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Sustainability of Greenhouse Gas Emission Reduction Practices (GHGERPs) Usage: Evidence from Commercial Chicken Farms in Nigeria

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A R T I C L E I NFO

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ABSTRACT

Production of chicken in Nigeria moved to a larger scale with the ban of poultry product importation in the 2002. This has triggered the emission of greenhouse gases; resulting to environmental degradation due to climate change. An increased in chicken production and the droppings from commercial farms have a direct relationship with the greenhouse gas emission and this constitutes a major source of both environmental, social and health issues. This necessitates the reduction practices of greenhouse gas emission among commercial chicken farms. Therefore, this study assessed the sustainability of such practices in commercial chicken production with a view to unvailing the sustainability status of farms with respect to the practices. Structured and validated questionnaire with a reliability value of 0.72 was used to collect the cross-sectional data used for the study, through a two-stage sampling procedure to sample 349 commercial chicken farms in north central and south west geopolitical zones in Nigeria. Sustainability index and binary logistic regression were used to analyze the data. Test of significance were carried out at 5% level. The findings showed that the mean sustainability index of 0.47 was not sustainable as most of the farms practices of reducing greenhouse emission were categorized as unsustainable. However, it was observed that access to credit; capital investment and size of farms were the significant determinants of the level of sustainability at 95% level of probability. It was recommended that government should encourage more investment in chicken production and facilitate access to credit in order to improve the status of sustainable greenhouse gas emission reduction practices.

Introduction

The Nigerian livestock industry is the most commercialized subsector of the agricultural sector of the economy (Ogunsina and Taiwo, 2019), thus, it provides employment opportunities to various categories of people (Agricultural Transformation Agenda, ATA, 2012, Emokaro and Erhabor, 2014). According to the United States Department of Agriculture (2003) and Heise, Crisan and Theuvsan (2015), the poultry industry is the most active sector and the mainstay of the livestock sector in Nigeria. Similarly, Bamiro, Ajiboye and Adeyonu (2017) opined that in addition to poultry contributing to Nigeria's Gross Domestic Product (GDP) and providing employment, it is also a major source of cheap protein through the consumption of eggs by old and young. The most popular of the domesticated birds in the poultry family is chicken. Others are turkey, quail, pigeon, peafowl, ostriches, pheasants and other game birds. Chicken farming is basically the rearing of birds either for table meat or egg production. In both cases, the nutritional derivation is unitary, and it is protein. It has been argued by Kim and Self (2013) that the societal desirability and the market acceptability of a product is a function of its usefulness and cultural barrier if any. Interestingly, in case of chicken, the secular mix of the Nigerian society does not bear any indication against the consumption of eggs or meat.

Owing to the general acceptability of chicken products and the enterprise, many people derirve their livelihood from it. Hence, many commercial chicken farms are found across Nigeria. In terms of employment figure, Akpan (2020) stated that over 20 million people are directly or indirectly employed into the poultry sub-sector of the agricultural sector and by this; the sector contributes about 21% to the Nigerian GDP. According to Africa Sustainable Livestock 2050 (2018), chicken production in Nigeria amounts

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up to 454 billion tonnes of meat and 3.8 million tonnes of eggs per year with a standing population of 180 million birds. About 80 million chickens are raised in extensive systems, 60 million in semi-intensive systems and the remaining 40 million in intensive systems. With the huge chicken population and considering the number of commercial chicken farms in Nigeria, practices that reduce Greenhouse gas emission are being utilized in order to reduce the impact of climate change through the emission of this gas that is poisonous to the chicken birds and to humans.

The efforts by the commercial chicken farms engaged in Greenhouse Gas Emission Reduction Practices (GHGERPs) to yield remarkable outcomes in the reduction of greenhouse emission will lead to the reduction in the adverse effect of climate change. This will eventually translate to a cleaner air, environmentally friendly status of the poultry farms which will lead to an improved health, sustainable profit and reduction in the mortality of flocks. The reduction in greenhouse gas emission is one of the Sustainable Development Goals (SDG) 13. Similarly, the Food and Agriculture Organisation (FAO, 2010) crafted the Climate Smart Agriculture (CSA) idea on three pillars; increased sustainable farm productivity, enhanced resilience of agriculture and food security system and the reduction of greenhouse gas emission. The Nigerian government 2016 Agricultural Promotion Policy (APP) road map also known as the Green Alternative was however hinged on the third pillar of the Climate Smart Agriculture (Ifeoma, 2019).

Dunkley and Dunkley (2013) and Im *et al.,* (2020) stated that; there are some practices used worldwide in chicken production to reduce greenhouse gas emission. Some of such GHGERPs include; use of good quality feed, use of enclosed pens, greenhouse gas emission friendly energy use which is term energy use reduction, use of circulatory fans, use of radiant heating system, use of spark ignition brooders, use of fluorescent or LED lights and the use of drum composter. Here in Nigeria, in addition to the aforementioned practices are the use of digestive enzymes in chicken feed, use of larvicides, use of energized water, use of wood shavings and the application of alternative sources of digestible protein. (Dunkley & Dunkley, 2013) and this assertion was supported by the preliminary investigation.

With the size of the chicken industry in Nigeria growing and the attendant challenge of the greenhouse gas emission, one major issue that is emerging is how to sustain the GHGERPs in order to achieve healthier and cleaner lives. Sustainability in this context is meeting the need of the present without compromising the ability of the future generations to meet its own needs. In line with this study, sustainability means commercial chicken farms will operate in a way they will emit greenhouse gases in order not to affect futher generational to peoples' health, environmental degradation like climate change and global warming among others. Sustainable practices are the management of natural resources to prevent their depletion or the destruction of the environment which not only affects the productivity of the birds but also it affects humans. Therefore, the sustainability of the greenhouse gases reduction practices worth investigating so as to ascertain the economic and environmental implications.

Statement of the Problem

The Nigerian government in 2002 placed a total ban on the importation of some poultry products like day old chicks, eggs and frozen chicken. The ban was aimed at boosting internal production and self-sufficiency through domestic production. The ban also led to the review of the general livestock policy. However, Liverpool-Tasie *et al* (2017) reported that there is the existence of chicken importation despite the ban in 2002 by the Nigerian government, which has also opened a huge potential for its domestic production. This spur in domestic chicken production has come with its own environmental issues which are climate change related. However, a direct relationship with increased production is the increase in the emission of greenhouse gases.

The droppings from commercial chicken production constitute a major source of greenhouse gas emission. The large amount of pullet and broiler birds being produced in Nigeria has resulted to the monumental emission of greenhouse gas and it has been reported that the highest carbon dioxide (CO_2) amounting to about 1,665.342kg comes from manure, while the highest methane

(CH_4) amounting to about 126,207.84g comes from the feeds and the highest nitrous oxide (N_2O) amounting to about 20,316.87g comes from the beddings in modern broiler commercial chicken farms (Suffian *et al,* 2018). The emission of these gases has been confirmed to be dangerous. However, it is believed that, greenhouse gases are induced substances in the atmosphere (Franzluebbers *et al.*, 2015; Global Research Alliance on Agricultural Greenhouse Gas, 2015). The atmosphere contains a lot of heat confined in it as a result of enourmous levels of carbon (iv) oxide (CO_2) and other heat-trapping gases that prevent it from releasing heat into space thereby, creating a phenomenon known as the

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"greenhouse effect" (Aiyeloje, 2021). The short-wave energy from the sun is trapped and re-emitted as heat, producing long wave radiation which will increase atmospheric temperature (MacCarthy *et al.*, 2018).

The other primary gases responsible for causing the greenhouse effect are ammonia (NH_3), sulphur hexafluoride (SF_6), perfluorocarbon (PFCs) and hydrofluorocarbons (HFCs). In 2010, the emission of CO_2, NO_2 and CH_4 translated to 66.5 percent, 17.2 percent and 15.4 percent of the global greenhouse gas emission, respectively (MacCarty *et al*, 2018). Dunkley and Dunkley (2013) stated that for every pullet birds and every ton of broiler bird produced, certain amount of greenhouse gas (1kg of nitrous oxide, 11kg of ammonia, 1 kg of methane, some amount of carbon (iv) oxide as well as hydroflorocarbon are being emitted into the atmosphere.

According to With (2013) and Caro *et al.*, (2014), cattle, chicken, buffalo, pigs and small ruminants also emit greenhouse gases but in all of them the N_2 emission effect from poultry is higher than other ruminants. Apart from climate change variables, air and water pollution, biodiversity loss and land degradation, the other known major greenhouse gas emission contributors are; the commercial chicken farms (Dunkley and Dunkley, 2013; Kumar & Chakabarti, 2019; Yona *et al.*, 2020). There is a change in climate with increasing global temperature which now has negative effects on how the fauna and flora survive as a result of the outcome of greenhouse gas emission (Hiraishi *et al.*, 2014). Therefore, poultry farms must adopt practices that would reduce the future impact of the currents practices that are being used to reduce the volume of greenhouse gases released in poultry farms in Nigeria.

This necessitates the reduction practices of greenhouse gas emission among commercial chicken farms. Some of the farms are deliberately of inadvertently engaging in some practices that tend to reduce the effect of these emissions on the environment (Dunkley, 2012). Though, studies on the investigation of the sustainability of these practices are scanty in literature. Hence, this study was conducted to investigate the sustainability of greenhouse gas emission reduction practices showing evidence from commercial chicken farms in Nigeria. Specifically, the study examined farm characteristics, analyzed profitability and isolated factors that determine sustainability of the GHGERPs in the sampled commercial chicken farms in Nigeria with a view to unraveling the sustainability of the use of the practices.

Methodology

Brief Description of the study area

The study was carried out in Nigeria. It is geographically divided into two: Northern and southern regions. For this study, it specifically used North Central and South West zones with two states each from the selected regions; these are: Kwara and Plateau in north central and Oyo and Ogun in the southwestern zone based on the fact that these identified states are the major hubs of chicken production. The choice of Kwara and Plateau out of the six States of the North Central and Ogun and Oyo out of the six States of from the South West was because from the Poultry Association of Nigeria (PAN) register, the States have more numbers of commercial farms where chicken birds (broilers and layers) are raised.

Sampling Procedure and size

Structured and validated questionnaire was used to collect the cross-sectional data used for the study through two-stage sampling techniques described as follows: The first stage involved a purposive selection of the North Central and South West zones which are the major commercial chicken production hubs in Nigeria from the PAN registers. At this stage, Krejie Morgan (1970) sample size table was used to select statistically represented sample at 5% level of probability. At the second stage, a proportionate-to-size random selection of 380 commercial chicken farms from the two zones using the register of PAN as the sampling frame was obtained. At the end of the data collection, about 31 copies of the questionnaire meant for 31 farms were dropped during the cleaning of the data because they were not properly filled by the farm managers from glaring facts and perceived exaggeration of information provided. This gave the response rate of 91.8%. The farms served as the unit of analysis but the farm managers provided information on the farm visited with the use of questionnaire.

Method of data collection

This study used primary data obtained from cross-sectional survey of commercial chicken farms with the aid of a well-structured questionnaire. The questionnaire with a reliability coefficient of r = 0.72 using Spearman Rank Order Correlation was found reliable. Data were collected on socio -economic characteristics of farms, farm size, amount and cost of feed, veterinary drugs, vaccines, labour, other variable cost, prices of crates of eggs and kilogram of meat, return to chicken production per 1,000 birds per cycle based on extent use of GHGERPs as well as the

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classification and determinants of sustainability of the use of GHGERPs. These were complemented with the commercial chicken farms groups' checklist and were administered through the participatory approach using Focus Group Discussion (FGD) sessions and Key Informat Interview (KII) to validate some of the findings from the data collected with the use of questionnaire.

Method of Data Analysis

Sustainability index and binary logistic regression were used to analyze the data. Test of significance were carried out at 5% level.

i. Classification of Sustainability of Use

The classifications of sustainability of use of GHGERPs were achieved with the aid of a sustainability index. This was calculated by assessing the four sustainability statements of the study which were derived from three statements of the economic sustainability; what is your view on the effect of the practice on reduction in the cost of production? To what extent does the usage of practice increase the weight of birds? To what extent does the usage of practice affect mortality of birds? and one statement of the environmental sustainability; what extent does the usage of practices affect smell in the farm? were used. Thereafter, weights were assigned to the statements on a scale of 1---5 with 1=very low, 2=low, 3=moderate, 4= high and 5= very high. The total responses of all the commercial chicken farms managers were collated to give a total weight. The first three statements of the economic sustainability were multiplied by 5, which is the highest weight attained by the farm managers to get 15. The commercial chicken farms manager individual scores were gotten by adding them together which was thereafter divided by 15 to arrive at the individual index for the farm managers. The indexes for the individual managers were summed together to get 0.77. For the environmental, the only sustainability statement was multiplied by 5 which is the highest weight attained by respondents to get 5. Just as with the economic sustainability, the individual scores of the farms were added together and thereafter divided by 5 to get the individual index for the commercial farm managers. The manager's individual index was summed together to get 0.22. The sum of 0.77 and 0.22 gave a figure of 0.94 for both the economic and environmental sustainability. This was further divided by 2 to get the average of 0.47 as the sustainability index for the study. This was used for the classification.

ii. **Binary Logistic Regression**

Regression methods have become an integral component of any data analysis concerned with describing the relationship between a response variable (outcome or dependent) and one or more explanatory variables (predictor or independent). It is often the case that the outcome variable is discrete taking on two possible values. Binary discrete phenomena usually take the form of a dichotomous indicator or dummy variable with values of 1 and 0. The dependent variable takes the value of 0 and 1 but the predicted values for regression take the form of mean proportions or probabilities conditional on the values of the independent variables.

The binary logistic regression is a type of regression analysis that is used to estimate the relationship between a dichotomous dependent variable and ratio-level independent variables. Many different variables of interest are dichotomous, e.g. whether it is sustained or unsustained. These types of variables are often referred to as discrete or qualitative. Dichotomous or dummy variables are usually coded 1, indicating "sustainable" or 0 "unsustainable". There are a number of alternative approaches to modeling dichotomous outcomes including logistic regression. It is a type of regression analysis that is used to estimate the relationship between a dichotomous dependent variable and dichotomous interval and ratio-level independent variables. It is a type of regression analysis where the dependent variable is a dummy variable coded 0 and 1.

The logistic regression model is given as:

$$\text{Logit}(p)=\ln[p/(1-p)]$$
$$=\beta 0+\beta_1X_1+\beta_2X_2+.....+\beta_5X_5+\beta_6X_6+ u \quad ……..(1)$$

Where:

P= probability that the chicken farms sustain the GHGERPs use.

p(Y=1) (1-p) = probability that the farms do not sustain GHGERPs use p(Y=0)

P/(1-p) = the "odds ratio"

ln[p/(1-p)] = the log odds ratio, or "logit"

X_1 = Capital invested (~~N~~)

X_2 = Farm age (years).

X_3 = Access to credit (dummy, 1 if yes, 0 if no)

X_4 = Total feed quantity used (kilograms)

X_5 = Farm size (number of birds)

X_6 = Labour (number of manday used)

$\beta 0$ = constant

β_1.....β_6 are vectors of the respective parameters which are estimated using maximum likelihood method

u = Error term.

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Measurement of Variables used in the Model.

(i) Sustainability of GHGERPs use (β)- This was measured in economic and environmental sustainability. An index was calculated for measuring it into sustainable and unsustainable.

(ii) Capital invested (X1)- This was the amount of capital used for the purchase of the GHGERPs by the commercial farms both from the formal and informal sources during the 2019 production year. It is an important input in chicken production. It was measured in Naira (₦).

(iii) Farm age (X2)- This was measured in years by how long the farms have been in chicken production. It also serves as proxy for farm experience of GHGERPs practices. The older the farm, the more the chances of embracing the practices.

(vi) Access to credit (X3)- This is a dummy variable. It was measured by those with access to credit are classified as 1, while those that did not have access to credit are classified as 0.

(v) Feed quantity (X4)- This was the amount of feed used for rearing the pullet birds for eggs production and broiler birds for meat production. It was measured in kilogram. Most of the chicken feed is sold in bags of 25kg. Those for the pullet birds were chick mash used from day old to six weeks, growers mash used from six weeks to 18 weeks and the layers mash from the 18th week to the end of the laying period which in most cases extend to between 85weeks to 100 weeks. The broiler birds were fed with broiler super starter mash from day old to two weeks, broiler starter from the two weeks to three weeks and broiler finisher mash from the three weeks to six weeks.

(vi) Farm size (X5)- This was measured by the number of birds. It was the number of chicken birds reared during the 2019 production year. Those farms with 1-5,000 birds were classified as small size and those greater than 5,000 birds were classified as large size.

(vii)Amount spent on labour (X6)- Labour was measured by the number of days worked by the labour on the farms. It included permanent, hired, contract and family labour. For all paid labour, the cost was calculated for each of the individual activities like brooding, cleaning, stocking, feeding, giving of water, culling, medicating, vaccinating, dressing and packaging done in chicken rearing. This was achieved by multiplying the wage rate of the activities by the paid labour recorded for that activity throughout the production season. The value of family labour was imputed using the going wage rate. The aggregated sum of amount of the labour cost for all the activities was used for individual farms.

Results and Discussion

Farm characteristics

Evidence in Table 1 shows that classification of the commercial chicken farms according to size. The two classified farm sizes are small and large. The operations of the commercial chicken farms are classified into sizes as documented by Akpan (2020). The farms were stratified into two categories of less than 10,000 birds as small commercialized with 20.4% and ≥ 10,000 birds as large commercialized with 79.6% respectively. This shows that most of the farms were large commercialized ones due to their large-scale involvement to the chicken subsector. The larger the farm size, the higher the likelihood of controlling dominance on the chicken value chain in the subsector. Also, the commercial chicken farms according to breed of chicken reared as day old chicks as ISA brown, hyline brown, bovan nera, delkab, arbor acre+, marshal, ross, hubbard and cobb ventress. As presented in Table 1, over 50 percent of the farms reared broiler birds for meat stock Arbor Acre+ and ISA brown breeds for pullet birds stocked in the last one year. While the least breed reared were Dekalb, Hyline brown and Bovan nera. The use of the two identified major breeds may not be unconnected to the fact that they have better characteristics such as; high productivity, disease resistance and high maturity status. Nwogwugwu *et al*. (2018) reported that the prominent birds in many of the fast- growing Nigerian farms are those with high potentials in terms of productivity. This finding confirmed the previous study made by Afolabi (2013) that most broiler farms in Nigeria rear the Arbor acre+ breed.

Furthermore, results in Table 1 show that most of the farm managers were male (71.6%). This shows that male dominated the management position in the sampled farms since the managers direct the affairs of an organization, though with the directives from the Central Executive Officer (CEO) if any. This may not be unconnected with the cultural norms in many parts of Nigera where males are noted to muscle out women in the control of resources and position of authority. Kameri-Mbote (2007) posited that there are gender differences in access and control over resources in many African countries and male usually have more and better access to resources than the female. In poultry farms, access to land especially in commercial capacity may not easily be accessed by the female as their access to land is limited. This is because land has both economic and cultural values to an average African community; hence, allowing women who may transfer the ownership and title of the land to the husband (who may not necessarily be related to the women community) is seen as a reason for limiting women access to farmland. In line with the above assertion, Allendorf (2007) opined that citing a chicken farm requires ownership of land and Doss, *at*

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al (2015) argued that there were claims that less than 2 percent of the world's land is owned by women or that women make up less than 5 percent of agricultural landholders in North Africa and about 15 percent in Sub-Sahara Africa. These studies further argued that, the low rate of land ownership significantly obstruct access to financial loans including credit and savings which are resources that could be invested into a business-like commercial chicken farm. Imogie and Eraikhueme (2008), Obielumani (2010) and Nakpodia and Urlen (2012) submitted that many training opportunities and career ladders have been either closed to women or considerably less opened to them than men. This is an indication that women are disadvantaged when it comes to education and control of resources. This might be responsible for the results obtained where women were in less proportion in ownership of farms as well as in the management.

Most of the farm managers acquired tertiary education as shown from the result of the study. There was a little less than five percent of the farm mangers that attended none or primary school education. The implication of this finding is that farm managers with higher education might have the educational requirements to perform better in GHGERPs than those with less education. Famakinwa, Adisa and Alabi (2019) reported that for a better performance of task, education was a critical factor that influenced role performance of community leaders in rural development in South West, Nigeria. Furthermore, Enete and Amusa (2010), found education as a determinant contribution to a productive farming. Thus, there is every possibility that a better educated farm manager is more likely to apply GHGERPs because it would enhance the knowledge of apractice that would increase productivity as opined by Oduro-Ofori, Aboagye and Acquaye (2014). Majority of the farm managers have agricultural background as discipline of study. They may likely manage GHGERPs in chicken farms better as they might have been taught while in their training years.

As for the age of the chicken farms sampled, the findings reveal 40 as the maximum numbers of years and 5 minimum numbers of years with a mean of 8 years. This shows that chicken farms in the study area had a long history of existence. The findings corroborate the assertion of Eruvbetine (2008), which stated that some parts of South West and North Central, Nigeria had a long history of the existence of chicken farms. This goes to show that some of the farms earlier commenced as subsistence chicken farming until they grew into commercial chicken farms as evident by Eruvbitine (2008). On the years of experience of the farm managers on commercial chicken production, results show that it had a maximum and a minimum of 30 and 3 years, respectively with a mean year of approximately 5 years.

Table 1: Farm characteristics

Number of birds	**F**	**%**	**Mean**
<10,000	17	20.4	
> 10,000	278	79.6	15,591.55
Breeds			
ISA brown	188	53.8	
Hyline brown	2	0.57	
Bovan near	17	4.87	
Delkab	1	0.29	
Arbor acre+	190	54.4	
Marshal	47	13.5	
Ross	36	10.3	
Hubbard	25	7.2	
Cobb ventress	35	10.3	
Age of farm (Year)			*7.45*
Educational Status of managers			
None	3	0.8	
Primary	14	4.1	
Secondary	67	19.2	
Tertiary	265	75.9	
Field of study of managers			
Agric related	213	61.1	
Non-Agric	136	38.9	
Sex of manager			
Male	248	71.6	
Female	101	28.4	

Source: Field Survey, 2019.

Profitability of poultry farms

Results in Table 2a, the returns per production cycle with low GHGERPs use, the chicken farms averagely incurred a total of ₦1,500,818 out of which ₦24,100 went for fixed cost after depreciation of building, feeders/drinkers and fluorescent /LED light and ₦1, 476,717 was spent on variable cost of good quality feed, veterinary drugs, vaccines and labour for the production cycle. The revenue realized from the sales of eggs was ₦257, 371, meat was ₦1, 383,147 and spent layers were ₦203,540 giving total revenue of ₦1, 844,058. The return on capital investment was 1.23 percent. This showed that for every ₦100 the chicken farms invest on GHGERPs, they will realize ₦23 as return on investment.

While the return per production with high GHGERPs use (Table 2b), the chicken farms on the average spent ₦12,249,420 as total expenditure with ₦487,851 incurred as fixed costs, after the depreciation of use of enclosed pens, energy use reduction, use of circulation

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fans, use of radiant heating systems, use of spark ignition brooders, use of fluorescent or LED light, use of drum composter and the use of drinkers/feeders and ₦11,761,569 spent on variable costs of good quality feed, veterinary drugs, vaccines and labour for the production cycle. The revenue got from the sales of eggs was ₦2,124,783, meat was ₦13,057,684 and spent layers was ₦1,100,234 to give a total revenue of ₦16,282,701. The return on investment capital invested was 1.33 percent. This implies that for every ₦100 the chicken farms invest on GHGERPs use, they will realise ₦33 as returns on investment.

From the study, there is a progressive increase of returns per production cycle of 23 percent and 33 percent for low and high GHGERPs use respectively for commercial chicken farms in Nigeria This confirmed the assertion by Lewis (1998), Aiyeloja and Popoola (2008), Laride and Aiyeloja (2009), Emokaro, Ekunwe and Achille (2010) and Aiyeloja and Ogunjinmi (2013) that farming is a profitable venture. This implies that chicken farm managers can continue with its rearing in order to increase their sources of income. This result agrees with the findings of Popoola, Aiyeloja and Ogunjinmi (2009), Erhabor and Emokaro (2010), Larinde and Aiyeloja (2013) and Oladele, Aiyeloja and Aguma (2013) who stated that chicken farming is profitable in Nigeria and that farm managers should be encouraged to go into its production. The results of the Focus Group Discussion (FGD) and the Key Informant Interview (KII) showed that chicken farming is a profitable enterprise but with huge investment based on the report of the participatory appraisal. This agrees with the earlier assertion by Olomu (1996), Erubetine (2008) and Kwari *et al* (2014) that quality feed which contains about 70 percent of cost of agro inputs are becoming expensive with the escalating prices, of its raw materials.

Table 2a: Return on Investment per production cycle for low GHGERPs use.

Item	Useful life	Purchase Price(N)	Annual cost(N)	Depr cost/cycle(N)	Total(N)
Fixed cost					
Building	10	1,184,800	118,480	19,747	
Feeder/drinkers	3	61,313	20,437	3,406	
LED light	0.5	2,843	5,686	948	
Total Fixed Cost					24,101
Variable cost					
Feed				1,195,841	
Drugs				54,344	
Vaccines				8,152	
Labour				218,380	
Total Variable Cost					1,476,717
Total Cost					1,500,818
Revenue					
Eggs				257,371	
Meat				1,383,147	
Spent layers				203,540	
Total Revenue					1,844,058
ROI(TR/TC)					1.23

Source: Field Survey, 2019

Table 2b: Return on Investment per production cycle for high GHGERPs use.

Item	Useful life	Purchase Price	Annual cost	Depr cost/cycle	Total
Fixed cost					
Enclosed pen	10	10,695,529.25	1,069,552	178,258.80	
Energy use reduction	10	733,430.50	77,243	12,873.80	
Circulation fan	10	6,646,397.10	664,639	110,773.30	
Radiant heating system	10	6,550,413.30	655,041	109,173.60	
Spark ignition brooder	10	1,472,868.20	147,286	24,547.50	
LED	0.5	11,530.00	23,060	3,843.40	
Drum composter	10	2,441,650.40	244,165	40,694.30	

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Item	Useful life	Purchase Price	Annual cost	Depr cost/cycle	Total
Drinkers/feeders	3	140,160	46,720	7,686	
Total Fixed Cost					487,851
Variable cost					
Feed				10,333,123	
Drugs				259,304	
Vaccines				64,326	
Labour				1,104,816	
Total Variable Cost					11,761,569
Total Cost					12,249,420
Revenue					
Eggs				2,124,783	
Meat				13,057,684	
Spent layers				1,100,234	
Total Revenue					16,282,701
ROI(TR/TC)					**1.33**

Source: Field Survey, 2019.

Sustainability of the use of GHGERPs

Classification of the sustainability of the GHGERPs was obtained as described under the research methodology and presented in Table 3. With the mean sustainability index of the use at 0.47, a classification was carried out with a range of <0.5 and >0.5 of mean by filtering the data. It was observed that about 61.6% of the farms GHGERPs used were classified as unsustainable while only 38.4% was classified as sustainable. This shows that most of the farms practices are unsustainable and the implication of this is that the greenhouse gas emission would have negative effects on the future generation if the practices are not sustained. See FGD translation on the excerpts from PRA for the study**.**

Table 3. Classification of Sustainability of the use of GHGERPs

Range	Frequency	%	Classification	Categorical
< 0.5	215	61.6	Unsustained	0
> 0.5	134	38.4	Sustained	1
Total	**349**	**100**		

***Sustainability Index=0.47**

Determinants of sustainability of GHGERPs in farms

The determinants of the sustainable use of GHGERPs by the commercial chicken farms are presented in Table 4. From the binary logistic regression estimates, the result shows the model (regression line) fits the data reasonably with the large Log likelihood of -169.49. The model had an adjusted Pseudo R^2 of 0.27 approximately implying that the observed explanatory variables in the model explained about 27 percent of the variation in the model. Furthermore, the regression of the sustainable use of GHGERPs analysed shows that capital invested (Odd ratio = 3.58), size of the farm (Odd ratio = 1.51) and access to credit (Odd ratio = 2.42), were significant at 5% level. This shows that these above significant factors influence sustainability of use of GHGERPs in the sampled farms. The result showed that the sustainability of use of GHGERPs was influenced by the capital invested by the farm. The odd ratio of the capital invested of the farm was 3.58 implies that the likelihood of practicing sustainable GHGRPs would increase by 3 times with high capital investment while access to credit had a likelihood of increasing farms sustainable greenhouse emission reduction practices by 2 times and having a big farm size would likely increase the chance of practicing sustainable greenhouse emission reduction. Based on model performance criteria, the explanatory power of the model is high, with the coefficient of multiple variation, pseudo $R^2 = 0.27$ and thus explains 27 percent of the total variations in the determinants of the sustainability of GHGERPs. The LR chi^2 statistic of joint significance of the explanatory variables was 125.86, with a probability > chi^2 =0.000

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indicating that the model parameters were jointly significant at 5 percent level and adequate in fitting the data. The implication of the finding is that the unsustained use of the identified GHGERPs may be attributed to the farms knowledge and cost involved in the management of GHGERPs as supported by the results of participatoryappraisal as follows.

…we heard about it (GHG) at the farmers" workshop held in our states. We heard it through newspapers and radio programmes usually live on radio in our zone. Information on how to sustain the reduction practices. The manager ended his comments, by saying, "the program presenters usually warn that farms must find a way to sustain the practices for the good of our lives and the environment."…. ***Excerpts from PRA for the study.***

Table 4. Determinants of Sustainability of the use of GHGERPs

Sustainability level	Odd ratio	Std Error	z-value
Capital Invested	3.58	4.01	3.92*
Feed quantity	2.80	5.88	0.90
Farm age	0.97	0.02	-1.20
Farm size	1.51	2.65	3.15*
Access to credit	2.42	0.47	4.59*
Labour	0.99	0.00	-1.50
Constant	0.11	0.03	-6.60
Number of observations =349			
LR chi^2 (6) =125.86			
Prob > chi^2 =0.000			
Pseudo R^2 = 0.27			
Log likelihood = -169.49			

Conclusion and Recommendations

Based on the findings of this study, it was concluded that most of the commercial chicken farms in the study area practices of reducing greenhouse gas emission are not sustainable. However, with higher investments, access to credit and increase in farm size, their level of sustainability would appreciably increase at a probability level of 95%. Therefore, stakeholders in the poultry subsector of the agricultural sector should ensure that they encourage more investment in the chicken farms and link farms with friendly source of credits (with 1 digit interest rate) with the aim of improving the level of sustainable greenhouse gas emission reduction practices. This will promote cleaner environment and healthy living.

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