Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 12(X), 2023:
http://dx.doi.org/10.7770/safer-V12N1-art2300

Evaluation of effect of pig production to the environment in Enugu State, Nigeria.

Evaluación del efecto de la producción porcina en el medio ambiente en el estado de Enugu, Nigeria.

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ABSTRACT

The research was aimed at accessing the effect of pig production to the environmental effect in Enugu State, Nigeria. A total of sixty (60) farmers were selected using purposive and multi stage random sampling techniques. Structured questionnaire and oral interview were used to collect information on the objectives of the study. Percentages responses, probit analysis, multinomial logit models and factor analysis were used to capture the objectives of the study.. The results showed that most of the respondents were aged, educated, had large household size and member of organizations. The effect of pig production on the environment were odour, noise, flies, dust, mosquitoes and rodents. The pig management technologies adopted by the farmers were proper housing, proper manure disposal; precision feed management and proper disposal of animal carcass . The waste disposal methods employed by pig farmers were open lagoons, dumping in the farm, heap waste and burn and store in bag. The result of probit analysis of technologies adoption showed that in all the variables considered, only the coefficients of age, extension services, membership of organization and off – farm income activities that were positive. As well, the analysis of the choice of adopting of the management technologies against environmental hazards using multinomial logit regression, showed that only rearing experience and extension services were positive .Finally, poor access to credit, poor housing, extension services, disease problem, drug, high costs of labour and location of veterinary posts in the urban area were the major challenges faced by farmers in the study area. There is need to

ensure farmers' access to credit, extension services, membership of organization and off farm income activities

Keywords: Effect, Pig Production, Probit model, Environment, Multinomial logit Enugu State, Nigeria.

RESUMEN

La investigación tuvo como objetivo acceder al efecto de la producción porcina en el efecto ambiental en el estado de Enugu, Nigeria. Se seleccionó un total de sesenta (60) agricultores utilizando técnicas de muestreo aleatorio intencional y multietapa. Se utilizó un cuestionario estructurado y una entrevista oral para recopilar información sobre los objetivos del estudio. Se utilizaron respuestas porcentuales, análisis probit, modelos logit multinomial y análisis factorial para capturar los objetivos del estudio. Los resultados mostraron que la mayoría de los encuestados eran ancianos, educados, tenían un hogar numeroso y miembros de organizaciones. Los efectos de la producción porcina en el medio ambiente fueron olor, ruido, moscas, polvo, mosquitos y roedores. Las tecnologías de manejo de cerdos adoptadas por los granjeros fueron alojamiento adecuado, disposición adecuada del estiércol; manejo de alimentación de precisión y eliminación adecuada de cadáveres de animales. Los métodos de eliminación de desechos empleados por los criadores de cerdos fueron lagunas abiertas, vertido en la granja, amontonamiento de desechos y quema y almacenamiento en bolsa. El resultado del análisis probit de adopción de tecnologías mostró que en todas las variables consideradas, sólo los coeficientes de edad, servicios de extensión, afiliación a organización y actividades de ingreso extrapredial fueron positivos. Asimismo, el análisis de la elección de la adopción de tecnologías de manejo contra peligros ambientales usando regresión logit multinomial, mostró que solo la experiencia de crianza y los servicios de extensión fueron positivos. , los altos costos de mano de obra y la ubicación de los puestos veterinarios en el área urbana fueron los principales desafíos que enfrentaron los ganaderos en el área de estudio. Es necesario garantizar el acceso de los agricultores al crédito, los servicios de extensión, la pertenencia a organizaciones y las actividades de generación de ingresos fuera de la explotación

Palabras clave: efecto, producción porcina, modelo probit, medio ambiente, logit multinomial, estado de Enugu, Nigeria.

INTRODUCTION

Agriculture is crucial in the economy of most countries in developing countries as it plays significant roles in food security and poverty alleviation of the citizenry, provision of employment, enhancing nations' total gross domestic product (GDP) and labour force (FAO,2008). The livestock sub-sector of agriculture is vital in among others; providing significant proportion of protein of animal origin, especially now it's malnutrition and the disease related problem are ravaging children under five years and pregnant women in most rural areas of the region(Ume, *et al;* 2018). In line to the above aforementioned important, several governments in that region have fronted programs and policies to enhance livestock productionand productivity. For instance, in Nigeria successive governments have enacted such programs, included farm settlement scheme, Agricultural Development Program (ADP) (Ume, *et al*; 2018).While the efforts by governments in this region could be applauded but its serious consequences on the environment especially under mismanagement is causing serious concern to scientist and policy makers/planner in the region (Okoli, 2011)

Among the Livestock, pig rearing is of pre-eminence in the region (Ogunfowora; *et al*; 1980, Ajala and Osunbor, 2004, Okoli, 2011, Ironkwe and Amefule, 2011). The reasons for the popularity as deduced by studies (Ewuziem, *et al* , 2001, Okoli, 2011, Ume, *et al*; 2018) inferred that pigs have intrinsic features of possessing high survival rate, highly prolific, efficient feed converters and reaches slaughter weight of about 80 to 90kg in about 7 to 9 months under good management. These innate characteristics of the animal and in conjecture with the nearness and cheap source of spent grain for feeding pig from AMA brewery have lead to indiscriminate and spontaneous pig production in the study area. Here, pigs are raised in unconventional houses such as part of residential houses and uncompleted residential building without recourse of upholding to the Environmental Protection Agency (EPA) regulation of adhering certain distance to residential houses (usually 500 metres) (Ume, *et al*; 2018). The aforementioned scenario (inappropriate housing) coupled with other inappropriate pig management's practices such as improper disposal of the animal manure and waste handling and poor precision feed management predispose the whole environment to different forms of pollutions (Ewuziem *et al,* 2009, Steinfield *et al.,* 2014). The environmental pollutants of wastes from pigs according to literatures included nutrients, pathogens, veterinary pharmaceuticals and naturally excreted and hormones (Power, *et al*; 2011) These contaminants when discharge into the environment in concentration sufficient enough might result in ecological distortion, damage

or destruction (Hatfied, 2008). The concentration of pollutants as reported by Young (2009) depends on the amount of pollutant generated at a particular time and the nature of the substance as well as the space available. For instance, although, the rate of air pollution differs in different environments but chiefly determined by the rate of emission of pollutants per unit area, the distance down wind that a mass of air may move through the area, the average speed of the wind and the height to which potential pollutants may be thoroughly mixed in the lower atmosphere (Steinfeld; *et al*; 2014).

The environmental pollution through pig production is capable of resulting in health related illness to man, in particular young, the elderly, pregnant women, and immune - compromised individuals (Donham, 1998) .The health related-illness as opined by Donham, (1998) range from respiratory disorders, headaches, shortness of breath, bronchitis and asthma. In addition, pig wastes contamination of drinking water and consumed by man may possibly lead to diseases like samonellosis, giardiasis, chlamydia, meningitis, crytosporidiosis, worms and influenza (Burkholder, *et al*; 2007).Furthermore, the dermal contact with pig contaminants could predispose the victims to skin, eye, or ear infections (Donham, 1998). Also, the proliferation of nuisance; noise, odour, flies and rodents(rats, snakes etc) are common in vicinities where pigs are reared (Lee, 2007, Rademacher, 2009). The health consequences of such annoyance according to literature are enormous. Studies show that high levels of noise can contribute to noise – induced hearing loss, cardiovascular effects in humans and an increased frequency of coronary artery disease (Power, *et al*; 2011). In animals, noise can escalate the risk of death by altering predator or prey detection and avoidance; inhibit reproduction and navigation (Le, *et al,* 2012). The flies and mosquito are capable of spreading diseases such as cholera, dysentery, typhoid, malaria and bilarial (Aarnink, 2007). In addition, air pollution through improper waste management is capable of emitting gases such as methane, zinc, nitrogen, phosphorous and cupper to the environment which threatens not only the ecosystem but human health. For instance , the emission of green house emission is capable of perforating the lithosphere leading to global warning (release of heat) of the earth and acidic rain (Le, 2009,).

The reduction of pollution concentration to acceptable levels from the point of views of human and environmental quality has been the goal of every environmental protection agency or regulation bodies whether in the developed or developing countries(Hatfield, 2008,Power; *et al*; 2011). However, with stringent adherence to livestock environmental laws and policies as stipulated by Environmental Protection Agencies (EPA) of the Nations concerned will help to reduce pollution concentration in such country to acceptable levels

(Hatfield, 2008, Powers, 2011). These could be achieved according to Ewuziem *et al.,* (2009) and Okolo, (2011) through among others better and more efficient waste disposal, pre emission treatment of pollutants as well land use planning. However, while countless developed countries have achieved tremendous success, many of the developing countries are still lagging behind (Aarnink, 2007) .Nevertheless, corruption, inadequate environmental personnel, lack of effective mechanisms to enforce environmental laws and legislation and lack of public awareness/enlightens on environmental issues are often cited by many literatures as responsible for environmental degradations in most developing countries (EPA, 2012). In Nigeria, Federal Environmental Protection Agency Act of 1985 (FEPA Act) helps to protect the environment against pollutions of various types (air, water and soil), with its regulatory agencies; included National Environmental Impact Assessment Act of 1992 (EIA, Act), Harmful Waste (Special Criminal Provisions etc) Act of 1995 and National Environmental Protection (Effluent Limitation) (Ewuziem, 2009; EPA, 2012). This study tends to ascertain how far these regulatory and policies have affected pig production and environmental pollution in the study area. The study is hoped to reveal the effects of environmental hazards associated with inappropriate pig management to the eco system and human health. This study could guide Environmental Protection Agency (EPA) and other environmental regulatory bodies in formulation of policies and regulations to check messy situation among small holder pig farmers in particular. Moreover, this study may help to acquaint pig farmers with environmental pig management friendly technology in order to curtail maximally the pollutions often associated with inappropriate pig management practices which could be detriment to the eco system. In addition, this study will guide pig farmers in controlling the associated green gases emission from the animal waste through precision feed management. Moreover, the study will equip pig farmers with better technology of waste disposal as against open lagoon as popularly practiced by farmers which has the potentials of causing air pollution. The specific objectives of the study are to describe the socio economic characteristics of the respondents; identify the effects of pig production to the environment; identify pig farmers' management technologies in order to safe guide against environmental pollution; analyze the effects of farmers' socio-economic characteristics on their technology adoption decision; identify the waste disposal methods by the farmers; determine the factors affecting the choice of management technologies by the farmers and identify the constraints to adoption of pig management technologies in the study area.

MATERIALS AND METHODS

Study Area: Enugu State of Nigeria is the study area. It is located between latitudes 6°30/ N and 7°10/N of Equator and longitudes 6°35/ E and 7°30/E of Greenwich Meridian. The state has an estimated population of about 4,1671 million people (National Population Commission, (NPC), 2006). The State has a land area of 16,727 square km2.

Enugu State has four agricultural zones, namely; Enugu West, Enugu East, Enugu North and Enugu south. The state is bounded in the West by Anambra State, in the East by Abia State, in the South by Imo State and in the North by Benue State. Enugu State is known to be characterized of wet climatic zone with a rainfall of about 1800mm - 2500mm per annum, temperature range of 290C to 350C and relative humidity of 68%. The State is agrarian with lots of pig farmers. Also, the inhabitants engage still in other non agricultural activities such as trading, vulcanizing, salon, auto-mechanics and civil service

Sampling Procedure and Sampling Size: A purposive sampling and multi-stage sampling procedure were employed to select agricultural zones, Local Government Areas (LGAs), communities, villages and respondents. In stage 1, purposive selection of three Agricultural zones based on closeness to AMA brewery (source of spent grains for feeding the pig). The selected Agricultural zones were Enugu North, and Enugu West In stage 2, two out of six Local Government Areas (LGAs) were purposively selected. from each zone , based on high pig production intensity The selected LGAs for Enugu North; Udi and Awgu, while for Enugu West; Nsukka and Uzo Uwani. This brought to a total of four LGAs. Stage three involved a random selection of three communities each from the each of the four selected Local Government Areas. In stage 4, ten pig farmers were selected from each community, giving a total of one hundred and twenty pig farmers. for the detailed study.

Data Collection: A structured questionnaire and oral interview were used to collect information on primary data in respect to the objectives of the work

Analytical Techniques: Percentage responses and frequency distribution table was used to describe the socio economic characteristics of the respondents, identify the effects of pig production to the environmental, identify pig farmers' management technologies in order to safe guide against environmental pollution and identify the waste disposal methods by the farmers.. Furthermore, the Probit Regression model was used to address the effects of farmers' socio-economic characteristics on their technology adoption decision. In addition, Multinomial Logit model, and Factor analysis were used to capture the factors affecting the

choice of management technologies by the farmers and identify the constraints to adoption of pig management technologies in the study area respectively.

Model Specification

Probit Model Analysis

The Probit model is statistical model use for studying data with binomial distributions. The Probit model can be expressed in probability, thus;

$$Prob(Y = 1) = \quad 1 - F[-\sum_{K=1}^{K} \beta_K \, b_K] = F[\sum_{K=1}^{K} \beta_K b_k] = \varphi[\sum_{K=1}^{K} \beta_K \, b_K]$$

…….. (1)

The equation for probability of non event is then:-

$$Prob(Y = 0) = \quad 1 - \varphi[\sum_{K=1}^{K} \beta_K b_K]$$

……..(2)

The farmer's decision on use of a particular technology depends on the criterion function:-

$$Y^* = \quad \gamma Z_i + U_i$$ ……(3)

Where,

Y^* =Underlying index reflecting the difference between the use of an input and its non-use.

γ = Vector of Parameters to be estimated

Z_i = Vector of Exogenous Variables which explain Use of an Input

U_i = Standard Normally Distributed Error Term

Given the farmers' assessment, which Y_i^* crosses the threshold value, 0, we observe the farmer using the input in question. In practice, Y_i^* is unobservable. Its counterpart is which is defined by;-

If (Farmer I use the technologies in question), and If otherwise

In the case of normal distribution function, the model to estimate the probability of observing a farmer using an input can be stated as :-

$Y_i = 1$ If $Y_i^* > 0$ (Farmer I use the input in question), and $Y_i = 0$ If otherwise

In the case of normal distribution function, the model to estimate the probability of observing a farmer using an input can be stated as :-

$$P\left(Y_i = \frac{1}{X}\right) = \varphi(X\beta) = \int_{-\alpha}^{X\beta} \frac{1}{\sqrt{2\Pi}} exp\left(\frac{-Z^2}{2}\right) dz$$ .....(4)

Where,

P = Probability that the ith farmer use the input and 0 otherwise

$X \quad = K$ by 1 Vector of the explanatory Variables.

Z = Standard Normal Variable (i.e and $Z \quad \sim N(0, \delta^2)$

$\beta \quad = K$ = by 1 Vector of the Coefficients estimated.

For a non-dichotomous variable, the marginal probability is defined by the partial derivative of the probability that $Y_i = 1$ with respect to that variable. For the jth explanatory variable, the marginal probability is defined

$$\frac{\partial P}{\partial X_{ij}} = \varphi(X_i\beta)\beta_j$$ .....(5)

Where,

$\varphi(.)$ = Distribution Function for the Standard Normal Random Variable

β_j = Coefficient of jth explanatory Variable.

The Probit model specification in this analysis can be written as:-

$$Y_i^* = X_i\beta + \varepsilon_i$$ .....(6)

$$Y_i = \begin{cases} 1 \; if \; Y_i^* \geq 0 \\ 0 \; if \; Y_i^* < 0 \end{cases}$$

Where,

Y_i = Observed Dichotomous Dependent Variable which takes Value 1 when the ith Smallholder Farmer use management technologies to abate environmental pollution and 0, otherwise.

Y_i^* = Underlying Latent Variable that indexes the use of agrochemicals.

X_i = Row Vector of Values of K Regressors for the ith Farmers.

β = Vector of Parameters to be estimated

ε_i = Error term which is assumed to have standard Normal Distribution.

The model is specified in an explicit from as follows:

$Y=X_1+X_2+X_3+X_4+X_5+ei$

X_1 = Age of the farmers (years), X_2 = Educational attainment (years), X_3 = Household size (in number), X_4 = Rearing experience (years), X_5 = Extension contact (yes=1 and 0 otherwise), X_6 = Member of farmers organization (yes=1 and 0 otherwise), X_6 = Off – farm income (Yes; 1, otherwise; 0) and X_7= Access to credit (yes =1 and 0 otherwise).

Multinomial Logit Model (MNLM)

Model specification; Multinomial logistic regression:

The Multinomial Logit (MNL) model is used to capture the factors affecting the choice of management technologies by the farmers in Ananbra State, Nigeria. The model was preferred because it permits the analysis of decisions across more than two categories in the dependent variable; hence it becomes possible to determine choice probabilities forthe different OSMP's. On the contrary, the binary probit or logit models are limited to a maximum of two choice categories (Maddala, 1983). The MNL was preferred for this study because it is simple to compute

than its counterpart, the multinomial probit model (Hassan and Nhemachena, 2008).

The MNL model is expressed as follows:

The MNL model is expressed as follows:

$$P(y=j/x) = \exp(x\beta_j)/\left[1+\sum_{h=1}^{J}\exp(x\beta_h), \quad j=12,\ldots..J\right] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

where, *y* denotes a random variable taking on the values {1, 2, …, J} for a positive integer *J* and *x* denote a setof conditioning variables. *X* is a 1xK vector with first element unity and βj is a K×1 vector with j = 2, …, J. Inthis case, *y* denotes organic soil management practices or

categories while *x* denotes specific household and institutional characteristics of the maize farmer. The inherent question is how changes in the household and institutional characteristics affect the response probabilities *P*(*y* = *j/x*), *j* = 1, 2, …, *J* . Since the probabilities must sum to unity, *P*(*y* = *j/x*) is determined once the probabilities for *j* = 1, 2, …, *J* are known. For this study, the OSMPs used in the study area were characterized, after which the most common techniques preferred by farmers (or decision categories) were identified. These techniques comprised the decision categories for the multinomial Logit model. In order for the parameter estimates of the MNL model in Eq. (1) to be unbiased and consistent, the Independence of Irrelevant Alternatives (IIA) is assumed to hold (Deressa *et al*., 2008). The IIA assumption requires that the probability of using one OSMP by a given maize farmer must be independent of the probability of choosing another OSMP (that is,

Pj/Pk is independent of the remaining probabilities). The basis of this assumption is the independent and homoscedastic disturbance terms of the basic model in Eq (1).

The parameter estimates of the MNL model only provide the direction of the effect of the independent variables on the dependent (choice) variable; thus the estimates represent neither the actual magnitude of change nor the probabilities. Instead, the marginal effects are used to measure the expected change in probability of a particular technique being chosen with respect to a unit change in an independent variable from the mean (Greene, 2000). To obtain the marginal effects is differentiated with respect to the explanatory variables as shown in Eq. (2):

$$\frac{\partial P_j}{\partial X_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{J-1} P_j\beta_{jk}\right) \quad \text{……………………………………………………(2)}$$

It has also been noted that the signs of the marginaleffects and respective coefficients may be different (Hassan and Nhemachena, 2008), since the former depends on the sign and magnitude of all other coefficients. The empirical specification for examining the influence of explanatory variables which are described in Table 7 on the choice of management technologies practices by Pig Farmers in the study area is given as follows:

$$Y_i = \text{In}\,(P_i, P_1) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + ei$$

Where;

Y_i= adoption practices (adequate pig pen, adherence to 500 metres from pig pen to residential houses, adequate waste storage facilities and proper feed precision management).

$X_{i,}$ where I = 1,2,….10 are explanatory variables,

X_1 = Sex of the farmers (male =1 and 0 otherwise), X_2 = Age of the farmers (years), X_3 = Educational attainment (years), X_4 = Household size (in number), X_5 = Rearing experience (years), X_6 = Flock size (no) , X_7 = Member of farmers organization (yes=1 and 0 otherwise), X_8 = Extension contact (yes=1 and 0 otherwise)

X_9 = Residential distance to the pig house (km) and X_{10} = Access to credit (yes =1 and 0 otherwise).

Factor analysis: Factor analysis was employed to identify the constraints to adoption of pig management technologies by pig farmers. The principal component factor analysis with varimax –rotation and factor loading of 0.3 was used. The constraints observed by farmers were grouped into three factors using varimax rotation and factor loading of 0.30. The principal component factor analysis model is stated thus

$D_1 = b_{11}\, k_1 + {}_{b2}\; k_2 +$----------$bn_1\, k_n$…….. (10)

$D_2 = b_{21}\, k_2 + b_{22}\, k_2 +$ ----------b^2nk……..(11)

$D_3 = b_{31}\, k_3 + b_{32}k_2+$----------$b^3nk_n$……(12)

$D_{\,n} = b_{n1}k_1 + b_{n2}k_2 +$ ----------$b_{nn}k_n$……(13)

Where

$D_{\,1} = d_n$= observed variable /constraints in adoption of pig management technologies pdts

$b_1 = b_n$ = factor loading or correlating coefficients

$k_1 = fk_n$ =unobserved underlying limitation adoption of pig management technologies

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RESULTS AND DISCUSSION.

Table 1; The definition of variables used in the Probit model analysis

Variable	Definition of Value	Expected Sign
Age of household head	Number of years of Head of Household	+
Rearing experience	No. of rearing experience in years	
Access to credit	Able to have access to credit from lending agencies	-
Educational Level	Number of years of schooling	
Membership of cooperative	1= yes and 0= no	+
Off farm income activities	Money yielding activities outside farming engaged by the farmer	+
Extension Services	No. of visits to the farmer and the farm	+

Socioeconomic Characteristics of the Farmers: The results of the socioeconomic characteristics of the farmers were presented in Table 2

Table 2: Distribution of Respondents According to Pig Farmers' Socioeconomic Characteristics

Variable	Frequency	Percentage	Mean
Gender			
Male	55	91.7	
Female	5	8.3	
Age			
Below 40	20	33.3	13.4
Above 40	40	66.7	
Educational Level			
No Formal Education	22	36.3	
Primary	20	33.3	
Secondary	10	16.7	
Tertiary	8	13.3	
Rearing Experience			
Below 5	4	6.7	
6 – 10	10	16.7	12.2
11 – 15	30	50	
Above 16	16	26.6	
Extension Services			
Yes	20	33.3	
No	40	66.7	
Access to Credit			
Yes	40	66.7	
No	20	33.3	
Organization			
Yes	35	58.3	
No	25	46.7	
Household Size			
1 – 3	2	3.3	
4 – 6	25	46.7	9.6
7 – 10	15	25	
10 and above	8	13.3	
Distance from pig house			
1 -200metre	6	10	
201 – 400 metres	18	30	72.5metres
< 400 metres	36	60	

Source; Field Survey, 2018.

Table 2 showed that 91.7% of the respondents were males and 8.3% were females. This implies that males engaged in pig production than females. Labour intensiveness of pig production and management is labour intensive and may possibly be accomplished by males whom are endowed with sufficient strength (Abiola, *et al*; 2015). As well, most of the respondents (66.7 %) were above the age brackets of 40 years, while 33.3% were below 40years of age. This implies that most of the respondents were aged people. Age correlates with experience, which could help such farmer to set realistic goals towards efficient pig production that will abate environmental degradation of its vicinity (Ume, *et al;* 2018). Furthermore, most of the respondents (63.7 %) were educated against a*priori* knowledge that most farmers in the developing countries are illiterates. Nevertheless, only 36.3% had no formal education. Education makes farmers receptive, prudent in resources and risk averse in adopting innovations that could dissuade pollution of the environment as result of the piggery business (Steinfeld *et al.,* 2014). The findings of Ume, *et al*; (2018) concurred to the assertion. Beside76.6 % of the respondents had rearing experience of 10 years and above, while 23.4% had below 10 years. The mean of years of experience was 12.4. The number of years of farmers' rearing experience equipped the he or she with the necessary management skills to withstand certain innate pig management problems which has high propensity to pollute the environment. Rahman, *et al*; (2008) opined that years of rearing experience improves farmers' resource managements. Additionally, 66.7% of the respondent had no contact to extension services and 33.3% had .access The poor extension outreach could be ascribed to negligence of change agents to their duties of innovation dissemination, thus predisposing the farmers to risks and uncertainties to their health and their immediate environs (Ewuziem, *et al*; 2009).

Additionally, majority (66.4%) of the respondents had access to credit, while 33.6% had no access. Credit facilitates the farmers in procuring necessary feed ingredients in practicing precision feeding management and in purchasing waste disposal equipment in their pig farms in order to lessen environmental pollution through reduced odour (Ezeibe, 2010). Beside, 58.3% of the respondents were members of farmer' organization, while 46.7% were not. Membership of organization through cross fertilizations of ideas could enhance their efficiency in pollution management in their pig business (Ume, *et al*; 2018). As well, 86.7% of the respondent had household size less than 10 persons, while 13.3% had above 10 persons. The implication is that since the household size is relatively moderate, that the farmers may not spend much of their income in consumption but save a significant amount in procuring the necessary inputs to enhance their efficiency in pig managements in order to decrease possible pollution of the surrounding (Pond and Maner,

1994). Table 1 shows that majority (60%) of the respondents had their pig farms located between 500m and above to residential houses, whilst, only 40% do not. Literatures showed that houses that allocated to the appropriate distance of 5000 metres are less predisposed to pig mismanagement nuisances, included proliferation of flies, rat, noise and odour (Steinfeld *et al.,* 2014)

Environmental Effect of Pig Farming

Here the results of environmental effect of pig farming as reported by the respondents were presented and discussed in Table 3.

Table 3: Distribution of Respondent According to Environmental Effect of Pig Production

Environmental effect	Frequency	Percentage %
Odour	46	76.7
Noise	44	73.3
Flies	34	56.7
Mosquitoes	23	38.3
Rats	12	20.0
Dust	10	16.7
Total	60	100.0

Multiple Responses.Source: Field Survey, 2018.

Table 3 shows that 76.7% of the respondents complained that odour from pig farms constituted the major environmental annoyance to the respondents (workers and neighbourers to pig farm). Indeed, literatures show that odour from pig pen is not caused by a single compound, but it is rather as result of large number of compounds including ammonia (NH_3), volatile organic compounds (VOCs) and hydrogen sulphide (H_2S) ((Le, 2009); Steinfeld *et al.,* 2014). The emission of odours from pig house according to Le, (2009) mostly depends on the frequency of animal-house cleaning, on the temperature and humidity of the manure, on the type of manure storage, and on air movements.

Furthermore, 73.3% of the respondents complained about noise. Beside, causing hearing loss, it can also result in psychological and possibly physiologic damage to respondents bodies (Aarnink, 2007). The noise in pig pen according to Gekara *et al*., (2009) may possibly arisen during pig mating, feeding and clashing of farm implements in the pen. In addition, 56.7% of the respondents complained about flies around their environment. Powers *et al.,* (2011) reported that flies are widespread when the animal waste is wet and

might transmit diseases such as cholera, dysentery, typhoid, filarial, and dengue fever to the respondents. Also, 38.3% of the respondent complained about mosquitoes proliferation in the area. Mosquito breeding is common especially where the animal waste is wet condition and this is responsible for malaria disease as frequently complained by respondents living within the vicinity (Le, 2009). Moreover, 20% of the respondents complained about rats breeding. This animal thrives on the stored animal feeds and capable of attacking household belongings in the environs (Steinfeld *et al.,* 2014) .The careful use of rat poison, cat and trap are often recommended in order eradicating this menace. Finally, 16.7% of the respondent complained about dust. Dust is generated from feed, manure and animals themselves (Steinfeld *et al.,* 2014). The determining factors to the amount of dust in pig pen are cleanliness of the building, animal activity, temperature, relative humidity, ventilation rate, stocking density, and feeding method (Le, 2011; Power, *et al*; 2011)

Pig Management Technologies

The result of pig management technologies is presented in Table 4

Table 4: Distribution of Respondents According to Pig Management Technologies

Technology	Frequency	Percentage	Ranking
Proper housing	50	83.3	1st
Proper manure disposal	38	63.3	2nd
Precision feed management	30	50	3rd
Proper disposal of animal carcass	25	41.7	4th

*Multi responses

Source; Field Survey, 2018

Table 4 shows that 83.3% of the respondents used proper pig housing in curtailing environmental pollution and ranked first. Le, (2011) reported that pig pen should be tidy with good ventilation system, good floor design and dust control. Proper design of the floor according to Okoli, *et al* (2011) could have large impact on the odour generated from a swine building as solid concrete floors with scrapers or small flushing gutter tend to increase the production of odour. On dust control, (Aarnink, 2007) reported that internal pig building surfaces should be well cleaned, disinfect all the interior surfaces and add oil to swine ration in order to reduce dust. In addition, 63.3% of the respondents used proper manure disposal. Ajala, and Osunhor, (2004) reported on the need to collect and remove manure from the building as often as possible in order to reduce odour accumulation through ammonia built up in the environment. Also, 50% of the respondents used precision in feed management

technology. Literatures (Rademacher, 2009, Lee, 2009 ; Gekera, et al 2009) stipulated that precision feed management involves among others formulating feed nutritional requirement of pigs for different production and growth stages of pig in order to reduce the amount of nutrients excreted by the animal using good quality, uncontaminated and use of low phosphorous diets. Finally, 41.7 of the respondents used proper disposal of animal carcass as method of reducing the effect of pig production on the environment. This is because improper disposal of animal carcass is capable of causing air and water pollutions. Okolo, (2011) reported the methods of disposing carcass included burning, incineration, composting and rendering.

Waste Disposal Methods

Table 5 Distribution of Respondents According to Waste Disposal Methods

Waste disposal methods	Frequency	Percentage
Open lagoons	50	83.3
Dumping in the farm	38	63.3
Heap waste and burn	23	38.3
Stores in bags	45	75

*Multiple Responses.

Source; Field Survey, 2017

Table 5 shows that 83% of the sampled farmers dump their pig wastes in lagoons in their farms. From the lagoons, sales can be made to farmers who could use it for soil amendment in order to boost their crops productivity. This is because pig dung is rich in nitrogen, potassium and phosphorus (NPK) and other trace elements like copper and magnesium that are essential for plant growth. The problems with use of lagoon are that very often air and water pollutions are very prevalent. This is perhaps due to the fact that most lagoons do not have lid cover, thus leading to proliferation of odour to the environs (Okoli, 2011). Furthermore, most lagoons are not well constructed that seepage of some of the nutrients such as nitrogen from the waste into the soil and nearby water bodies leading to death of soil and aquatic organisms through eutrophication (FAO, 2008). In addition, Also, pig manure has lots of nitrogen, which may be harmful to plant cell, as well result in methemoglobinemia, a blood disorder in infants, known also as "blue baby disease", if the contaminated water is consummated by humans (Ume, *et al*; 2018). Also, 75% of the respondents store their wastes in bags with the mouth tied. This method helps to checkmate problem of spreading of odour and building of rodents, flies and mosquitoes especially if the waste is damp (Gekera, et al 2009). Moreso, 63% of the respondents dumps their wastes in

the farm. The pig wastes, just like other animal wastes if not properly incorporated into the soil could pollute the environment with odour and other nuisance, including flies and mosquitoes, which can spread diseases such as cholera, dysentery, typhoid, malaria, filaria and dengue fever (Rahman, *et al*; 2008).

Socio-Economic Characteristics and Technology Adoption

The effect of the pig farmers' socio-economic characteristics on their technology adoption decision using probit Regression Model were discussed below.

Table 6: Probit analysis Result on Socio-Economic Characteristics and Technology Adoption.

Variable	Coefficient	Std. Error	Z	Marginal Effect
Constant	1.791	0.130	13.777***	2.055
Age	0.633	0.112	5.652***	0.210
Educational level	0.0013	0.0012	0.108	0.002
Household size	0.441	0.202	2.183**	1.003
Farming experience	0.223	0.234	0.952	0.023
Extension contact	0.615	0.081	7.592***	0.009
Organization	0.879	0.252	3.480***	0.221
Off farm income	2.007	0.619	3.242***	0.000
Access to credit	-0.871	0.326	-2.671**	0003
No of observation	120			
LR chi^2 (19) =	79.32			
Pseudo R^2	0.6721			
Probit > chi^2	0.0526			
Log likelihood	-59.657284			

*,**and*** implies significant at 10%, 5% and 1% respectively, figures in parentheses are the t-ratio

Source; Field Survey: 2018

The coefficient of age of household head was positive to technology adoption in contrast to aapriori expectation and significant at 1% probability level. The affiliation may perhaps be owing to the concept that old age is often associated with long years of farming experience and experimentations which might positively influence their adoption decision process (Adeshinwa and Ogunmode, 1995). The findings of Ironkwe and Amefule, (2011) and Rhman, *et al;*, (2008) concurred to the above assertion but Umeh, *et al*,(2015) result digressed. They were of the opinion that as farmers become older, they become less energetic, unable-bodied and less active and cannot supply the much needed farm labour in the management of pig production enterprise. More so, this farming group in the opinion of

Adetunji and Adeyamo, (2012) cannot withstand the rigors and stains in pig production and as well often risk averse to adoption of technology.

The coefficient of household size was positive and statistically significant at 10% probability level. This implied that as household size increases, adoption of improved pig production/management technologies also improves. Family size is an important socio-economic characteristic as it often determines how much family labour will be put into use on the farm and also determines the extent to which a household is able to respond to innovative change. Large household size implies proxy of cheap labour in implementing improved technological changes in pig management (Gekara *et al*., 2009). Nevertheless, the findings of Ikani and Datwang, (1995), Bamiro, (2008) and Ume *et al*., (2017) did not concur to the sign identity of the coefficient. They were of the opinion that when the household members are of dependent population (children and old age), the high the propensity to consume compares to save for further investment. This is owning to the fact that such household head needed more money for upkeep of the family members.

Against expectation, the coefficient of access to credit use was significant and had negatine influence on the adoption of pig management technologies in abating environmental pollution usually associated with pig production. The negative sign of the coefficient could be associated with the diversion of agricultural credit to nonfarm uses (Ajala and Osunhor, 2004). Also,Ikani and Datwang, (1995) was of the view that the sign identity of the coefficient could be linked to poor access to credit by the farmers, which is of great disincentive to agricultural development. However, the findings of Aarnink, 2007) did not concur to the aforementioned relationship. He opined that credit use is expected to assist farmers to purchase necessary inputs which could aid in adoption of pig technologies in order to curtail minimally odour and other environmental effects associated with pig mismanagement. Besides, the coefficient of membership of organization had a direct relationship with technology adoption in correspond to the findings of Ume, *et al;* (2018) and Rahman, *et al*; (2008). They opined that apart from exchange of thoughts among cooperators on information relating to environmental pollution, organization, might train her members in the same subject matter using professionals in that field of study.

Aligned with anticipation, the coefficient of access to extension services was positive to several studies (Duniya, *et al*; 2003; Bamiro, 2008; Umeh, *et al*; 2015; Ume, *et al*; 2018) and significant at 5% alpha level. Extension services support pig farmers in improving their rearing techniques aimed at not only for environmental sustainability but in enhancing their production efficiency and income, improving their wellbeing and elating the rural

dwellers' social and educational values (Adetunji and Adeyamo, (2012). Nevertheless, Abiola, *et al*; (2015) had a negative sign identity of the coefficient in their study. They attributed that to factors limiting the adoption of technologies, included negative attitude of extension agents, high cost of improved inputs, lack of market and among others. The coefficient of off-farm income had a direct correlation to technology adoption 99% confidence level. Off- farm income activities as reported by Ezeibe, (2010) helps farmers in off setting their financial liquidity problem that could be used in procuring obligatory inputs that might propel technology adoption.

Choice of Management technologies Practices by Pig Farmers

The factors influencing the choice of waste disposal method by pig farmers using Multinomial Logistic Model were discussed presented in Table 7.

Table 7 Multinomial Logistic Regression Estimates for the Choice of Management technologies Practices by Pig Farmers in the Study Area

Variable	Proper Housing	Proper manure Disposal	Precision feed management	Proper disposal of animal carcass	No adoptionarmion
Constant	-23.232789[-0.01]	-9.643218[-2.13]	3.480675[2.46]	4.58006(0.56)	2.356333[1.32]
Gender (Dummy)	43. 690980[0.04]	1.446610 [1.17]	0.4678923[0.62]	7.28864(0.62)	-.250354[1.006]
Age(year)	5.6389087[2.10]**	-1.0687439[-0.12]	-6.087314[-1.62]*	- 3.59380[0.54]	-3.150865[1.06]*
Education(Years)	-12.0881[0.17]	0.218937 (0.28)	0.8631031(0.32)	0.522472[1.31]	3.322752[1.24]
H. hold size(No.)	-31.00446[-0.01]	2.143515[1.76]	-1.5674631[-0.39]	-1.80528[2.112]	2.054060[1.46]*
Experience(Years)	42.2705009[0.00]	2.43609[0.34]	1.5020299[1.56]*	2.338905(3.64)***	5.226301[1.52]**
Number of pigs[No.]	-17.34009[-0.02]	2.003733[1.44]*	-1.550097[-2.27]**	-1.229009[0.28]	5.110366[2.26]
Farmers organization [Dummy]	-10.2179087[-1.036]*	3.11120987[0.27]	2.6540947[2.28]**	2.0081987[0.26]	2.76516789[.1.00*]
Extension services	-12.0862456[-0.01]	0.00878[0.21]	0.17897062[0.27]	2.4509017[0.26]	1.167390[0.22]
Distance residence	-6.45432[-0.00]	-2.3727652[-1.05]	-2.598435[-0.3.54]***	12.0287436[0.02]	-1.2909230[0.09]

Log likelihood = -58.3678540

Pseudo R2 = 0.5231

LR chi2(60) = 82.17

Base outcome = adequate waste storage facilities. ***, ** and* shows significant at 1%, 5% and 10% levels of probability respectively. Figures in bracket represent z-values.

Source; Field Survey; 2018

The result of multinomial logistic model shows that the factors affecting the choice of adoption of adaption coping strategies by pig farmers in the study area. Table 3 shows that

the factors affecting the choice of adopting of adaption coping strategies introduced into multinomial logistic model, visa via proper housing, proper manure disposal, precision feed management and proper disposal of animal carcass. The likelihood ratio statistics was indicated by statistics R^2 (-52.31) and was significant, signifying the high explanatory power of the model. The coefficient of age of the household had indirect relationship with the choice of management technologies by pig farmers and significant at 5% alpha level. This connotes that as the farmers are advancing in age, the probability of adopting management technologies in pig production using precision feed management and proper disposal of animal carcass. This could be because at old age, they may not be able to withstand the rigors and stains in pig production (Ume, *et al*; 2018). Similarly, Adetunji and Adeyamo, (2012) described old people to be less motivational, innovative and adaptive individuals. In addition, coefficient of the years of rearing experience had a positive and significant effect on all the management technologies with exception of proper disposal of the carcass in surmounting the consequences of environmental pollution as result of pig rearing. Literatures inferred that farmers with long years of rearing experience are capable of being efficient in resource utilization and setting realistic plans in prevail over environment pollution as result of their piggery business (Ume, *et a;* 2018). Surprisingly, the coefficient of farmers' membership of organization was negative and had significant effect in adapting of management technologies practices of all the technologies excluding precision feed management in order to curtail air, soil and water pollutions linked to inefficient management of pig production. The negative sign of the coefficient could be a function of the fact that members of the association may be overwhelmed with the organizational activities to the detriment to their pig business, resulting in filthy environment with odour, rampant breeding of flies and rodents (Lee, 2009). Nevertheless, the finding of Adetunji and Adeyamo, (2012) contradicted the above assertion, as. they opined that organizations aid her members in having access to information on improved innovations on abating environmental degradation as result of pig production and access to credit in acquiring production inputs for efficient management and payment of labour.

Against expectation, the coefficient of the educational status of the respondents also had a negative and significant effect on all the management technologies practices aimed at suppressing environmental effect of pig production. The sign identity of the coefficient could be associated to the negative attitude of the educated people to agriculture in preference to white collar job [Ume, *et al* 2018]. However, Osondu, *et al*; (2011) reported that education helps to release the innate ability and intrinsic innovativeness of the farmer in order to be compliant to the need of altering state of affairs. The coefficient of extension services had

positive relationship with the choice of management technologies by pig farmers. The positive sign of the coefficient could prompt in the adopting of proper housing, proper manure disposal and precision feed management in checkmating pollution in pig production. Extension services facilitate in farmers' adoption of innovation on pig production and management technologies and as well provide technical assists to that effect, thus reducing environmental pollution as result of the animal production (Ume, *et al*; 2018).

Adoption of Adaptation coping Strategies to Climate Change

Table 8: Varimax-Rotated Factors Affecting Adoption of Adaptation coping Strategies to Climate Change in the Study Area.

Constraining Variables	Factor 1	Factor 2	Factor 3
poor access to extension services	0.324	0.250	0.231
Poor Access to Land	0.347	0.347	0.320
Experience	0.361	0.363	-0.442
High cost of Labour	0.190	0.238	0.434
Drug problem	0.218	0.172	0.312
High cost of transportation	-0.126	0.420*	0.205
Veterinary post	0.219	-0.302	0.125
Poor access to credit	0.316*	-0.264	0.218
Housing problem	0.146	0.359	0.129

Source: computed from SAS 2018.

Only variable with factor loading of 0.30 and above at 10% overlapping variance were used in naming the factors.This is line with the finding (Ume, et al 2018) who were of the opinion that varibles with factor loading of less than 0.30 and variables that loaded more than one factor were discarded. Variables that loaded more than one factor like access to land and no experience were revealed. In identification of the variable, Ume, et al (2018) stated that each factor is given a denomination based on the set of variables or characteristics it is consist of. Constraints under the economic /institutional factor include poor access to credit (0.316), poor access to extension services (0.324) and pests and diseases (0.304). Poor access to credit constituted great hindrance to pig production in the study area. Ezeibe (2010) reported that credit facilities in the adoption of improved pig management technologies, encourage capital formation in procuring technological material inputs and improves production efficiency of pig production aided at lessening the environmental risks, in form of pollution associated with the production. Additionally, the negative attitude of the change agents to their duties, irregular payment of salaries and

other incentives and wide ratio of extension agents to farmers may perhaps be liable for decrease in their effectiveness and efficiency (Bamiro, 2008). More so, the problem of pest and disease such as mastitis, brucellosis, swine fever, dysentery and coccidiosis are causing vicious cycle of poverty among pig farmers. For instance, Abiola,,(2015) reported that African swine fever is a major disease threat to pig production in the tropic as it account for a substantial decimation of pigs, especially piglets in many countries in sub Saharan Africa.

Variables that loaded under factor 2 (infrastructural factor) included; high cost of transportation (0.420), housing problem (0.311) and veterinary post (0.317). The problem of housing of pigs is thing of concern in most rural areas in Africa. For instance, in the study area, pigs are housed in unconventional houses that are poorly ventilated, inadequately floored and poorly located items of the direction of wind, hence may perhaps aggravate odour. Adequate housing of pigs helps to guide the animal against adverse temperature and relative humidity especially to piglets, hence curtailing their mortality and lessening odour emission from pig pen through adequate ventilation (Ajala and Osunbor, 2004). In addition, problem of poor road network could be linked to deplorable conditions of our roads especially our rural and farm roads. The roads in many areas are impassable especially during rainy season. This situation does not only impair greatly the evacuation of pig output to urban areas but as well the inputs into the rural area (Ironkwe and Amefule, 2011). Besides, most government veterinary posts are situated in urban areas in most developing countries, thus limits greatly the farmers access to its services. The few veterinary posts in the rural areas, the veterinary personnel in charge is living in urban area and occasional comes up to show face and depart immediately The veterinary private sectors in the rural areas extort mercilessly these poor resource farmers, consequently most of them restored to use Indigenous Known Technologies (IKT), which often reported by literatures to have low potency (Babatunde and Fetuga, 1990)

The constraints under the socioeconomic factors were pests and diseases(0.304); high cost drug (0.312) and high cost of Labour (0.434). The problem of veterinary drug constitutes a clog in the wheel of development of livestock sector of agriculture in many developing countries. For instance, the drugs are very costlier, often adulterated and sub-standard and low potency of the vaccines as they are not kept in cold chain, thus affecting adoption of related technologies by the farmers. (Ume, *et al;* 2018).In addition, piggery enterprise is very labour intensive, especially where unconventional house is used in the business compare to where they are reared under adequate housing. Unfortunately, very

many labourers detest working in piggery farms for fear of being bitten by the animal, which never be, Thus, the few that agree to work there charges very high

As conclusion and recommendation, the result of farmers' socioeconomic characteristics showed that most of the farmers were aged, educated, had large household size and member of organizations. In addition, the effect of pig production on the environment were odour, noise, flies, dust, mosquitoes and rodents. Additionally, proper housing, proper manure disposal; precision feed management and proper disposal of animal carcass were the pig management technologies adopted by the farmers in the study area. More so, open lagoons, dumping in the farm, heap waste and burn and store in bag were the waste disposal methods employed by pig farmers. The result of probit analysis, also revealed that the determinants to pig management technologies adoption were age of household head, extension services, and membership of organization and off – farm income activities. As well, the determinant factors influencing the choice of adopting of the management technologies against environmental pollution were rearing experience and extension services The limiting factors to technology adoption were poor access to credit, poor housing, extension services, disease problem, drug, high costs of labour and location of veterinary posts in the urban area

Based on the finding the following recommendations were proffered;

1. National veterinary research institute in Vom plateau State should be adequately funded to ensure sufficient availability of veterinary drugs and vaccines that are localized to our environment, instead of importing of drugs and vaccines that are partially adaptive to our local conditions.

2. Farmers' access to credit through microfinance banks, commercial banks and other credit facilities by government agencies concernedand nongovernmental Organisation (NGO) should be ensured.

3. There should be balance between animal's genetic potential and the quantity of nutrients consumed, since most of the nutrients (Protein (nitrogen/amino acids) and minerals like phosphorous (P), Cupper (Cu), and Zinc (Zn), although essential for animal development but their excretions are capable of constituting hazards to the environment.

4 Pig wastes should be managed and disposed off in accordance with rules and regulations of Federal Environmental Protection Agencies (FEPA) to avoid the action possessing

hazardous situation to the environment in order to ensure an environmental balance and safety.

5. The recycling of pig manure is of paramount important, since it is a cost-effective way to checkmate the environment degradations associated with the manure .

6 The proliferation of flies and mosquitoes can be restricted by curtailing the exposure of the surface of manure in contact with air and lessening the water content of the litter through the inclusion of hydrophilic materials like saw dust, rice husk and among others.
7Dead animals should be properly buried or burnt to prevent the risk of contaminating the environment.

.8. There need to reduce odour ion poultry house through amomg others;

(a)Spoiled feed should be spot through regular inspection in order to minimize odour in pig house and its' environs.

(b). The need to wash the pen floors regularly or use slotted floors to keep animals clean in order to reduce odour is essential

©. There is need to collect and remove manure from the building as often as possible in order to reduce odour accumulation in the environment.

(d) infuse slurry manure or sludge into the soil to forestall odour that might generate by that.

. (9) Proper and timely maintenance of feeders, augers, and other feed handling equipment is required for proper dust control.

(10) Extension personnel should be well equipped with information regarding pollution management through seminars, workshops, conferences and other forms of educational programs. More so, extension personnel's efficiency and effectiveness in discharging their duties through payments of their incentives, other out of pocket expenses as at when do and provision of the necessary logistics required in accomplishment of their assigned responsibilities

(11)Farmers should be encouraged to join or form cooperatives in order to have access to government amenities such as credit, improved inputs, technical assistants from government agencies concerned and among others in order alleviate some of their problems, perhaps environmental management in pig production. Also cooperatives are

capable of giving training and technical assistants to her members on issues bothering the environmental sustainability without their productive efficiencies compromised.

(12)The need for government and non- governmental organizations to provide source sof off farm income activities to the farmers through embarking into serious rural infrastructural and industrial developments.

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Received: 18th August 2020; Accepted: 16th March 2021; First distribution: 12th March 2022.

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