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Research Paper

Impact of Bio-Methane Emission, Awareness And Adoption Of Nutritional Strategies Among Ruminant Livestock Farmers In Akwa-Ibom State.

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ABSTRACT
*Methane from ruminants is a principal contributor to greenhouse gases consequently, sustainable mitigation strategies for enteric emmission is in high demand. This study examines the entitled "Impact of bio-methane emission; awareness and adoption of nutritional strategies among ruminant livestock farmers" is aimed at analyzing the **a**wareness among livestock farmers on hazards associated with bio-methane emission.Data sample collected for analysis was information on farmer's awareness, their sources of information and adoption level of feed additives among ruminant livestock farmers. Response from the questionnaire was analyzed using. SPSS version 21 and Microsoft Office Excel 2010 by a series of logical and range checks producing summary statistics and tables. Descriptive results were expressed as frequencies and percentages and chi square test (x^2) was used to measure the possible association between nominal variables. Criterion for statistical significance of 0.05 is used. The result of this research reveals that no respondent had at any time heard about mitigation of bio-methane emission in ruminant livestock using plant based additives other nutritional strategies. The study reveals farmers lack of adequate knowledge of methane emission in livestock farming and its impact on climate change as well as its impacts on human health. This study demonstrates that awareness among livestock farmers on hazards associated with bio-methane emission is still lacking. Furthermore, the major constraint that affected the adoption of nutritional supplement for bio-methane emission reduction in livestock farming is lack of information on the subject matter. This shows why adoption of nutritional supplement for mitigation of methane emission in ruminant livestock is probably low among farmers. This is an indication that extension organizations, agencies, boards etc have not developed messages in that area for dissemination to ruminant livestock farmers. This study demonstrates that awareness among livestock farmers on hazards associated with bio-methane emission is still lacking. However, Counseling, advocacy, training and re- training of farmers on phytogenic mixed feed additive is highly recommended.*

Keywords: ***Bio-Methane Emission, Awareness, Adoption, Nutritional Strategies Ruminant Livestock Farmers***

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I. INTRODUCTION

According to Grossi et al., 2019 globally there will be continuous expansion of the world population, human demand for meat and milk is expected to increase by 73% and 58%, respectively, by 2050. Therefore, to meet future needs, animal production must be increased. Even though the livestock sector, especially ruminants, plays an essential role in food security, it is considered a significant source of greenhouse gases (GHGs), such as methane (CH_4) and carbon dioxide (CO_2), representing approximately 14–18% of global anthropogenic GHG emissions.

Globally, livestock sector is the pillar of the food system and a contributor to food security and agricultural development. According to FAO 2022, livestock production contributes 40 percent of the global value of agricultural output and supports the livelihood and nutrition of almost 1.3 billion people. Increasing the sustainability of livestock supply chain is key to limiting the GHG emission rate in the future and this can be achieved by decreasing GHG emission per unit of product through improved livestock management. Livestock has a significant contribution to methane emission as a portion of their ingested energy, which is wasted in the form of methane (2–15%), and ammonia (75–95%).

The Agricultural Sector has been fingered globally as the third largest source of GHG emission with major contributions from manure and enteric fermentation producing methane. Livestock, especially cattle play a crucial role in GHG emission. Universally, ruminant livestock produce about 2.7 Gt CO_2 equivalent of CH_4 per annum, or about 5.5% of total global GHG emissions from human activities. Cattle account for 77% of these emissions (2.1 Gt), buffalo for 14% (0.37 Gt) and small ruminants (sheep and goats) for the remainder (0.26 Gt). Reducing enteric methane ($\boldsymbol{E}CH_4$) emission in livestock farming would make a significant contribution to climate change on a shorter time scale due to its relative short lifetime compared with that of carbon dioxide. (Department of Primary Industries and Regional Development (DPIRD, 2019).

Recent literature shows that the share of greenhouse gas emissions produced in agriculture is significant. In Poland, about 9% of greenhouse gases emitted to the atmosphere come from agricultural production; in the European Union, it is about 10%. Livestock production generates about 18% of all greenhouse gases emitted to the atmosphere. (Gebska et al., 2020).

Enteric fermentation as described by FAO (2021) is a natural part of the digestive process of ruminants where microbes decompose and ferment feed present in the digestive tract to produce energy, protein along with methane. Enteric fermentation is simply a by-product of this process and is expelled by the animals through burping. The other products of the decomposition and fermentation process are used by animals to make products such as meat, milk, and wool. The amount of enteric methane expelled by the animal is directly related to the type of forage fed to animals which itself has impact on the animal's weight, level of productivity, reproductive status and environmental factors such as temperature. Between 2-12% of a ruminant's energy intake is typically lost as methane.

Emissions profile of enteric methane (CH_4) differ significantly across the world and are expected to go higher in Sub Saharan African countries (Ethiopia, Kenya, Uganda, Tanzania, Benin, Burkina Faso, Senegal, Mali, and Nigeria) where milk and meat production is growing fast to meet demand of her growing population. According to U.S. environmental protection agency, US-EPA (2019), sources of methane emission includes; natural gas and petroleum system which accounts for 31%, enteric fermentation accounts for 27%, landfills accounts for 16 %, manure management accounts for 9% and coal mining accounts for 8%methane emission in united states of America.

Methane from ruminants is a major contributor to total greenhouse gases. Therefore, ruminant nutritionists have proposed strategies to mitigate methane emissions, such as chemical inhibitors and ionophores. However, dietary manipulation including natural feed additives is considered to be more practical, considering consumer preferences. Bharanidharan, et al., (2021)

The estimates showed that methane emission from cattle, goat and sheep accounted for over 95% of total emissions while emissions from camel, horses, pigs and poultry contributed less than 5%. Stressing that emissions from cattle are expected to increase from 620 Gg in 2013 to 710 Gg by 2025 while emissions from sheep and goats for the same period will increase from 210 Gg to 251 Gg and 303 Gg to 330 Gg, respectively. Moreover, the implementation of the National Livestock Policy might lead to increase in the stock level of cattle, goat and sheep which will result in increased methane emissions.

Kataria (2015) reported that the rising concentration of methane is correlated to increasing populations and currently about 70% of methane production arises from anthropogenic sources and the remainder from natural sources. Agriculture is considered to be responsible for about two-thirds of the anthropogenic sources. Biological generation in anaerobic environments (natural and man-made wetlands, enteric fermentation and anaerobic waste processing) is the major source of methane. Agricultural sources derived from enteric fermentation (81-92 million tonnes), paddy rice production (60-100 million tonnes), biomass burning (40 million tonnes) and animal wastes (25 million tonnes) are the major sources responsible for methane production. At a global scale, livestock farming contributes to 30-50% of total greenhouse gas emissions.

In the last decades, milk supply and demand has increased by 26% and 2.4% annually and will rise by 25% in the coming years (Matthews et al., 2019). Livestock contributed about $1.4 trillion to the global asset (Thronton, 2010), equal to 50% of the total economy of the agricultural sector (Herrero et al. 2016). Livestock contributed about 5.6- 7.5 gigatonnes of methane to the global anthropogenic GHGs emissions, equivalent to 14.5% of total GHGs emissions. Approximately 44% of global livestock emissions occur in the form of enteric methane ($\boldsymbol{E}CH_4$) (Matthews et al. 2019). China, India, Brazil, USA, and Pakistan are the top five livestock farming countries, and together, they contribute 46% of global livestock-mediated anthropogenic GHGs emissions (FAO, 2019).

Enteric Methane-reducing feed additives and supplements inhibit methanogens in the rumen, and subsequently reduce enteric methane ($\boldsymbol{E}CH_4$) emissions. Methane-reducing feed additives and supplements are most effective when grain, hay or silage is added to the diet, especially in beef feedlots and dairies. In ruminant livestock, the microbes involved in digesting cellulose-rich diets (Hay/grass) and carbohydrate- rich diet (corn or distillers grains) are different resulting in different level of methane emission. Less methane will be produced in carbohydrate rich diets. Methane-reducing feed additives and supplements can be Synthetic chemicals, Natural supplements and compounds, such as tannins and seaweed, Fats and oils. Direct –fed microbes (DFM) is a feed additive that contains a source of live microorganisms. DFM commonly used in ruminants is yeast.

According to the Department of Primary Industries and Regional Development (DPIRD) (2020) Synthetic chemicals, such as antibiotics, are sometimes used to improve the efficiency of feed conversion in cattle, although it is not a recommended practice to use these additives to reduce methane emissions.

A critical review of the recent progress made toward the development of nutritional additives for reducing methane production in ruminant livestock farming especially cattle has shown that sea weed, aged garlic, organic acid (orange peel), Aloe-vera waste, carbohydrate rich diet (corn or grains), coconut oil, linseed oil, organic acid, yeast, cashew nut extract amongst others has yielded tremendous impact in reducing enteric methane emission ($\boldsymbol{E}CH_4$) in ruminant livestock. With this progress, manure management for reduction of methane emission will be greatly reduced. This study is aimed at analyzing the **a**wareness among livestock farmers on hazards associated with bio-methane emission. This will be achieved through the following objectives;

1. Determine farmer's awareness of Nutritional supplement towards reduction of methane emission in livestock farming.
2. Determine the sources of farmer's information of Nutritional supplement in reduction of methane emission in livestock farming.
3. Determine farmer's adoption of Nutritional supplement in reduction of methane emission in livestock farming.

IMPACT OF BIO-METHANE EMMISSION

The devastating effects of climate change as a result of the emission of greenhouse gases into the environment have assumed global proportions. Climate change is the single biggest health threat facing humanity. The impacts of climate change on our ecosystem are already visible throughout the world. It is expected that certain activities and populations will be more affected and at a faster rate than others. The fact remains that all regions of the world are undergoing and will continue to undergo the effects of this climatic disorders with varying magnitude and consequences. Climate change affects the social and environmental determinants of health. (clean air, safe drinking water, sufficient food and secure shelter.

Saunois et al. (2016) reported that atmospheric methane concentrations are rising faster than at any time in the past two decades and are now approaching the most green house gas intensive scenarios. Saunois et al. (2016) has been tracking emissions with detailed measurements in the Arctic, Europe and the tropics, as well as with modeling studies, and proposes that the methane surge since 2007 appears to be mostly the result of increased biogenic emissions (mostly from agricultural animal including cows, sheep and goat), predominantly in the tropics. Among several factors, this activity has been accelerated by warming temperatures and increased rainfall causing the expansion of tropical wetlands.

Jackson et al. (2020) described that methane was not much of a worry 20 years ago, but that's changed since 2007, as methane emissions have accelerated, spiking in 2014 and again in 2018. Stressing that methane is a far more potent greenhouse gas than CO_2, even though it only lasts about a decade in the atmosphere, whereas CO_2 persists for a couple of centuries i.e. Global warming potential of 1kg of methane is estimated to be 21 times 1kg of carbon dioxide when the effects are considered. A continued rise in the amount of methane in the air could easily cancel out any near-term progress made in reducing CO_2 emissions.

Methane is the low-hanging fruit in the effort to combat planetary warming. With global demand for livestock products continuing to grow strongly in almost all developing countries, it is imperative that the sector starts working now to achieve these reductions, to help offset the increases in overall emissions that future growth in livestock production will entail. Reversing this trend in methane emissions is now probably the most

urgent challenge in the fight against global warming, even more than the ongoing need to tackle CO_2 emissions. Additional attention is urgently needed to quantify and reduce methane emissions.

Dreyfus et. al., (2022) warned that, cutting methane emission and other short lived climate pollutant (SLCP) sharply now is crucial as focusing on carbon dioxide (de-carbonisation) alone will not be enough to keep rising temperatures within livable limits. Emphasis being that this approach will give the world a chance of starving off climate catastrophe. Furthermore, these non CO_2 targeted mitigation measures (cutting methane emission and other short lived climate pollutant (SLCP)) when combined with de-carbonisation can provide net cooling by 2030 (0.26^0C lower), which is four times more than pursuing CO_2 cuts alone over this time frame. Explaining further that mitigation measures that target only de-carbonisation are essential for strong long-term cooling but can result in weak near-term warming (due to unmasking the cooling effect of co-emitted aerosols) and lead to temperatures exceeding 2^0 C before 2050. In contrast, pairing de-carbonisation with additional mitigation measures (SLCP) slows the rate of warming a decade or two earlier than de-carbonisation alone.

Measures have been put in place overtime to solve this problem for instance Bio digesters. Bio-digesters do have some drawbacks. They are complex expensive projects that farmers can't afford on their own, they cost 3-5 million dollars each and typically requires public subsidies to build in the form of federal loans, state grants, tax credits rebate programs and a plethora of other incentives. In the past, diary producers built and operated their own bio-digesters. But in recent years, as the project has become more complex, the price tags have dramatically increased and big developers have taken over their funding, building, operating and maintenance. Because of the expense and scale of the projects, digesters are now geared towards huge dairy farms (2,500 cows) thwarting the move to a farming system that supports smaller scale producers, reduced herd sizes and cows on pasture feeds. According to U.S. environmental protection agency, USEPA (2019) an average cow produces approximately 120 pounds of manure every day. California alone houses 1.7 million cows with about 1,300 diaries. Reducing emissions from California alone is no small feat.

The current situation according to Jackson et. al. (2020) is that global emissions of methane have reached the highest levels on record. Increases are being driven primarily by growth of emissions from coal mining, oil and natural gas production, cattle and sheep ranching, and landfills. Between 2000 and 2017, levels of the potent greenhouse gas barreled up toward pathways that climate models suggest that it will lead to 3-4 degrees Celsius of warming before the end of this century.

Climate change affects the social and environmental determinants of health (clean air, safe drinking water, and sufficient food as well as secure shelter). The impacts of climate change are already here and accelerating. The persistence of methane emission can lead to negative impact on human health as well as the environment i.e. this is a dangerous temperature threshold at which scientists warn that natural disasters, including Spread of vector borne diseases, extreme heat waves, wildfires, emergence of disease and pest (due to the changing climate of their normal habitat), dust storms, air pollution resulting in respiratory issues as well as droughts and floods, desertification, mangrove decay, coral bleaching, ocean acidification and social disruptions such as famines and mass migrations will soon become commonplace by compounding threats to human health, threats to water and food supply as well as threats to economic stability.

In terms of threats to human health, Global warming is linked to heat stress which can cause kidney stones, heat strokes, heat cramps, heat syncope, allergic responses and heat exhaustion in humans (Becker et al., 2011 & Sun et al., 2019). Also, global warming is associated with respiratory diseases such as asthma (Guleria et al. 2019, Sulistyawati et al. 2018). Additionally, it can result in drought, crop failure, and an increase in vector and water—borne diseases which indirectly affect the health of humans (Sivaramanan, 2015) thus, increasing chances of high mortality among humans. The effects of climate change also affect people's mental health. In particular, climate- or weather-related disasters can increase the risk of adverse mental health consequences, especially if they result in damage to homes and livelihoods or loss of loved ones. The mental health impacts of these events can range from minimal stress and distress symptoms to clinical disorders, such as anxiety, depression, and post-traumatic stress.

Additionally an increase in vector and water—borne diseases which indirectly affect the health of humans (Becker et al., 2011 & Sun et al., 2019) thereby, increasing chances of high mortality among humans. This view is supported by World Metrological Organization (2020), the average global temperature in 2020 is set to be 1.2^0C above the pre-industrial level. There is at least a one in five chance of it exceeding 1.5^0C by 2024. Climate change exacerbates some existing health threats and creates new public health challenges. Worldwide, only considering a few health indicators, additional 250,000 deaths per year will occur in the next decades as a result of climate change if the emission level of green house gases is not controlled.

In Nigeria, climate change is causing considerable variations in temperature and rainfall patterns. Rainfall regime has been shifting towards a longer dry season. Nigeria is likely to experience greater rainfall variability and higher temperatures in the future, while rain fall is projected to decrease in most of agro-ecological zones. Such changes will shorten the growing season with low productivity implications for the

agricultural sector. With changes in temperature and precipitation patterns, Food security is compromised and human health is threatened through malnutrition and high cost of food.

Nigeria is a signatory to the Paris Agreement to meet the Climate Change culture. It ratified the agreement in 2017. Through this, the country had pledged to reduce its greenhouse gas emissions by 20% by 2030. After recording the fifth anniversary of the Paris agreement on climate change, efforts and commitments by Nigerian government are currently not on track and more efforts are needed. Achieving this goal requires countries to move rapidly from high level commitments to country level strategies, policies and action plans. However, meeting the obligations of Paris agreement on climate change is met with several barriers because these emissions are generated by individual animals meaning that any intervention must be within the animal, by using Nutritional strategies and feed management. In Nigeria, the effects of climate change are already evident for example extreme heat waves, drought, flooding, Emergence of disease and pest, desertification among other effects.

The intergovernmental panel on Climate change says that methane must be reduced at least 37% by 2030 if there's any hope of keeping warming levels less than 2^0C. Keeping global warming below 2^0C is a challenging target. Intergovernmental panel on climate change (IPCC) reinforces the need for societies to take highly strategic adaptative and mitigation actions to protect human health from adverse consequences of climate change. If there wasn't already enough reason to act, reducing methane has benefits beyond global warming. The toxic gas is also a building block of what is called ground level ozone, an air pollutant that kills an estimated one million people every year in addition to 110 million tones of crops and animals.

Reducing methane emissions doesn't just have profound implications for earth's long- term habitability; it matters for the hundreds of thousands of humans round the world right now. The multiple benefits that can be achieved should motivate all government industry and investors to act now. Decreasing methane emissions from these sources by 10 to 15% would stabilize atmospheric methane at its present level and is a realistic objective. Hence, enormous efforts are being made across the world to find methods that are cost effective, safe and sustainable. The impacts of climate change are already here and accelerating. Immediate reductions to the emission of these super pollutants are the "first aid" that can assist avoid near-term and irreversible impacts and reduce the rate of warming. This is a key part of the foundation for any successful climate strategy. Methane has been identified as an important mitigation opportunity because of its notable differences among individual greenhouse gases and their individual impact on climate change. In the next decade, Population is expected to increase as well as demand for livestock product.

Methane emission levels is also expected to escalate impacting directly on the determinants of human health, if nothing is done. Yusuf et al. (2016) investigated livestock data in Nigeria from 1961-2012, using Auto-regressive integrated moving averages (ARIIMA model) to project methane emissions from livestock in Nigeria from 2013-2025. The estimates showed that methane emission from cattle goat and sheep accounted for over 95% of total emissions while emissions from camel, horses, pigs and poultry contributed less than 5%. Stressing that emissions from cattle are expected to increase from 620 Gg in 2013 to 710 Gg by 2025 while emissions from sheep and goats for the same period will increase from 210 Gg to 251 Gg and 303 Gg to 330 Gg, respectively. Moreover, the implementation of the National Livestock Policy might lead to increase in the stock level of cattle, goat and sheep which will result in increased methane emissions.

The reason for this research is to reduce methane emission which would make a significant contribution to climate change on a shorter time scale due to its relative short lifetime compared with that of carbon dioxide. These expected enteric methane ($\boldsymbol{E}CH_4$) emission increases could be mitigated by adopting dietary modification and supplementation, selection of high- quality grasses, increased grain level in feed and increase food conversion efficiency.

II. LITERATURE REVIEW:

Farmers Awareness of Nutritional Supplement to Reduce Methane Emission in Livestock Farming.

Awareness is a significant factor and usually the first step in adoption process of any innovation. Awareness of methane emission from ruminant livestock is a significant and critical factor for getting involved in mitigation measures. The first stage in adoption of any technology is awareness of such technology. According to FAO, (2020) Government and other key stakeholders including civil society, farmer organization, research bodies and the private sector all have a role to play in creating an environment that enables innovation to flourish and generate solutions. Success hinges on connecting the drivers that influences innovation uptake.

Furthermore, it is critical for people to be knowledgeable about dangers and risks associated with global warming to their health and wellbeing. , it is wise to exclusively investigate people's knowledge concerning the impact of global warming to get a vivid representation of their understanding on its health ramifications. i.e. people need to understand the health risks associated with global warming, so they can embark on relevant procedures to protect themselves and also actively participate in national mitigation agenda

or activities. This will go a long way to sustain their health and physical wellbeing of the populace. It is not accurate or substantive enough to assume the public are well informed about global warming, just because of its policies and worldwide publicity.

Global warming is estimated to negatively affect human health particularly in developing countries like Nigeria, Ghana and other sub Saharan African countries by aggravating already existing health problems. This is further worsened by a weak healthcare system and poverty. However, baseline studies to investigate farmer's knowledge on health threats of global warming seem to be elusive in Nigeria, thus, leaving a wide gap in global warming and climate change impact studies in Nigeria,. Yet, this remains critical to stakeholders, with regard to the environmental impact on the health of the citizenry.

Gazzaz et al., 2021 assessed the Level of Knowledge of Climate Change of Undergraduate Science and Agriculture Students enrolled in the Faculty of Agriculture and Science (FAS) in Jarash University, Jordan. This study was conducted to assess the level of CC knowledge of undergraduate physical science and agricultural science students in Jarash University, Jordan. The study used specifically-designed Climate Change Knowledge Test (CCKT) as the data collection tool. Population of the study was undergraduate science and agriculture students enrolled in the Faculty of Agriculture and Science. The study sample consisted of 285 students, comprising 103 science students and 182 agriculture students. The results indicate that the sample students have high levels of knowledge of the nature, causes, and effects of CC. However, on the average, a higher number of the sample students posses knowledge of effects of CC (n = 223, % = 79.3%) than its nature (209, 73.5%) and causes (190, 66.9%). Additionally, it was found that the female students have higher levels of overall CC knowledge than their male peers and that the agriculture students possess higher levels of CC knowledge than their science peers.

These results emphasize the need for curriculum review and reform to ensure equipping the university graduates with comprehensive knowledge of CC. Ultimately the introduction of climate change (CC) courses in universities is critical for helping future generations and leaders in recognizing the global challenges of CC and finding ways for adapting with it. People's knowledge of CC can influence success of any planned CC mitigation and adaptation programs and activities. Thereupon, it is vital for environmental planners and researchers to conduct regular assessments of this knowledge to determine need for curriculum reform, if any.

Odonkor et al. (2020) carried out an Assessment of Public Knowledge and Potential Health Impacts of Global Warming in Ghana. Knowing the gap in people's knowledge and understanding of global warming impacts on their health is essential for its adaptation and minimization. The aim of the study was to investigate public knowledge of global warming and its effects on human health. A nationally representative survey of Ghanaian adults (N-1130) was conducted from November 1, 2018 to February 28, 2019. Results show that 84.4% of the respondents understood the meaning of global warming. . However, 49.2% of the respondents indicated that global warming is very bad to human health, 34.7% indicated it was bad, 2.8% said it was good, while 2.1% and 11.2% said it was bad and do not know, respectively. A significant number of respondents indicated global warming was an act by the gods. It is worrying to note that, although majority of the respondents know global warming has an impact on human health, they are unaware of the degree of the impact to their health.

Respondents' perceived causes of global warming include natural processes, deforestation, act of the gods, burning of fossil fuel, and carbon dioxide ($CO_{2)}$ emission from vehicles and industries. The majority of the respondents (83.4%) indicated that global warming has an impact on human health, while 8.5% indicated that it does not. Majority (78.6%) of the respondents are willing to support efforts to reduce the intensity of global warming. Television (19.1%) and social media (18.6%) were the leading preferred methods for receipt of global warming information. These findings provide useful insights for policy directions. The Government of Ghana and other stakeholders in health should develop a communication strategy to increase and sustain publicity and education of the citizenry on global warming.

Gebska et al., (2020) investigated Polish farmer's awareness of environmental sustainability with regards to animal and crop production. The paper shows how farmers value the advantages arising from sustainable production. The study was carried out among 300 farms classified by type (dairy, beef cattle, pork, and crop production). The research instrument used was a questionnaire, with the Likert scale. The results show that dairy cattle farmers and pork farmers declared higher knowledge and better implement sustainable practices than other farmers.

The producer's views on the benefits coming from sustainable agriculture varied. However, the two most significant advantages were recognized—the protection of water against pollution and the reduction of greenhouse gas emissions. Reduction of greenhouse emissions was recognized as the most significant environmental benefit. Compliance in this respect occurred among farmers from pork, dairy cattle, and crop production farms. On the other hand, producers of beef cattle mainly pointed to the increase of biodiversity in the natural environment. The most vital element was knowledge and experience acquisition. The results suggest

that implementing sustainable development rules depends significantly on farmer's awareness/knowledge as well as the implementation of best practices.

In the Nigerian agricultural sector, translation of policy level commitments into practice remains a challenge, and has so far been impeded by low public expenditure on agricultural research and extension, limited and inappropriately trained human resources in the agricultural sector.

Climate change is a major issue around which global development policy is being framed over the past few years. Because of low adaptive capacities and the projected impacts of climate change, a consensus has emerged that developing countries are more vulnerable to climate change than developed countries. This is due to the predominance of rain-fed agriculture in their economies, the scarcity of capital for adaptation measures, their warmer baseline climates and their heightened exposure to extreme weather events. The Niger Delta region of Nigeria is known to be particularly vulnerable because of its fragile ecosystem and human activities such as gas flaring that have heightened the propensity of climate change and its impacts in the region. Unfortunately, knowledge of Niger Delta farmers about climate change leaves much to be desired. Recognizing this, the present study sought to investigate farmers' level of awareness of climate change and potential adaptive measure for climate change in the region.

Ado et al. (2018) study was undertaken to assess farmers' awareness and perceptions of climate change impacts in Aguie Department, Niger Republic. Descriptive statistics and a regression model were used for data analysis. The results from a descriptive analysis show that the majority of respondents (84.4%) were aware of climate risks, but had differing perceptions of climate change impacts on production and annual revenue. A regression test revealed that climate-related information is highly significant in determining farmers' awareness of climate change impacts. Most of the respondents reported negative impacts from climate change, and the majority, therefore, adjusted their farming system, albeit at different levels. A probit analysis shows that awareness, perception, education, crop production, soil fertility and annual revenue are highly influential on farmers' climate change impacts adaptation.

This research highlights farmer awareness and perceptions as key factors in the climate change impacts adaptation debate. The findings reveal that effective adaptation to climate change impacts is highly dependent on the extent of community awareness and how farmers perceive the impacts of climate change. The study highlights that institutions targeting households' livelihood improvement and making decisions concerning climate change adaptation need to focus on media outreach in local languages, improving locally adapted extension services, and developing water use efficiency measures such as improved irrigation for effective and long-term adaptation.

Nzeadibe et al. (2017) researched on Climate Change Awareness and Adaptation in the Niger Delta Region of Nigeria. The purpose of the study is to examine the level of awareness of Niger Delta communities about impacts of climate change and to identify and document innovations and practices for climate change adaptation by farmers in the study area. Multistage sampling technique was used to interview 400 heads of farming households in Cross Rivers, Delta and Rivers States. Analysis of the data utilized simple descriptive statistics while the results were presented as tables, figures and charts.

Two single gender Focus Group Discussions (FGDs) were conducted in each of the survey states giving a total of six FGDs. Data from the FGDs complemented the survey results. Findings of this study indicate that the level of awareness of local communities of climate change impacts was still low in the Niger Delta region of Nigeria. About 60% of respondents know little or nothing about climate change and its impacts. It was found, however, that the mass media played a major role in climate change awareness in the study area. At the policy-making level, it is recommended that policy makers should recognize and incorporate the innovative practices of the farmers in designing Agricultural and Climate Change Policy in Nigeria.

Fahad et al. (2020) researched on Farmer's awareness level and their perceptions of climate change, the purpose of research aims to examine the Pakistani farm household's awareness level of climate change and its associated factors. By using structured questionnaire in data of 400 study participants were collected from four districts of Khyber Pakhtunkhwa (KP) province of Pakistan through a household's survey. A stratified random sampling technique was utilized for collection of primary data. A probit model approach was employed to analyze the farm households' awareness of climate change and its associated socioeconomic and demographic variables. Results of the study exposed that 73 % farm households were aware of climate change. Socio economics and demographic variables such as age of farm households, education level, farming experience, land ownership status, extension and information sources access were pointedly related to farm households' awareness of climate change. The study further investigated the farm households' knowledge of climate change as well as their adaptation behavior.

Among the study participants and policy variables, extension services availability, land ownership and access to information services were strongly related to awareness of climate change. Findings of the study showed that the farm households surveyed indicated that they are already been engaged with active adaptation strategies. Also, study analysis of farm households' adaptation and perception behavior also propose a

comprehensive awareness of the importance of climate in defining the effectiveness of agricultural schemes. Furthermore, results of the study also revealed that the evaluation of farm households' adaptation behavior suggests that farm households are active in using several adaptation strategies such as crop diversification and use of irrigation.

Moreover, the strong association of extension services access with dependent variable revealing that a farm household having contact with extension officer may lead to increase probability of climate change awareness. The variable access to information illustrated a statistically significant relationship with farm households' awareness level, which shows that farm households who have adequate information access or knowledge about climate change are more aware of climatic variations. In the surveyed districts, farm households mentioned that the core information source was the government.

Ajuang et al. (2016) researched on determinants of climate change awareness level in upper Nyakach Division, kisumu county, Kenya. Improving the understanding of climate change awareness is one of the top priorities in climate change research. While the African continent is among the regions with the highest vulnerability to climate change, research on climate knowledge and awareness is lacking. Kenya is already grappling with the impacts of climate change, which are projected to increase in a non-linear and non-predictable manner. This study sought to determine climate change awareness levels among households residing in Upper Nyakach Division, Kisumu County, Kenya using common climate change markers viz heavy rainfall, floods, droughts and temperature. A cross-sectional survey design was adopted in which 384 household heads were selected as respondents from 11 sub-locations; all located within Upper Nyakach Division. A questionnaire was used to collect data. Most (90.9 %) respondents had observed changes in the overall climate. Awareness level of climate change varied significantly across the 11 sub-locations.

To further gain insight unto which variables were the most significant determinant of climate change awareness in upper Nyakach division, Kisumu county, a Generalized Linear Model (GLM) with Poisson error distribution was built. The model indicated that sex of the household head, education level and age significantly influenced respondents' awareness to climate change markers. Most (87 %) households reported rising temperatures over the past 20 years. Over half (55.2 %) the respondents had observed declining rains, with significant differences being observed across age groups.

Up to 75 % of the respondents reported increased droughts frequency over the last 20 years, with significant differences observed across gender. Most (86.7 %) respondents reported having observed changes in water sources with significant differences reported across age groups. The respondents reported an increased prevalence of malaria with significant differences being observed among the education levels and households' main livelihoods. The general population of the Upper Nyakach Divison is aware of changing global climate. However, more effort is required in mitigating climate change as per the local settings. Awareness campaign aimed at increasing knowledge of climate change markers among community members is recommended.

Chukwuji et al. (2019) researched on Awareness, Access and Utilization of Information on Climate Change by Farmers In Zamfara State, Nigeria. The study adopted survey research design. The population of the study consisted 1200 respondents comprising (staff of the Zamfara State Agricultural Development Project, FADAMA III Project, IFAD, Animal rearers and Farmers). Instruments of data collection used for the study were questionnaire, interview and discussions. One thousand two hundred questionnaires were distributed to respondents and only 988 (82.2%) were dully returned and found usable. The results of the responses were interpreted using simple percentage and frequency tables. The findings of the study include, that 95% of Zamfara State population are farmers, Maru and Gusau Local Government Areas recorded the highest farmers' population.

It was discovered that there were thirty (30) Climate Change Information available to farmers in the State, some of which are: Rainfall Prediction, Rainfall establishment, Drought prediction, Drought resistant crop varieties, causes of Flooding and its menace, windfall direction, relative humidity, time of fertilizer application. Sources of climate change information to farmers in Zamfara State include, Radio, Television, Face to face interaction with farmers (Extension Services), Zamfara Agricultural Development Project, International Fund for Agricultural Development, Nigeria Metrological Agencies and FADAMA III Project, others include Posters, Handbills, Newspapers, Pamphlets and Textbooks.

Farmers were aware of climate change information which include actual amount of rainfall, high temperature, flooding and its menace, rainfall prediction, drought prediction, soil cultivation, irrigation systems, bush fallow, time of fertilizer application, slight change in time and season and depression of underground water. Farmers in the state had access to the following information on climate change such as animal disease prediction, mitigation, fish farming, improved crop varieties, erratic rainfall, flood and rainfall prediction, planting of short time and longtime variety of crops.

Farmers in Zamfara State utilized information on climate change in the following areas: taking decision on when to or what to plant, planning mitigation, deciding on when to move the herd for grazing, time for fertilizer application, bush burning, planting of improved variety of crops and disease resistant crops. It was

also discovered that farmers in the State utilize climate change information like taking decisions on what and when to plant, planting improved crop varieties among others. There is also the challenges of reduction in annual rainfall, deforestation, insect-pests attack, high temperature among others. However nothing was reported on awareness with regards to bio-methane emission from livestock farming as well as its mitigation measures.

Falaki et al. (2013) researched on Analysis of Climate Change and Rural Farmers' Perception in North Central Nigeria. This study examined farmers' perception of temperature and rainfall between 1980 and 2009, and how age, sex, education and household size correlated with climate change perception. Simple random sampling with proportionate representation was used to determine sample size (411) from a sampling frame of 6000 farmers. Structured questionnaire was used for data collection and this was supplemented with interview of key informants. Temperature and rainfall records of Makurdi Meteorological Station were used as proxy for the study area.

Data were analyzed using regression and Pearson Product Moment Correlation. Results showed an increasing trend in temperature and rainfall amount, rainfall unpredictability, corroborated by majority of the farmers' perception. Bush burning and tree cutting were ranked as leading causes of climate change. Sex was significantly related to climate change perception and adaptation. Age, sex education and household size had significant impacts on the farmers' perception of climate change effect on social, biological and eco-system functions. In conclusion, rural farmers correctly perceived the changes in the climate.

Okonya et al. (2013) investigated Farmers' Perception of and Coping Strategies to Climate Change: Evidence from Six Agro-Ecological Zones of Uganda. In Uganda, weather-related events such as prolonged dry seasons, floods, storms, mudslides, extreme rainfall, and delayed/early rains have become more frequent and/or intense. This has left most of the rural poor farmers' food insecure and their livelihoods threatened. A total of 192 sweet potato farmer households distributed in six agro-ecological zones were interviewed to assess how farmers perceive the effects of changes in climatic variables, and how they have adjusted their farming practices to cope with the changes in climate. Gender of the household head and size of land owned significantly affected adaptation. Ninety nine percent of all households interviewed had observed a change in the climate in the last 10 years. Drought and floods had the highest impact on crop production across agro-ecological zones.

Coping strategies towards extreme events included storing food, income diversification and digging drainage channels. Other strategies were planting trees; high-yielding, early-maturing, drought-tolerant, disease and/or pest-resistant varieties; planting at onset of rains; increased pesticide/fungicide application among others. Farmers manage risks, including those related to climate, regularly as part of their everyday lives. However, there is a need for farmers not only to cope with the impacts of a changing climate but rather to adapt in order to reduce the negative impact of climate change. Socioeconomic and environmental factors have a big role to play in the way farmers perceive and later adapt to impacts of a changing climate. Coping strategies to protect farmers against climate related hazards included storing food, planting early and digging drainage channels. Other strategies included planting early-maturing varieties, high-yielding varieties, drought-tolerant varieties, disease- and/or pest-resistant varieties, income diversification, tree planting, increased pesticide/fungicide application, among others.

The smallholder farmer households studied have a high awareness of changes in rainfall and temperature and have taken measures to cope with effects of a changing climate. In this survey, factors that hindered adaptation included poverty (inability to pay for farm inputs, equipment and services like labor), unreliable weather forecasts, and shortage of food to store, among others.

Source of Farmer's Information on Nutritional Supplement used in Reduction of Methane Emission in Livestock Farming

Climate change is no longer a new phenomenon in Nigeria especially among farmers however, using nutritional supplement in reduction of methane emission in livestock farming is not popular among livestock farming in Nigeria. Knowledge and information are the basic ingredient for improved Agricultural productivity, however access to the right information, at the right time, in the right format may shift the balance between success or failure of the information adoption. Therefore research agricultural results should be presented to farmers through sources whose attribute are acceptable to the farmers to ensure a change process of a farming community. A source of information must be credible, reliable, and above all familiar to the user before he/she will adopt the technology and this insures sustainability of such innovation.{ FAO, (2014)}

Fidelugwuowo in (2020) researched on Knowledge and skills for accessing agricultural information by rural farmers in South-East Nigeria. Rural farmers make up the majority of crop producers in any developing economy. Their level of access to agricultural information stems from the knowledge and skills they possess. This article aims to identify the sources of agricultural information and the level of knowledge and skills rural farmers possess for accessing such information in South-East Nigeria. A structured interview schedule and focus

group discussions were used to collect relevant data. The method of analysis involves frequency counts, percentages and means. The study reveals that 41.7% of the respondents were between the ages of 41 and 50, while 62.6% were married, 84.8% were Christians and 29.8% had no formal education. The major source of agricultural information was through friends and co-workers, while the knowledge and skills they possessed for accessing agricultural information were generally low. The work provides an objective framework and measure of the existing competencies, and identifies the need for further skills acquisition.

Owolabi, in (2018) researched on Utilization of Agricultural Information and Knowledge for Improved Production by Rice Farmers in Ondo State, Nigeria. The main objective of this study was to examine the utilization of agricultural knowledge and information by rice farmers in Ondo State, Nigeria. Multistage random sampling technique was used to select a sample size of 80 respondents. Primary data was collected with the aid of a well-structured interview schedule. The data collected was analyzed with both descriptive and inferential statistics.

The results of the study revealed that rice farmers in the study area have a variety of information needs including information on pests and diseases management practices, mechanical land preparation and planting, use of farm machines, improved storage methods and agricultural credit/loan. Key sources of information used by the respondents were friends and relatives and radio. Access to and utilization of agricultural information and knowledge on improved rice production cultural practices were generally high among the respondents as the ground means were both 3.23. The result of the linear regression analysis indicated a significant relationship between farm size (b=0.802, t=12.104; p=0.05. Also, the result of the correlation analysis revealed that there was a significant relationship between respondents' access to extension services and utilization of agricultural information and knowledge (r=0.259; p=0.05).

Onu, et. al. (2018) researched on Essential Knowledge and Skills Required by Rural Farmers in Making Cell Phones Effective for Boosting Agricultural Production in Enugu State, Nigeria. The study determined the essential theoretical knowledge and skills required by rural farmers in making cell phones effective for boosting agricultural production in Enugu State. Five research questions guided the study while five null hypotheses were formulated and tested at 0.05 level of significance. The study adopted descriptive survey design. The population for the study was 87comprising 52 lecturers in tertiary institutions and 12 cell phone technicians and 23 extension agents. The sample size for the study was 87 made up of 52 lecturers in institutions, extension agents and 12 literate cell phone technicians in major towns in Enugu State. Purposive sampling technique was employed to select 12 literate cell phone technicians 23 extension agents while all the lecturers were studied.

The instrument for data collection was structured questionnaire and three experts validated the instrument while Cronbach alpha reliability method was used to determine the internal consistency of the items and a coefficient of 0.88 was obtained. Mean was used to answer the five research questions while analysis of variance was used to test all the null hypotheses at 0.05 level of significance. The study found out 99 items; 32 knowledge and skills to obtain agricultural information, 19 agricultural information, 16 operational skills, 19 maintenance skills and 14 precautionary measures were required by rural farmers for using all kinds of cell phones. There was no significant difference in the mean responses of respondents on the essential theoretical knowledge and skills required by rural farmers for using all kinds of cell phones for boosting agricultural production. Based on these findings, recommended include that all the essential knowledge and skills determined in this study should be utilized to organize workshop for rural farmers. It was also recommended that trainers should adopt appropriate procedures for effective training of rural farmers using the determined knowledge and skills.

Chinasa et al. (2020) researched on Information Needs of Rice Farmers on Inorganic Fertilizer Use in Ebonyi State, Nigeria. This study ascertained information needs of rice farmers on inorganic fertilizer use. One hundred and twenty rice farmers purposively selected from Ebonyi State, Nigeria constituted sample for the study. An interview schedule was used to collect data while percentage, mean scores and factor analysis were used for data analysis. Findings indicated that the majority (92.5%) of the respondents obtained information on inorganic fertilizer use from families and friends, all (100%) the respondents obtained fertilizer from the markets while 98.4%hadnotraining on inorganic fertilizer use. Important areas that respondents required information on inorganic fertilizer use for rice production were on how to get fertilizer easily (=1.89), how to detect good or bad fertilizer (=1.86) among others. Institutional, technical, logistic and health constraints limited the farmers from using inorganic fertilizer in rice production. Provision of fertilizer subsidy by

government (99.2%) and increase in accessibility of fertilizer by farmers (98.3%) were some of the strategies for improving inorganic fertilizer use on rice production. Extension should furnish farmers with information and training on where to get good fertilizer easily and how to use them in rice production.

According to Opara (2008) Agricultural information reaches farmers through different sources namely extension agents, mobile extension film shows, age grade, fellow farmers, contact farmers, extension leaflets, friends and relatives, farm demonstrations, banks, community meetings and agricultural shows. Describing the desire to use or not to use a particular source of information is affected by the source/channel because of the information credibility.

Opara (2008) who researched on sources of agricultural information available to farmers in Imo state reported that Nigerian farmer ranked the Extension Agent highest as a source of credible information and advice. The findings of this study emphasize the importance of the extension agent in the agricultural information transfer chain. The result showed 88.1% of farmers indicated agricultural extension agents as their credible source of information, 71.2% indicated fellow farmers, 63.2% indicated radio, 43.3% indicated television. FAO (2014) supported that about 78% of smallholder farmers in Uganda access information through conventional extension. Communication channels such as televisions (TVs), radios, videos and telephones can greatly enhance access to information and stimulate learning among farmers.

According to Karubanga et al., (2016) agricultural extension is perceived as the primary mechanism through which farmers expand their ability to adopt and adapt new technologies and ideas. The use of Information and Communication Technology like videos in extension is being fronted as an alternative to the conventional Face-to-face extension approach (F2FEA). A comparison of effectiveness of the Video-mediated extension approach (VMEA) and F2FEA among rice farmers in two districts of Uganda challenges the independent use of the two approaches. A cross-sectional survey of two non-equivalent groups subjected to VMEA in Kamwenge district and F2FEA in Hoima districts was conducted with 196 farmers.

The results indicate greater potential for integration of VMEA and F2FEA as the two are complementary in the various stages of the farmer learning framework developed. VMEA is significantly better in awareness creation and sharing of knowledge and experiences while the F2FEA is significantly better at enhancing knowledge acquisition and retention and application. The relative strengths of VMEA and F2FEA can best be harnessed through integration of the approaches. VMEA and F2FEA are complementary approaches, which could be integrated for better efficiency of extension services delivery. The integration however calls for rethinking of institutional arrangement, roles of the extension worker, and pragmatic retooling of the extension worker to embrace social learning principles that empower farmers to be more self-directed learners and innovators. Karubanga et al (2016) further confirm a known fact, in terms of creating awareness, the VMEA is more effective and yet cheaper in terms of mobilization compared to the F2FEA.

Karubanga et al. (2016) shows that farmers who participated in VMEA applied less of the acquired knowledge than those who participated in F2FEA. This was possibly due to follow up of farmers (individually or in groups) in the F2FEA by extension worker to provide technical assistance for putting acquired knowledge into practice. In the VMEA, farmers relied more on exchange between themselves and less technical support from experts as a follow up mechanism. However, it is also possible that the F2FEA focused more on priority needs of the farmers as compared to the VMEA where farmers had no opportunity to determine the content of the videos.

There was association between the extension approach used and level of sharing knowledge among farmers. A large proportion (86%) of farmers who participated in VMEA reported to have shared the knowledge they acquired and or generated through their own practice compared to 67% of those who participated in F2FEA.

Karubanga et al., (2016) concluded that the use of video in extension enhances more awareness, stimulate demand for technical support, foster farmer-to-farmer learning and enhance innovativeness, and creativity among the farmers. Appropriate integration of the two approaches implies that ICT developers and policy makers need to acknowledge that the two approaches cannot produce a desired farmer learning to enhance innovation in isolation but complement each other to ensure more effective and self-directed learning. However, the type and style of the extension itself has evolved much over time. For instance, advances in satellite mapping and information and communications technologies (ICTs) are transforming more traditional agricultural extension work today. Farming is becoming more precise and productive as a result.

Adi, et al., (2016) researched on the Use of Agricultural Information Sources and Services by Farmers for Improve Productivity in Kwara State This study was carried out to investigate the use of agricultural information sources and services by farmers for improve productivity in Kwara state, Nigeria. The objectives of the study was to determine the information sources and services available to farmers in Kwara State and assess the purpose for which farmers in kwara state utilize available information sources and services. The study adopted the survey design in a population of 55,522 farmers from whom 447 were sampled in six local government areas, which were made up of two from each of the three senatorial districts in the State. Questionnaire and interviews were used to generate data, which were descriptively analysed to answer the research questions.

The results showed that the information sources and service mostly used by the farmers included relations, fellow farmers, town criers, television, mobile phones, film shows, radio, etc. The need for information made the farmers to use it for crop and animal production; pests, diseases and weed control; fishing; disaster control and mitigation, fertilizer procurement and application; post-harvest technology; sourcing for labour; agricultural credit; etc. The study therefore suggested that Kwara State Government should train extension workers on how to use information communication technology such as mobile phone on how to subscribe for agricultural information and also there is a need to extend agricultural extension services to all the local government areas through established centers where farmers can obtain required information on agricultural productivity, marketing of farm produce and post harvest technology to increase their productivity.

Farmer's Adoption of Nutritional Supplement to Reduce Methane Emission in Livestock Farming.

Adoption is a decision to make full use of an innovation as the best course of action available and education has been found to be catalyst in the adoption of innovation for agricultural production. Rogers Diffusion of innovation theory is of the opinion that there are five factors that influence adoption of innovation namely, Relative advantage (the degree to which an innovation is perceived as being better than the idea it supersedes), compatibility (the degree to which an innovation fits with the existing values, past experiences and the needs of potential adopters), complexity (the degree to which an innovation is perceived as difficult to understand and use), trialability (the degree to which an innovation may be experimented with on a limited basis. Although, most innovations that require investing time, energy and resources are not readily adopted) and observability (the degree to which the result of an innovation are visible to the adopters). When key adopters of innovation perceive innovations as being simple to use, the innovation will be easily adopted.

It is the responsibility of people working in the agricultural extension to persuade farmers to embrace the new technology and agricultural technology processes. The adoption is a mental process which consists of several stages and relates to the farmer's decision to accept or reject a particular technique. Mitigation strategies that do not hamper production along with being able to reduce enteric methane ($\boldsymbol{E}CH_4$) emissions in ruminants have better acceptance among farmers and the industry. In practice, farmers are less likely to adopt any of the mitigation technologies that do not attain a minimum sustainable production level or are not economically viable, while reducing methane emissions. Several empirical studies have been carried out to investigate the factors that determine agricultural technology adoption.

According to FAO 2020, adoption of climate resilient agricultural practices in agricultural production remains a big challenge to young budding agri-prenuers because of the cost of inputs. Livestock Farmers are mindful of the production cost before adopting any feeding methods. Concluding that factors that influence farmers adoption include; Awareness, Education level, Farm size, Diversity of production, Annual revenue, benefitting from agricultural incentives and Membership to farmer's Association.

Gairhe et al., (2017) researched on adoption of improved Potato varieties in Nepal. Nepal is one of the top twenty countries where potato contributes substantially for the human diet. Enhancing adoption of improved potato varieties could impact on farmer's income, household food and nutritional security. A multistage sampling procedure was used to conduct a study to assess the determinants of improved potato varieties adoption in Nepal covering 180 samples in four districts, two in hills and two in Tarai region. The study examines the determinants of adoption of improved potato varieties in Bara district of Nepal. Data was obtained from 51 potato farmers through the use of structured questionnaires. The study employed descriptive statistics and regression analysis to assess adoption status and its determinants. The study revealed that; Kavre and Bardiya districts in the hills and Tarai, respectively, were dominated by improved potato varieties adoption. On the other hand, Dhankuta and

Jhapa in the hills and Tarai, respectively, were dominated by local potato varieties adoption. The informal seed sources followed by agro-vet and market were the major sources for improved varietal adoption.

The results of the regression analysis showed that household size has negative influence on adoption of improved potato varieties while land tenancy, cattle ownership, contact with extension agents, age and level of education have positive influences. Farmers' accesses to training and formal seed sources were important factor determining improved potato varietal adoption. However, households with larger farm size were less likely to allocate more area for improved potato varieties as many of farmers were reluctant to take potato cultivation as agri-business and still follow subsistence farming. Potato R&D programs, therefore, need to strengthen formal seed system to enhance access to quality potato seeds and build producer's capacity through regular training and exposure visits in order to improve adoption of improved potato varieties in Nepal. It is recommended that adult education should be provided to the adult farmers and the number of extension agents should be increased who would help introduce new potato varieties and improve technical and managerial skills of farmers through improved extension services.

Elahkwe et al., (2021) researched on Factors that determine the adoption of improved Irish potato technologies by farmers in the western region of Cameroon. This work examined the determinants of the adoption of improved Irish potato technologies by farmers in three divisions of the Western Region of Cameroon. Data were collected from 170 farmers from 14 villages in our study area using a mixed-method approach—structured questionnaires, focus group discussion, key informant interviews, and participatory observations with individual farmers and farmers belonging to cooperative and common initiative groups. The study employed descriptive statistics and regression analysis to assess the adoption status of farmers and its determinants. The logistic regression analysis showed that farmers' experience in the cultivation of potatoes, the number of follow-ups, and access to extension facilities after training had a significant positive effect on the adoption of these new technologies while membership to an association had a significant negative effect.

Additionally, farmers who received improved seeds from NGOs were more likely to adopt a technology than those who did not. Our results suggested that constant follow-up and training of experienced farmers and the provision of improved potato seeds have the potential of maintaining high rates of Irish potato adoption west in Cameroon irrespective of whether they belong to cooperative or not.

Furthermore, the development of a good memorandum of understanding between farmers and leaders of association and transparency in the management of funds and other benefits generated from the running of farmers association. Also, the number of follow-ups as well as extension training, and market linkages for farmers should be increased. Additionally, more farmers should join farmer groups such as cooperatives or common initiative groups to increase their awareness rate and adopt improved potato innovation through farm extension.

According to Rehman et al. (2016) a key determinant of sustainable Adoption is the profitability of agricultural enterprise and changing prices for agricultural product are shown to be a major factor in agricultural technology adoption. Farmers can abandon the technology if the expected benefits from adoption are lower than the prevailing cost. Explaining the basic challenge of sustainable adoption is to make better useage of internal resources. Moreover, due to less availability of agricultural credit facilities, small scale farmers are facing more difficulties in adopting new technologies to increase their agricultural productivity.

According to Panel et al. (2020) researched on predictions of the speed and extent of adoption of new agricultural practices and technologies are needed to inform decisions and plans in agricultural policy, research and extension. Using an existing tool for predicting the adoption of agricultural innovations in developed countries as the starting point, they identified a number of distinctive features of smallholder agriculture in developing countries that affect agricultural adoption.

Additional factors that need to be considered when making predictions of adoption by smallholder populations include: They may be relatively more heterogeneous in their constraints, capabilities, resources, attitudes and priorities; they may be more influenced by particular cultural norms; they may prioritize subsistence over profits; they may be less reliant on agriculture as their primary source of income; they may have relatively high future discount rates; non land owner farmers may be less able to capture the benefits resulting from an innovation; and there may be lower and slower diffusion of information across the farming population, with more variable extension quantity and quality.

Dhraief et al., (2018) researched on "Factors Affecting the Adoption of Innovative Technologies by Livestock Farmers in Arid Area of Tunisia". Economic, socio-demographic and institutional variables were selected as factors. A sample of 200 farmers were considered, only half of them adopted the IT. A binary logistic regression was used for the analysis. Regarding economic and socio-demographic factors, farm education, size of cattle flocks and off-farm income were statistically significant and positive influence on technology adoption while age and farm experience had significant and negative effects on IT adoption decision. For the institutional factors, member of association, extension services and source of technology knowledge were significant factors and affected positively the adoption decision. In contrast, it was found that labor and credit services do not significantly influence adoption of IT.

Harvey et al. (2018) researched on Climate change impacts and adaptation among smallholder farmers in Central America. The study surveyed 860 smallholder coffee and basic grain (maize/bean) farmers across six Central American landscapes to understand farmer perceptions of climate change and the impacts they are experiencing, how they are changing their agricultural systems in response to climate change, and their adaptation needs. Result showed that almost all (95%) of the surveyed smallholder farmers have observed climate change, and most are already experiencing impacts of rising temperatures, unpredictable rainfall and extreme weather events on crop yields, pest and disease incidence, income generation and, in some cases, food security.

For instance, 87% of maize farmers and 66% of coffee farmers reported negative impacts of climate change on crop production, and 32% of all smallholder farmers reported food insecurity following extreme weather events. Among the farmers perceiving changes in climate, 46% indicated that they had changed their farming practices in response to climate change, with the most common adaptation measure being the planting of trees. There was significant heterogeneity among farmers in the severity of climate change impacts, their responses to these impacts, and their adaptation needs. This heterogeneity likely reflects the wide diversity of socioeconomic and biophysical contexts across smallholder farms and landscapes.

The study demonstrates that climate change is already having significant adverse impacts on smallholder coffee and basic grain farmers across the Central American region. There is an urgent need for governments, donors and practitioners to ramp up efforts to help smallholder farmers cope with existing climate impacts and build resiliency to future changes. Results also highlight the importance of tailoring of climate adaptation policies and programs to the diverse socioeconomic conditions, biophysical contexts, and climatic stresses that smallholder farmer's face.

Gebru et al., (2021) researched on adoption analysis of agricultural technologies in Ethiopia. Agricultural technology change is required in developing countries to increase the robustness to climate-related variability, feed a growing population, and create opportunities for market-oriented production. This study investigates technological change in the form of adoption of improved wheat, drought-tolerant teff, and cash crops in the semiarid Tigray region in northern Ethiopia. Analyzing three rounds of panel data collected from smallholder farms in 2005/2006, 2009/2010, and 2014/2015 with a total sample of 1269 households. Double-hurdle models are used to assess how the likelihood (first hurdle) and intensity of technology adoption (second hurdle) are affected by demographic, weather, and market factors. The results indicate that few smallholders have adopted the new crops; those that have adopted the crops only plant small shares of their land with the new crops, and that there has been only a small increase in adoption over the 10-year period. Furthermore, we found that high population density is positively associated with the adoption of improved wheat, and previous period's rainfall is positively associated with the adoption of drought-tolerant teff. The adoption of cash crops is positively associated with landholding size and access to irrigation. The policy implications of these results are that the government should increase the improved wheat diffusion efforts in less dense population areas, make sure that drought-tolerant teff seed is available and affordable after droughts, and promote irrigation infrastructure for production of cash crops.

Abebe et al., (2018) researched on Determinants of adoption of improved forages in selected districts of Benishangul-Gumuz, Western Ethiopia. This study explores different socio-economic and institutional factors influencing the adoption of improved forage technologies in Assosa and Bambasi districts of Benishangul-Gumuz, Western Ethiopia. Moreover, research has not been conducted to determine the factors that influenced the adoption or lack of adoption by farmers in the area. This paper examines factors that influenced why farmers either adopted or failed to adopt the new forage technologies. Major household characteristics plus socio-

economic and policy factors affecting the adoption of improved forage crops are identified, and suggestions are made for strategies to increase rates of adoption.

A structured questionnaire survey was applied to collect information from 120 farm households, and a binary logistic regression model was used to quantify the factors determining farmers' decisions to adopt improved forages. The analysis revealed that access to agricultural extension services, participation in forage training sessions and higher cash income had the greatest positive influence ($P<0.05$) on adoption of forage technologies, while higher numbers of male adult labor units and use of fertilizers had a lesser effect ($P<0.10$). In contrast, farmers remote from offices of development agents and possessing greater numbers of equines were less likely to adopt improved forage technologies.

Access to training also had a highly significant and positive influence on forage adoption ($P<0.01$). The model estimate showed that, other things remaining constant, the odds ratio in favor of forage adoption increases by a factor of 9.5 as farm households receive training on forage production and management practices. The marginal effect of this variable indicated that, if the household has access to training, the probability of adoption of improved forage varieties increases by 38.8%.

It is suggested that adoption of improved forage technologies could be enhanced by providing farmers with training sessions, raising household income and providing greater access to extension services and that these factors should be considered by planning bodies. In Benishangul-Gumuz, where this study was conducted, crop production integrated with livestock farming is the main-stay of the population. Two farming systems are practiced, namely: shifting cultivation; and permanent farming systems. The former is an agricultural system where plots are cultivated temporarily and then abandoned. Improved forage species, including elephant grass *(Pennisetum purpureum),* oats *(Avena sativa),* rhodes grass *(Chloris gayana),* pigeon pea *(Cajanus cajan)* and *Sesbania* species, have been introduced in an endeavor to increase the amount and quality of available forage and have been promoted in the region by Assosa Agricultural Research Center for the last decade. However, adoption of these technologies by smallholder farmers has failed to reach expectations.

Beshir, H. (2018) researched on Factors Affecting the Adoption and Intensity of Use of Improved Forages in North East Highlands of Ethiopia. Analysis of crop-livestock integration aims at understanding the existing interactions between crops and livestock and assessing their potential for improvement in smallholders' farming systems. The objective of this study was to identify factors affecting the probability of adoption and intensity of use of improved forage technologies in mixed farming systems in two districts of south Wollo zone, in Ethiopia. A double hurdle model was employed using data collected from randomly selected 252 farmers between July 2009 and November 2009. The study revealed low utilization of improved forage seed which covered only 1.3% of total cultivated land in Ethiopia.

The results of the study provided empirical evidence of a positive impact of extension and credit service in enhancing the probability of adoption of improved forage technologies. The intensity of use of improved forage in the study area was influenced by labour available, size of livestock ownership and farm size. Physical characteristics like distance from farmers' home to all weather roads, markets and input supply played a critical role in the adoption of improved forage technologies. Therefore, the results of the study suggest that the adoption of improved forage should be enhanced by raising farm household asset formation, and providing extension and credit services.

Fekade et al. (2019) researched on Improved Forage Production in Ethiopia: Utilization, Challenges and Prospects for Adoption. There are several factors that hinder the productivity of livestock in Ethiopia of which nutrition contributes the largest share. The quality and quantity of feed are poor challenging livestock production. Nowadays, due to the rapid increase of human population and increasing demand for food, grazing lands are steadily declining by being shifted to arable lands for crop production. As a result, food crop residues are providing a considerable quantity of dry season feed in most farming areas of the country. However, the feeding value of crop residues is very poor. One way to alleviate this problem is supplementation of crop residue through the use of improved forage and fodder trees.

Research and development agents have been testing and identifying promising forages that are suitable for pasture rehabilitation in a wide range of agro-ecological zones besides animal feeding. Forage development strategy have been practiced long ago, but its adoption by the farming community has been very low because of various factors such as lack and unadoptable forage technologies, poor extension services, lack and high cost of

planting materials, reluctance of most smallholder farmers and size of livestock ownership and farm size. The use of forage legumes have a paramount role resulted in increasing soil nitrogen available for food crops because of their ability to fix nitrogen. Moreover, multipurpose browse trees and shrubs serve as fuel wood resource. Improved forage legumes and browse species provides protein which enhances the feed resources available for livestock.

The major impediments of improved forages production in different parts of the country are ecological deterioration, overgrazing, land tenure, border conflict, drought, weed and bush encroachment, lack of seed and planting materials. The diverse topography coupled with environmental heterogeneity offers favorable environments for pasture species, herbaceous legumes and browse trees/shrubs. Hence, assessing the conditions, challenges, opportunities and recommendations of improved forage production is very imperative for effective and efficient utilization of these feed resources to boost the productivity of the livestock sector in the country.

Tefera et al., (2019) researched on Farmers' utilization practice, yield and chemical composition of selected improved forages grown in natural resource management areas of Farta District, South Gondar Zone, Ethiopia. The study was conducted with the objective of assessing farmers' utilization practice, yield and chemical composition of selected improved forages grown in natural resource management areas of Farta District, Ethiopia. The methodology of this study encompassed questionnaire survey, group discussion, field measurement and laboratory analysis. Simple random sampling was used to select a sample consisting of 100 households in the district. Forage samples were collected from three sample places in mid and highlands Kebeles (lower level political administration in Ethiopia).-Samples of forages were taken after 2 months of equal cutting and used to determine the biomass yield and chemical composition.

The collected data were analyzed by SPSS and SAS software. The result indicated that of the total respondents 91% and 88% of in high land and midlands, respectively, did not use any forage improvement practice after plantation. Concerning forage utilization as feed, 96 and-94% in the high and midland, respectively, practiced cut and carry system. From the sampled forages, a biomass DM yield of Sesbania sesban in highland midland of the study area was 7.8 and 7.64t/ha, Elephant grass 14.28t/ha and 13.84t/ha and Tree Lucerne 7.65t/ha and-7.4t/ha, respectively. The crude protein (CP) content of sample forages was varying from 8.02% in Elephant grass to 25.9% in Sesbania sesban. Overall, improved forages grown in natural resource management areas have a very important function in terms of contribution of nutrients to livestock and indirectly for the household economy in both mid and highland areas. Hence, intervention on management and utilization of forages grown in the natural resource areas is crucial to exploit the resources.

Nwozuzu et al., (2021) researched on Percieved constraints to adoption of improved poultry technology among poultry farmers in owerri agricultural zone of Imo state, Nigeria. The study determined farmers' response to poultry extension services in Owerri agricultural zone Imo state Nigeria. Poultry farmers would not break even in their business enterprise without adoption of improved techniques of farming. One hundred and twenty farmers were randomly selected for the study and data was analyzed using descriptive statistics, mean score (Likert type rating scale), component bar chart and Ordinary least square multiple regression was used to analyze the hypothesis.

Findings revealed that education was an important factor that determined farmers participation in extension programmes. Young farmers were also more receptive to extension programmes. The results also revealed that their major sources of information were from extension agents with a mean of 2.7 and fellow farmers with a mean of 2.6. The farmers also adopted the use of improved breeds, regular litter replacement and regular vaccination of birds with a mean of 2.8 respectively. They however did not adopt the use of artificial breeds. Their major constraints to the adoption of innovation were finance and high cost of livestock feeds

Antwi-Agyei, et al., (2014) researched on "Barriers to climate change adaptation: evidence from northeast Ghana". Antwi-Agyei, et al., (2014) described effective adaptation as the ability to make and implement the best possible decisions. In dealing with climate uncertainty, these decisions need to be timely, creative and flexible. Decision-making for adaptation is iterative. Under uncertainty, flexibility is important, so that decisions can be reviewed and adjusted easily over time as circumstances change. 'Climate adaptation' refers to the decisions that people, communities, businesses and governments take to prepare for and respond to a changing climate. It also refers to the actions they take to manage climate impacts. It is similar in many respects to other actions or decisions that individuals or governments take every day to manage external shocks such as natural disasters or financial sector volatility.

Work carried out by the Department of Climate Change and Energy Efficiency (DCCEE) (2007) demonstrates that while some progress has been made, there are systemic barriers to effective adaptation in Australia. Cascading market-related and regulatory barriers are associated with limitations in our understanding of the risks posed by climate change and our ability to act on this understanding.

Purwanti et al. (2021) researched on Drivers of Climate Change Adaptation Practices in Smallholder Farmer's in Indonesia. The cross-sectional data were collected from 302 smallholder potato farmers in East Java, Indonesia, analyzed by a multivariate probit model to estimate the determinants. An ordered probit model was subsequently employed to understand the intensity factors.

The findings indicated that the significant factors that affect farmers' choice of on-farm adaptations were the farmer's education, their participation in farmers' groups, agricultural-related infrastructure, and agriculture output prices. In the district, there are various barriers that hinder the farmer's ability to adopt adaptation strategies. These include lack of information about the potential of climate change, lack of knowledge about appropriate adaptation options, lack of credit services and money, lack of own land, lack of adequate irrigation facility and lack of market access.

The highest number (26.4%) of the respondents reported that lack of information about the potential of climate change is one of the main barriers that hinder farmer's ability to embrace climate change adaptation strategies. About 20.7% of the respondents perceived lack of knowledge about appropriate adaptation options as a barrier that affects farmer's adoption of adaptation strategies. Meanwhile, the off-farm adaptations were significantly affected by the farmer's education, employed family members, agriculture-related infrastructure, and livestock ownership. The ordered probit model also suggested that participation in farmers groups and agricultural-related infrastructure were the most significant factors that encouraged adaptation. Therefore, adaptation planning should consider these factors to optimally improve farmers' adaptation capacity.

Chenani et al., (2021) researched on "Barriers to climate change adaptation: Qualitative evidence from southwestern Iran". This study uses a qualitative approach to identify and explore such barriers in the Susa county, a historic region of Khuzestan province in southwestern Iran. This study used a qualitative approach to identify and explore barriers affecting. Data used for this research were obtained from a series of focus group discussions (n = 50) and semi-structured interviews with key informants (n = 50). Results explored and categorized numerous responses to barriers to adaptation, such as social and cultural, economic, technological, informational, and market-based. It is important to note that, in reality, the margins between classifications are much subtler than many of the typologies indicate. Based on the study's findings, appropriate policy responses were recommended.

Gyimah, et al., (2020) researched on Climate Change Adaptation among Smallholder Farmers: Evidence from Ghana. This study aims to review knowledge on climate change adaptation for the ultimate goal of fostering climate-resilience among smallholder farmers. This paper uses purposive sampling to systematically review recent available literature on the theme "adaptation of smallholder farmers in Ghana". In order to avoid the duplication of the information and track data sources for accuracy purpose, Mendeley version 1.19.4 software was used to incorporate articles while MS EXCEL Version 2019 was used to categorize the types and key examples of adaptation strategies used by smallholders. It was found that the most utilized adaptation types are farm management and technology (67%) and diversification on and beyond the farm (20.6%) with less adoption for knowledge management, networks and governance (5.4%); farm financial management (4%); government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population (3%).

Although the strategies enlisted above help to adapt to climate change, challenges such as poor and unsustainable agricultural practices, challenges faced by smallholder farmers in Ghana, lack of government support in terms of relevant information on climate change, poor agricultural extension service delivery, high cost of irrigation facilities, lack of support from government, credit constraints, limited incomes, high cost of farm inputs, land constraint, etc. Further, statistics shows that the lack of sufficient extension coverage prevents from effective adaptation of smallholder farmers. In reality, the ratio of agricultural extension agent to farmers is 1:2500 socio-cultural constraints, institutional barriers and under-representation of other regions (except Northern Ghana) in the study of climate change adaptation of smallholder farmers in Ghana remain. The study therefore advocates for strengthening the link between research institutions and the extension officers and enhanced deployment of agricultural extension services to smallholder farmers in the rural areas among others.

Khanal et al. (2020) researched on Smallholder farmer's adaptation to climate change and its potential contribution to UN sustainable development goals of zero hunger and no poverty. This study investigates the extent to which climate change adaptations by smallholder farmers have the potential to contribute to the UN's sustainable development goals of no poverty (SDG 1) and zero hunger (SDG 2). To this end, the study measures the impact of such adaptations on food production using farm level survey data from Nepal.

The study utilized a matching technique and stochastic production frontier model to examine the productivity and efficiency of farmers. Results reveal that the group of farmers adopting adaptations exhibit higher levels of productivity and technical efficiency in food production as compared to the non-adopters. It is evident from the results that policy makers should encourage farming households in climate change adaptations, which have the potential to enhance farmers' productivity and efficiency in agriculture, thereby contributing to two of the United Nations Sustainable Development Goals (SDGs) of eradicating hunger and poverty.

Belay et al. (2017) researched on Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. This study investigated how smallholder farmers perceive climate change, what adaptation strategies they practice, and factors that influence their adaptation decisions. Both primary and secondary data were used for the study, and a multinomial logit model was employed to identify the factors that shape smallholder farmers' adaptation strategies. The results revealed that 90% of farmers have already perceived climate variability, and 85% made attempts to adapt using practices like crop diversification, planting date adjustment, soil and water conservation and management, increasing the intensity of input use, integrating crop with livestock, and tree planting.

The econometric model indicated that education, family size, gender, age, livestock ownership, farming experience, frequency of contact with extension agents, farm size, access to market, access to climate information and income were the key factors determining farmers' choice of adaptation practice. Farmers' capacity to choose effective adaptation options is influenced by household demography, as well as positively by farm size, income, access to markets, access to climate information and extension and livestock production. (Belay et al. 2017)

This implies the need to support the indigenous adaptation strategies of the smallholder farmers with a wide range of institutional, policy, and technology support, some of it targeted on smaller, poorer or female-headed households. In this case the role of government and NGOs is imperative. As the rainy seasons are recently becoming more and more unpredictable and uncertain, depending on rainfed agriculture in the area is less unlikely and hence policy driven actions to provide irrigation facilities based on both ground and surface water are vital. Furthermore, providing climate change information, extension services, and creating access to markets are crucial. Therefore, including these activities in the existing formal extension channels of the Ministry of Agriculture and other line ministries will be useful to farmers.

III. METHODOLGY

Research Design: The researcher adopted Quantitative Cross Sectional Analytical Research design for this study. i.e Quantitative Cross sectional Analytical survey of the knowledge of Ruminant livestock farmer's on nutritional supplement for methane mitigation was adopted for objective **1, 2,** and **3**

Study Area: Uyo is the capital of Akwa-Ibom State, Nigeria. The city lies between latitudes 0502' North and longitudes $07^0$56' East. Uyo has a natural day length of 12-13 hours. Uyo has a total area of 362 km^2 and records an annual rainfall range from 78-93% with relative humidity of 60-90% and annual temperature range from 28,4^0C-34.5^0C. (Meteorological Station Department of Geography, University of Uyo). Akwa-Ibom is one of Nigeria's 36 states, with a population of 5.451 million people in 2016. Rearing system predominant in the study area for livestock is intensive and semi-intensive rearing system for goat, sheep and cattle. The cross sectional analytical research involved all ruminant livestock farmers in Uyo L.G.A.

Population of Study: Population of the study includes all ruminant Livestock farmers in Uyo Local government area.

Sampling method: Multistage sampling technique was used for the purpose of the survey. Uyo L.G.A was divided into Urban, Sub urban and Rural areas namely; Ewet, Mbiabong and Mbak**.** In each zone, 30 livestock farming household was purposively selected based on their involvement in livestock farming and a total of 90 farms were selected for questionnaire to be administered. Heads of household were interviewed. The sample size is considered adequate to help achieve confident generalizations about the study area.

Nature/ Sources of Data – Primary and Secondary: This research used both primary data and secondary data. Secondary data was collected on each of the stated objectives. Literatures on the use of feed additives to modulate or adjust rumen fermentation in order to reduce enteric methane ($\boldsymbol{E}CH_4$) emissions, improve feed efficiency, and the quantity and quality of animal products was sourced from secondary sources like workshop proceedings, journals, research publications and conference monographs.

Data collection for this study was a structured questionnaire and was supplemented with interview of key informants. For the Cross Sectional Survey, a well structured questionnaire validated by three different animal science lecturers was administered to livestock famer's in the three secretarial districts of Uyo L.G.A in Akwa-Ibom State.
The questionnaire contains four sections (A, B, C & D), section "A" was designed to collect information on personal characteristics of farmers (age, sex, educational level and years of farming experience). Section "B" requires information on Farmer's awareness on Nutritional supplement and methane emission reduction, section "C" requires information on the famer's source of information while section "D" requires information on Farmer's adoption of information on Nutritional supplement and methane emission reduction in the study area. Questionnaire was used alongside Diagnostic surveys as well as formal interviews and field observations.

Analytical Technique: Objective 1, 2, 3 were analyzed using Cross sectional Analytical Research design with the aid of Survey Research Design.

Variables Specification: To assess farmer's awareness of Nutritional supplement for methane mitigation in ruminant livestock farming, the respondents were required to provide answers to specific statements about farmer's awareness, source of information and adoption of Nutritional supplement for methane mitigation in ruminant livestock farming. Against each specific statement, respondents were requested to tick "Yes" for a correct statement and "No" for an incorrect one. A correct response was scored one (1) while an incorrect one was scored zero (0). The awareness index of each respondent was determined by adding up the scores for the awareness questions and statements.

The awareness indices of the respondents were used to run regression analysis. Furthermore, the total score for each statement was converted to percentage and a score of ≥80% was regarded as very high, 60–79% as high, 40–59% as moderate, 20–39% as low while ≤19% was regarded as very low score. To assess farmer's source of information and adoption of Nutritional supplement for methane mitigation in ruminant livestock farming, the respondents responses was analyzed using frequency count, percentages, mean and standard deviation. Hypothesis 4 was tested using a chi square analysis.

All collected data were entered into the computer and validated (coded) using the SPSS version 21 and Microsoft Office Excel 2010 by a series of logical and range checks producing summary statistics and tables. Descriptive results were expressed as frequencies and percentages and chi square test (x^2) was used to measure the possible association between nominal variables. Criterion for statistical significance of 0.05 is used.

TABLE 1 : SOCIO-ECONOMIC DATA OF RUMINANT LIVESTOCK FARMERS IN UYO

SOCIO ECONOMIC DATA	Frequency (n=90)	%
Age		
20-29	14	15.6
30-39	35	38.9
40-49	25	27.8
50-59	8	8.9
60-69	8	8.9
Sex		
Male	82	91.1
Female	8	8.9
Marital status		
Married	68	70.3
Single	23	25.2
Divorced	4	4.5
Years spent in school		
No formal education	35	38.9
Elementary school	39	43.8
Secondary school	8	8.9
Tertiary	8	8.9
Rearing system		
Intensive	4	4.5
Semi-intensive	68	70.3

Extensive	23	25.2
Farming experience		
1-10 years	14	15.6
11-20 years	35	38.9
21-30years	25	27.8
31-40years	8	8.9
41-50years and above	8	8.9
Number of livestock		
10-20	8	8.9
21-30	14	15.6
31-40	35	38.9
41-50	25	27.8
51 and above	8	8.9
Membership of Farmers Association	7	7.8
Yes	83	92.2
No		
Extension contact		
Yes	82	91.1
No	8	8.9

Source: Author, field survey 2021

On table 1 above, Majority of ruminant livestock farmers surveyed in the study were men, as farming activities especially those related to ruminant livestock are performed mostly by men in Uyo L.G.A. Male respondent recorded (91.1%) and female (8.9%). The majority of the farmers (69.70%) interviewed were between 20 and 49 years old. Slightly more than 8% of the farmers were 50 years and over.

The dominant rearing system for ruminant livestock was intensive. the majority (89.1%) of respondents kept their animals under intensive system. goats and sheep were mainly managed under semi-intensive (80.4%) and extensive systems (35.2%). about 25% of the respondents kept their goats/sheep in intensive system. cattle farmers practice open grazing in Uyo L.G.A with very few attempting to ranch their animals. However some medium scale ranching system are springing up within Uyo L.G.A mostly for goat production.

Stock sizes varied from less than 30 animals to over 80 animals with an average of 50 ruminant livestock. A considerable number of the farmers (38.9%) were illiterate or had not completed elementary education, 43.8% had completed elementary education, only 8.9% had completed their secondary education, and 8.9% were educated to a tertiary level.

Most of the respondents (38.9%) had 11-20 years of farming experience, with 27.8% having about 30 years of farming experience. A smaller percentage of 8.9% had the farming experience of 31-40 years.

Table 2 : Chi Square Analysis for the Relationship Between Socio-Economic Characteristics of Respondents and Their Awareness About Bio-Methane and Nutritional Supplement.

VARIABLE	CALCULATED X^2 VALUE	df	p-value	Decision			
Age	10.42	4	0.03	Significant			
Sex	0.01	1	0.94	Not significant			
Marital status	0.31	2	0.23	Not significant			
Level of education	17.4	4	0.01	Significant			
Farming experience	19.78	4	0.20	Significant			
Farm size	6.23	3	0.10	Not significant			
Extension contact	10.34	2	0.02	Significant			
Farmer's association	19.76	2	0.03	Significant			
Awareness	10.14	1	0.00	Significant			
					998	908	90

Source: Author, field survey 2021

Table 2 above shows the result of the chi square analysis for the relationship between Socio-economic characteristics of respondents and their adoption of nutritional supplement for bio-methane mitigation. At $p \leq 0.05$ age, level of education, farming experience, Extension contact and farmers association and awareness was found to be significantly related to their adoption of Nutritive Strategies in bio-methane mitigation in ruminant livestock.

Age as revealed in this study is on the high side (majority i.e.40- 49, 50-59, 60-69) years and above at about 77.6%. Age is significant to adoption of nutritive strategies in bio-methane mitigation in ruminant livestock ($\square^2$=10.42, $p \leq 0.05$). The significance of extension contact ($\square^2$=10.34, $p \leq 0.05$) indicating that Extension

contact with ruminant livestock farmers on nutritional strategies is low. Farming experience is not significant ($\square^2$=19.78, p≥0.05) Farmers with high farming experience consider they know it all and will refuse to call for extension visit or belong to association.

Farmers association is also significant at ($\square^2$=19.76, p≤0.05), and found to be related to their adoption of Nutritive Strategies in bio-methane mitigation in ruminant livestock. Awareness of nutritive strategies in bio-methane mitigation in ruminant livestock is also significant ($\square^2$=10.14, p≤0.05). The extent of farmer's awareness of nutritive strategies in bio-methane mitigation in ruminant livestock influences the adoption of mitigation strategies. Furthermore, the first stage in adoption of any innovation is the awareness.

TABLE 3 : FARMER'S SOURCE OF INFORMATION ON NUTRITIONAL SUPPLEMENT AND METHANE EMISSION REDUCTION

SOURCES OF INFORMATION	NEVER (%)	WEEKLY (%)	MONTHLY (%)	MEAN SCORE	SD	RANK
Family and friends	25	33	55	1.15	0.87	1st
Radio	30	28	42	1.12	0.84	2nd
Television	32	32	36	1.05	0.83	3rd
Newspaper, Handbills, Pamphlet. Posters	85	10	5	0.19	0.50	4th
Environmental groups/ Extension workers	20	37	60	0.09	0.45	5th
Collaboration with Government Agencies	93	5	2	0.08	0.33	6th
Internet/ social media/cell phones	95	3	2	0.07	0.34	7th
Academic Journals/ Books	100	0	0	0.00	0.00	8th

Source: Author, field survey 2021 ***Multiple responses allowed***

The result reported in table 3 above reveals that the respondents received information mainly from the family and friends (88%) followed by local radio station (70.0%). Other sources such as television (68%), farmers' association/extension (9%) and mobile phones (5%) were far less important.

TABLE 4 : FARMER'S ADOPTION OF NUTRITIONAL SUPPLEMENT FOR MITIGATION OF METHANE EMISSION IN RUMINANT LIVESTOCK.

ADOPTION ITEM	NO (%)	YES (%)	MEAN SCORE	SD	RANK
Type of feeding materials used to feed your animals ? (Tick as many as you feel apply)					
Guinea grass *(Panicum maximum)*	2	98	1.85	0.97	1st
Elephant Grass (*Pennisetum purpureum)*	3	97	1.83	0.95	2nd
Giant star grass *(Cynodonplectostachium)*	5	95	1.82	0.91	3rd
Maize/corn based Concentrate feed	40	60	1.03	0.84	4th
Centro (*Centrosemapubecens)*	0	100	0.19	0.50	5th
Concentrate feed mixed Orange waste/peel	85	15	0.17	0.44	6th
Moringa leaves	93	7	0.09	0.32	7th
Sweet Potatoes vines	92	8	0.09	0.33	8th
Concentrate feed mixed Aleovera waste	99	1	0.01	0.13	9th
Concentrate feed mixed coconut oil	100	0	0.00	0.00	10th
Concentrate feed mixed with Garlic	100	0	0.00	0.00	11th
What were the main constraints/difficulties in changing your farming ways?					
lack of money	2	98	0.08	0.30	1st
Shortage of labour	90	10	0.01	0.11	2nd
lack of information	0	100	0.00	0.00	3rd

Source: Author, field survey 2021 Multiple responses allowed

The result reported in table 3 above reveals that the use of rumen modifiers like garlic and aleo-vera ranked 9th and 11th position respectively, showing very little or no usages of these rumen modifiers by ruminant livestock farmers. However in some farms, observations were conducted to verify farmer reports, and it was observed that farmers were feeding animals with over matured forage.

IV. Discussion of Result:

Farmers with high farming experience consider they know it all and will refuse to call for extension visit or belong to association.

Majority of respondent (91.1%) had contact with extension workers. The more the number of extension visits with credible information, the higher the chances that ruminant livestock farmers will obtain information on Nutritional supplement for methane mitigation in ruminant livestock farming and therefore the more knowledgeable they become with respect to bio-methane mitigation. However in some farms, observations were conducted to verify farmer reports, and it was observed that ruminant livestock farmers fed their animals with over matured forage.

These observations were supported by the responses of the interviewed farmers. Farmers indicated that information has been disseminated to them on various issues ranging from drugs, innovation, ideas and Agro-chemicals. This shows that extension officers are capable of efficiently disseminating information, ideas and innovation to ruminant livestock farmers when required. However, no respondent had at any time heard about mitigation of bio-methane emission in ruminant livestock using plant based additives. The age range of 20-49 years old indicate since young adults usually have longer life span and are, accordingly, more vulnerable than others to the long-term impacts of methane emission, their knowledge of this topic is of significant importance.

The study underlined the absence of some sources of information such as academic journals and the internet/ social media. These results are consistent with Umar (2016), who reported that in Katsina State of Nigeria, farmers mainly received information from relatives and friends. Similarly, Umar et al. (2013) reported that relatives were the main source of farmer's information. The implication of this result is that, farmers may not get adequate technical information from friend and relatives.

Use of internet among the respondents is absent, this may be as a result of low knowledge and skills needed for computer operation among the respondents and the fact that, accessing information from the internet may be difficult especially in rural areas where there is poor internet infrastructure and low computer skills. Majority (57.76%) of the respondents did not use radio as a source of information on mitigation of bio-methane emission in ruminant livestock, but rather for other purposes. It may be attributed to differences in the nature of programmes aired by the radio stations. This implies that radio massages is not fully utilized as sources of information mitigation of bio-methane emission in ruminant livestock among the respondents or radio stations in the study area were not airing adequate information related to mitigation of bio-methane emission in ruminant livestock using nutritional strategies.

Television as sources of information was seldom used by the respondents, this may be due to erratic power supply, and most of the rural dwellers have no television in their houses nor connected to electric power supply. The use of newspapers/handbills/ pamphlets/posters is not common among ruminant livestock farmers may not patronize information from newspapers due to low literacy level, cost, and accessibility. The implication of this is that, most of relevant information on mitigation of bio-methane emission in ruminant livestock found in newspapers may not be assessable to livestock farmers.

Respondents most likely used GSM phones to only call their friends, fellow farmers, relatives and the like instead of calling their contact extension agent for information on mitigation of bio-methane emission in ruminant livestock and other production technologies. However, availability and efficiency of extension services is not in place to use such media to pass information on mitigation of bio-methane emission in ruminant livestock to farmers. Respondent attributed lack of adequate information on bio methane emission as being responsible for them not adopting nutritive strategies for mitigation of bio-methane emission in ruminant livestock.

Farmers indicated that information has been disseminated to them on various issues ranging from drugs, innovation, ideas and Agro-chemicals. This shows that extension officers are capable of efficiently disseminating information, ideas and innovation to ruminant livestock farmers when required. However, no respondent had at any time heard about mitigation of bio-methane emission in ruminant livestock using plant based additives other nutritional strategies. This shows why adoption of nutritional supplement for mitigation of methane emission in ruminant livestock is probably low among farmers. This is an indication that extension organizations, agencies, boards etc have not developed messages in that area for dissemination to ruminant livestock farmers.

The use of rumen modifiers like garlic and aleo-vera ranked 9^{th} and 11^{th} position respectively, showing very little or no usages of these rumen modifiers by ruminant livestock farmers. However in some farms, observations were conducted to verify farmer reports, and it was observed that farmers were feeding animals with over matured forage. This means, for over matured forage a longer fermentation time in the Rumen is required .i.e. residence time for feed in the rumen is prolonged when animals are fed with over matured forage because of the low digestibility of older forages and the resultant effect is high methane emission. These observations were supported by the responses of the interviewed farmers. Furthermore, the major constraint that

affected the adoption of nutritional supplement for bio-methane emission reduction in livestock farming is lack of information on the subject matter.

V. SUMMARY OF FINDINGS

Methane mitigation through dietary manipulation which involves changing the feed composition remains the most uncomplicated and inexpensive or cost effective approach to lessen enteric methane levels. This strategy alone could curb up to 70% of ruminant methane emissions, depending on the method or nature of the nutritional intervention. However, awareness among livestock farmers from hazards associated with bio-methane emission is still lacking. Respondent attributed lack of adequate information on bio methane emission as being responsible for them not adopting nutritional strategies for mitigation of bio-methane emission in ruminant livestock.

Farmers indicated that information has been disseminated to them on various issues ranging from drugs, innovation, ideas and Agro-chemicals. This shows that extension officers are capable of efficiently disseminating information, ideas and innovation to ruminant livestock farmers when required. However, no respondent had at any time heard about mitigation of bio-methane emission in ruminant livestock using plant based additives.

This shows why adoption of nutritional supplement for mitigation of methane emission in ruminant livestock is probably low among farmers. This is an indication that extension organizations, agencies, boards etc have not developed messages in that area for dissemination to ruminant livestock farmers. This knowledge deficit has hampered the adoption of nutritional strategies for the reduction of methane.

VI. CONCLUSION:

In conclusion it is worth noting that the solution to bio-methane emission from enteric fermentation which contributes significantly to climate change is not going to be achieved solely from those who research and develop earth system models. It is also unlikely to come from government policy alone. Alternatively, the main driver of this solution will be stakeholders (livestock farmers) that are directly involved in these processes. However, it is equally important to develop methods and technologies to Mitigate methane $\{CH_4\}$ emissions efficiently in terms of their availability, accessibility and cost.

Mitigation strategies that do not hamper production and are able to reduce CH_4 emissions in ruminants have better acceptance among farmers and the industry. In practice, farmers are less likely to adopt any of the mitigation technologies that do not attain a minimum sustainable production level or are not economically viable, while reducing methane emissions.

The adverse effects of bio-methane on climate change resulting in extreme changes to weather patterns have been widely documented. This study investigated bio-methane production and nutritional strategies for emission reduction of bio-methane in livestock farming. This study demonstrates that diet modification can be used by the Livestock farmers to reduce its greenhouse gas emissions. However, awareness among livestock farmers on hazards associated with bio-methane emission is still lacking. The study reveals farmers lack adequate knowledge of methane emission in livestock farming and its impact on climate change as well as its impacts on human health.

This knowledge deficit has hampered the adoption of nutritive strategies for the reduction of methane. To increase farmer's knowledge about the impact of methane to human health and the environment as well as methane reduction/mitigation in livestock farming, the following recommendations for adopting nutritional strategy which will limit the catastrophic effect of climate change are made. Nutritional supplements with plant based additives are recommended as a viable option for bio-methane mitigation in livestock farming because this method of mitigating methane emission is cost effective, safe for the environment and also sustainable.

RECOMMENDATION

1. This study pointed to significant illiteracy rates among livestock farmers, and this represents a challenge in the design of appropriate training programs. Given that most farmers are unable to read and write, a more interactive and participatory training model is required, for example, by using pictograms or short video clips to simplify Bio-methane mitigation strategies and communicate its impact on climate change.

The pictograms should be unambiguous and easy to understand, to prevent misinterpretations of the risk information. Using pictograms is seen as a key element for overcoming literacy challenges in transmitting methane reduction information. Knowledge of the farmers can further be reinforced through field demonstrations by Environmental/Extension officers. Such capacity-enhancement activities will provide farmers the opportunity to learn and understand how to handle of nutritional supplement and methane emission reduction in livestock farming.

2. To improve Farmers resilience towards methane mitigation, climate variability and change awareness should be created. Extension organizations, agencies, boards etc should developed messages for bio-methane

mitigation for dissemination to ruminant livestock farmers. To ensure healthy production system in the livestock sector, Government must play a significant role by creating awareness and sensitizing livestock farmers on methane emission in livestock farming and its impact on climate change. i.e. Counseling /Advocacy / Training of farmers on the different nutritional strategies for reducing emission intensity of methane gas in ruminant livestock farming.

3. A new way of feeding farm animals which involves weighing and blending all food stuff with the feed additives into a complete ration to ensure that all animal nutrients requirements are met. Using this "total mixed ration" will help to reduce labour cost, increase farmers yield and give farmers greater flexibility with feed additives/ingredient. All these factors put together improve farm profitability, reducing the cost of feed and maximize milk production and reduce methane emission in ruminant livestock.

4. Finally, the result of this survey indicated that the ruminant farmers in the study area are within the age bracket of 20-49years, the young adults usually have longer life span and are accordingly more vulnerable than others to the long-term impacts of methane emission, their knowledge of nutritional supplement for bio-methane mitigation is of significant importance as Farmers resilience will be increased towards methane mitigation, climate variability and change

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