1logX_1+b_2logX_2+b_3logX_3+b_4logX_4\ldots+ei.\ldots (12)$$

Exponential function:

$$Lny =b_0+b_1X_1+b_2X_2+b_3X_3+b_4X_4\ldots+ie\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. 4$$

Where Y=pig

X_1 =Temperature (^{0}c)

X_2 =Rainfall (mm)

X_3 =Relative humidity (%)

X_4 =Sun Shine (kg)

X_5 =Wind (Knots)

X_6 =Pressure (Pa)

X_7 =Cloud Cover. (Okta)

Multi-Nominal Logit Model (MNLM)

This was used to analyze the factors influencing households' choice of climate change adaptation strategies. According to Magombo *et al*. (2011), MNL model for choice of adaptation strategies state the association between the likelihood of choosing an adaptation choice and the set of explanatory variables. The adaptation strategies are grouped into six groups, since the households use more than one plan and one group is "no adapting to climate change". Thus the groups are destocking.

The MNL Model is stated implicitly as follows:

$$Y_i = \quad In\ (P_i,\ P_I) = \beta_0 + \beta_1x_1 + \beta_2x_2+ \beta_3x_3+ \beta_4x_4+ \beta_5x_5+ \beta_6x_6+ \beta_7x_7+ \beta_8x_8+ \beta_9x_9+ ei \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

Where

Y_i = adaptation strategy (no adaption; heat tolerant breeds, adequate cross ventilation, adequate and clean water in the

warrowing trough, appropriate roofing materials, less fatty food in their feed and any other strategies).
X_i, where i = 1, 2, 8 are explanatory variables,
X_1 = Gender of the farmers (male=1, otherwise=0)
X_2 = Age of the farmers (years)
X_3 = Educational attainment (years)
X_4 = Experience in farming (yearrs)
X_5 = Availability of Extension Services (access=1, otherwise=0)
X_6 = Membership to social network (member=1 otherwise=0)
X_7 = Access to credit (access=1, non access =0)
X_8 = Climate change information (access=1, otherwise=0)
ei = error term

Model Specification
The multinomial logit (MNL) model is used to examine the determinants of farmers' choice of adaptation strategies in South East Nigeria. This method can be used to analyze crop choices as techniques to adapt to the negative impacts of climate change. The gains of the MNL is that it allow the analysis of decisions across more than two categories, permitting the determination of choices for diverse categories (20) and it is as well computationally easy. Let x be a 1x k vector with first element unity. The MNL model has response probabilities.

P(y = j/x) =

$$\frac{\exp(x_{\beta}j)}{[1+\sum_{h=1}^{J}\exp.(x_{\beta}h), j = 1, \ldots, j]} \qquad \ldots 13)$$

Where βj is kx1, j=1,…,j.

To describe the MNL model, let y denote a random variable taking on the values {1, 2,..., J} for J, a positive integer, and let x denote a set of conditioning variables. In this case, y denotes adaptation alternatives or group and x contain diverse household, institutional and environmental features. The question is how cetirus paribus variation in the elements of x
Affect the response probabilities (P(y = j/x), j = 1, 2,..., J. Since the probabilities must sum to unity, P(y = j/x) is resolute once we recognize the probabilities for j = 2,..., J.
Let x be a 1 _ K vector with first element unity. The MNL model has response probabilities:

Pðy ¼ jjxÞ ¼ expðxbjÞ 1 þPJh¼1 expðxbhÞ; j ¼ 1;... ;Jhi …………………………………. (14)

Where Bj is K - 1; j ¼ 1;...; J:
Unbiased and reliable parameter estimates of the MNL model in Eq. (1) entails the assumption of independence of extraneous options (IIA) to grip. More intentionally, the IIA assumption necessitated that the possibility of using a exact adaptation system by a given household desires to be autonomous from the odds of choosing another adaptation method

Results and Discussion
From Table 1, 70% of the respondents were males, while 30% were females. This implied that men are more involved in pig production in the study area than women. The reason for this is likely stern from the fact that pig farming is labour and capital intensives that men are more capable of handling it [2].

Table 1: Distribution of Respondents According to Socio-economic Characteristics

Variable	Frequency	Percentage
Gender		
M	84	70
F	36	30
Age		
< 20	6	5
21 – 41	32	26.7
42 – 62	52	43.3
63 – 83	30	25
Level of education		
Primary	22	18.3
WAEC	52	43.3
Tertiary	46	38.3
Farming Experience > 5	14	11.7
6 – 10	66	55
11 – 15	36	30
16 and above	4	3.3
Access to climatic information		
Access	76	63.3
No access	44	36.7
Member. Of Organ.		
Members	84	70
Non members	36	30
Access to Credit		
Access	76	63.3
Non Access	44	36.7
Access to exten. Service		
Access	52	43.3
No Access	68	56.7

***Source*:** Field Survey, 2016

From table 1, it was observed that 43.3% of the respondents fell between the age bracket of 42 – 62, 25% were within 63 – 83 of age, 26.7% were 21 – 41, and 51% were less than 20. According to [61] ageing and teenage populations are less able to source and synthesize information on climate change and even to engage in modern agricultural practices. Table 1 reveals that all the respondents were educated, with 43.31% of the respondents having secondary school education, 38.3% had tertiary education, 18. 3% attended primary school. Education is an important factor that could enhance farmers' ability to evaluate, understand, and accept new innovations on climate change [4]. From table 1, most (56%) of the respondents had 6 – 10 years of farming experience, 30% had 11 – 15 years and 3.3% had 16 years and above. Experienced farmers are always capable of noticing climate change encroachment/signs, hence could adapt the necessary coping mechanisms to avert it [59].
In addition, 56.7% of the respondents had no access to extension services, while 43.3% do. This implies that most farmers had poor access to extension services, hence, could likely not to enjoy the services of extension programme as regards to climate change, source of improved pig breeds and

technical assistance [69]. More so, 63% of the respondents had access to credit, while 67% had no access. Credit help farmers to pay for labour and procure inputs to offset likely climate change challenges [6]. Furthermore, majority (63%) of the respondents were aware of climate change, while 37% do not. This is in line with [52], who opined that when people are aware of climatic information, they tend to adjust through short and long term coping strategies to cushion the effects. Table 1 also shows that 70% of the respondents belonged to one or more social organizations, while 30% belonged to none. Membership of Organization through exchange of ideas/interaction among members could impact into themselves information as regards to climate change adaptation method [39].

Table 2 reveals that 76.67% of the pig farmers used cross ventilation mechanism to avert the effects of climate change in pig production.

Table 2: Distribution of Respondents According to Adaptation Strategies

Adaptation Strategies	Frequency	Percentage (%)
Cross ventilation	96	80
Heatresistant roofing material	36	30
Adequate water for wallowing	94	78.3
Feeding with less fatty feed	37	30.8
Enough drinking water	64	53.3
Using heat-resistant animal	85	70.8
Planting of tree as shade	70	58.3

***Source*:** Field Survey, 2016
*Multiple Response

Cross ventilation as asserted by [30, 46] is capable of controlling the indoor air quality in order to provide a healthy and comfortable environment needed by hug to meet the metabolic requirements to dilute and remove pollutants emitted within a space. In addition feeding with less fatty feed during high temperature was adopted by 28.3% of the respondents. The performance of sows and gilts depend on nutritional adjustment such as decrease in fatty feed intake in hot weather in order to reduce the effect of heat stress and increase efficiency in lactating sows. [38].

The Table more so, indicates that 40% of the pig farmers used enough drinking and wallowing water in their piggery especially during prolonged temperature increase. Studies infer that pigs needed water to maintain optimal production levels, as water is the single largest constituent of the body, making up to 82% of a young pigs, 55% of market hog body weight and also a major component of secretions made by the pig in milk and saliva [36, 46]. Moreover, 91.7% of the respondents used heat – resistant animal to guide against menaces of climate change in their pig farms. The genetic selection of improving heat -tolerant pigs is one of the most promising long term options to overcome constraints from heat stress and sunburn [1, 12, 15, 54, 58]. Finally, planting of shades round the farm house was used by 50% of the farmers. Trees provide a cost – effective, long – term means of reducing odours, dust, and noises associated with operation. Furthermore, strategically planted trees help to reduce ammonia emission by physically capturing both the ammonia – laden dust particles and as well as clean air by capturing carbon dioxide, a green house gas, storing the carbon in the wood and releasing oxygen back into the air for animal use [21, 29].

Based on the statistical and econometric criteria, Cobb Douglas production function was chosen as lead equation as shown in Table 3. The coefficient of determination (R^2) was 0.891, implying that 89.1% of the variation in the output of the pig farmers were accounted by the explanatory variable included in the model, while the remaining 11.9% were due to error term. The coefficient of rainfall was positively related to pig production and significant at 10% alpha level.

Table 3: Multiple Regression Result of Effect of climatic variability on pig production.

Variable	Cob Douglas	Exponential	Linear	Semi Log
Constant	597.589 (11.496)***	4.587 (16.882)***	0.246 (2.393)**	616.072 (1.957)*
Temperature	2.181 (4.336)***	0.561 (4.714)***	0.268 (1.971)*	54.513 (1.496)
Rainfall	14.143 (1,887)*	4.714 (1.128)	0.021 (0.156)**	0.569 (0.022)*
Relative Humidity	593 (6. 6346)***	0.049 (3.268)*	0.021 (0.156)**	0.569 (0.022)*
Sunshine	0.41 (0.291)	0.133 (2.145)**	0.121 (2.821)*	0.157 (3.007)***
Wind	1.051 (2.098)**	0.020 (2.502)***	0.006 (1.338)*	9.507 (3.276)**
Pressure	10.410 (5.078)***	0.212 (3.359)***	0.025 (5.063)***	3.200 (3.624)***
Cloud	0.001 (0.002)	8.239 (1.095	0.146 (0.951)	20.211 (0.698)
R^2	0.841	0.801	0.779	0.830
F – value	15.891***	5.587***	5.121***	15.021***

*, **, and *** implies significant at 10%, 5% and 1% respectively
***Source*:** Field Survey, 2016

The finding s of [28, 63] reported that warming and changes in rainfall distribution may lead to changes in spatial or temporal distributions of those diseases sensitive to moisture such as anthrax, blackleg, haemorrhagic, septicaemia,and vector-borne diseases of livestock, pigs inclusive.

As expected, the coefficient of temperature was positively signed and significant at 1% alpha level, implying that temperature affects pig production since it has no sweat gland which help in regulating of heat stress conditions unlike other livestock. Temperature rise above the optimal level for pig as reported by [15; 23, 49] could result in reduced efficiency of its production (through reduction in fertility, fitness, mortality and reduced longevity), product outputs and increased costs of production.

Table 4: Multiple Regression Result of Effect of climatic variability on pig production.

Variables	Cob Douglas	Exponential	Linear	Semi Log
Constant	597.589*** (11.496)***	4.587*** (16.882)***	0.246 (2.393)**	616.072*** (1.957)*
Temperature	2.181 (4.336)***	0.561 (4.714)***	0.268 (1.971)*	54.513 (1.496)
Rainfall	14.143 (1,887)*	4.714 (1.128)	0.021 (0.156)	0.569 (0.022)*
Humidity	6.593 (6.346)	0.049 (3.268)*	0.008 (3.304)*	25.082 (2.082)
Sunshine	0.41 (0.291)	0.133 (2.145	0.121 (2.821)*	0.157 (3.007)***
Wind	1.051(2.098)**	0.020 (2.502)***	0.006 (1.338)*	9.507 (3.276)**
Pressure	10.410 (5.078)***	0.212 (3.359)***	0.025 (5.063)***	3.200 (3.624)***
Cloud cover	0.001 (0.002)	8.239 (1.095)	0.146 (0.951)	20.211 (0.698)
R^2	0.891	0.801	0.779	0.830
F – value	15.891***	5.587***	5.121***	15.021***

***Source*:** Field Survey, 2016

*, **, and *** implies significant at 10%, 5% and 1% respectively

Surprisingly, the coefficient of wind was negative and significant at 5% probability level. The sign identify of the variable could be linked to the destruction of animals' pens at extreme situations. This finding is not synonymous with [58], who reported that wind helps in ensuring proper ventilation of the animal pen to avoid odour and disease and pests building up.

The coefficient of pressure had direct relationship with the dependent and significant at 10% probability level. Studies [38, 46, 48] infer that pressure is beneficial in regulating circulatory system in pigs and also determines its heart beat rate.

Table 4 shows that the choice of adaptation options insert into Multi Nominal Logit (MNL) model were cross ventilation, resistant roof material, adequate water for wallowing, less fatty food, drinking water, heat resistant breed, planting of shade trees and no adoption were ran. The likelihood ratio statistics are indicated by statistics π^2 (182:31) and was highly significant, suggesting that the model has a strong explanatory power.

Table 5: Multi Nominal Logit Model Result of Factors Influencing Farmers Choice of Adaptation

Variable	Cross Ventilation	Resistant Roofing Material	Water for Wallowing	Less fatty Feed	Drinking Water	Resistant Breed	Planting Shadetrees	No Adaptation
Age	2.9962 (1.2848)	2.137622* (1.1167)	2.4651** (0.9738)	1.2647 (0.8406)	3.1132** (1.2364)	22.6695 (37.7794)	0.6088** (0.7788)	1.3362*** (0.9213)
Education	0.1691* (0.0914)	0.1910906** (0.0890)	0.1196 (0.0755)	0.0360 .0.0727	0.2491*** (0.0843)	5.5897*** (3.4220)	1.0620** (0.05860	
Farm size	4.970192*** (1.7845)	4.64486*** (1.6835)	3.9060** (1.6586)	2.7451* (1.6256)	5.3243*** (1.6836)	39..4085 (72.1760)	1.9718 (1.4732)***	
Extension Service	0.1780341** (0.0848)	0.3467 (1.1110)	0.6491*** (0.0261)	0.0571 (0.9319)	0.5163 (0.9502)	46.6609 (49.1402)	103.2457** (62.6012)	
climate information	311.3437*** (3.7115)	188.0761*** (3.2061)	2.8153 (1.4732)	1.5196 (3.3668)	4.3274** (2.2310)	248.1665 (5484.2530)	1.0682 (0.9671)	
Constant diagnostics	-18.7954	-25.1960	-3.3879	-3.6407	-9.0988	210.0384	2.3146	
Base category								
Number of observations	120							
LR chi-square (50)	182.31***							
Log Likelihood R^2	-160.79297 0.3565							

***Source*:** Field Survey, 2016.

The coefficient of age of the household had a positive and significant impact on the choice of adaptation strategies to climate change. This implies that as the farmer gets aging, the probability of adopting adaptation to climate change in pig production using resistant roofing material, water for wallowing and water for drinking. The finding of [35] was in line with this assertion. Coefficient of the educational level of the sampled household head had a positive and significant effect on the use of adaptation strategies such as use of resistant heat breed, use of fatty feeds, resistant roofing materials and cross ventilation in overcoming climate change effect in his/her pig production. Educated people are usually prudent in resource use, expose to information to climate change as related to the different adaptation strategies [5, 60, 61].

Access to extension services had a significant effect in adapting to climate change through use of heat resistant breed, planting of shade trees, cross ventilation and use of water in wallowing trough. The coefficient of access to extension service was positively signed, which implies that farmers who had access to extension services have more access to information as regards to climate change adaptation strategies compared to farmers without access.

The coefficient of access to climatic information was positive and had significant effect on adaptation strategies to climate change. This implies that the more farmers are well abreast with information on climate change, the more likelihood of using adaption measures such as use of cross ventilation in the pig house, use of heat – tolerant pig breeds, use of fatty feeds, and resistant roofing material. Availability of better climate and agricultural information according to [40, 61, 66] help farmers make comparative decisions among alternative animal management practices and this allows them to make better choice of strategies that make them cope well with changes in climatic conditions

Table 4 shows that 55% of the respondents reported poor access to credit as a challenge towards adaptation to climate change strategies.

Table 6: Distribution of Respondents According to Factors Limiting Farmers' Adaptation Strategies

Poor Access to credit	**80**	**55**
Lack of improved Agricultural technology	38	18.3
High cost of labour	68	25
Poor access to information	78	53.3
Poor access to improved pig breed	66	31.7
Poor government involvement	24	5
Poor access to extension services	45	20

Source**:** Field Survey, 2016

The poor access to credit by the farmers could be associated with high interest rate as charged by the lending agencies, short period of payment and collateral [72]. According to [52] lack of fund/credit is the bane to pig industry development in most developing countries. Also, 53% of the pig farmers encountered poor access to information problem as a challenge to adaptation strategies to climate change. Inadequate information about climate change limits the extent to which the local farmers adapts to the changes in the climatic variables. For instance farmers' access to timely weather information helps them in their production decision making and selection of adaptation options [46, 47, 48]. Furthermore, 31.7% of the respondents reported that poor access to improved pig breeds was as constraint to adaptation to climate change. It is important to state that most of improved and high prolific pig breeds in most developing countries have poor adaptability to extreme high temperature that is often associated with the tropics. The local breeds that are heat resistant breeds are characterized by low and poor lettering ability [10, 27]. Moreso, 20% of the respondents encountered the problem of poor access to extension services. Extension services help to increase farmers awareness of changing climatic conditions and their knowledge of appropriate adaptation measures [9, 60, 64].

Again, 18.3% of the respondents reported poor access to improved agricultural technologies as a limiting factor to adopting climate change adaptation strategies. This is in line with [76] which noted that farmers that have access to electricity, and technology such as automated feeders and drinkers, water splashing system etc are more likely to adapt to changes in climatic conditions.

Conclusion and Recommendation

Based on the study, the following conclusions were deduced;

The result on climate change adaptation strategies among pig farmers shows that males dominated in pig production, farmers of age range of 42 – 63 years dominated the study and the farmers had moderate level of education. Also, the use of heat resistant breeds, heat resistant, roofing materials, and use of cross ventilation were most predominant adaptation strategies by the respondents in order to reduce the negative impact of climate change in the study area.

Furthermore, the factors affecting households' choice of climate change adaptation strategies were age of the household head, farm size, educational level, access to extension services and access to climatic information. In addition, farmers were faced with the challenges of poor access to credit inadequate information, inadequate access to technology, poor access to extension services and poor access to pig heat – resistant breeds in adopting of the adaptation strategies to climate change.

Based on the findings, the following recommendations were proffered;

1. Ensure credit access to farmers through micro credit institutions and other financial institutions. This entails that farmers should form themselves into groups such as co-operative society to enable them strengthen their bargaining ability, especially during credit negotiation..
2. Extension agents should be adequately motivated and equipped with climate change information in order to aid farmers in abating the negative effect of climate change through information dissemination and technical assistance.
3. There is need for policies aimed at enhancing farmers' level of adaptation through support of department of meteorological services by reporting and alerting households about weather challenges in advance, so that they can be able to plan for the future when farming.
4. There is need in enhancing farmers' access to farm inputs such as improved breeds of piglets and other piggery equipment at subsidized prices by appropriate government and non - governmental organization (NGO) in order to boost farmers' adoptability to climate change adaptation strategies.
5. There is need to enhance farmers' access to educational programme (adult education, seminars and workshops) as this is capable of increasing their adoptability and in decision making on the best adaption options based on their resources and information available to them

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