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Do Rice Farmers Have Knowledge of Greenhouse Gas (GHG) Emission Mitigation Strategies? New Evidence from Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors ENS and BOS did the conceptualization. Data collection and collation was done by authors ADC, CVC, OUT and ASN. Authors ENS and ASN did the methodology and formal analysis. Authors ENS and OKN wrote the original manuscript and prepared the draft. Writing, review and editing was done by authors CVC, SMK and VM. Authors ENS, BOS, RR, JA and VM did the Visualization. Authors BOS and JA supervised the work. All authors read and approved the final manuscript.

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ABSTRACT

In Nigeria, rice remains a major staple food source for the rapidly growing population of an estimated 210 million people. However, traditional rice production carried out in flooded soil is associated with greenhouse gas (GHG) emissions, mainly anthropogenic methane (CH_4) and nitrous oxide (N2O) in Nigeria. Both CH4 and N2O are harmful GHGs that raise the temperature of the planet by retaining heat in the atmosphere. Reduction of GHG emissions is critical, and understanding farmers' knowledge of GHG emission mitigation strategies would be crucial to reducing emissions from rice fields and producing rice in a cleaner environment. Incidentally, there is a dearth of empirical evidence in the current debate. The absence of this study creates a gap in research and makes it extremely pertinent that the study be systematically undertaken. Our study described the socio-economic characteristics of the rice farmers and ascertained their knowledge level on GHG mitigation strategies. We utilized questionnaire and focused group discussion (FGD) as the primary methods of data collection. Descriptive statistics and mean score analysis were used to analyze the data collected. On average, we found that the rice farmers were 45 years old. Most (72%) were male. Only 31% of the farmers had contacted extension agents and were visited twice per calendar year. We found that among various GHG emission mitigation strategies identified in the area, the farmers had significant knowledge of the use of Aerobic Rice Varieties (ARV) ($\bar{x}$ = 3.61; σ = 0.87) but low knowledge of the use of Alternate Wetting and Drying (AWD) ($\bar{x}$ = 1.88; σ = 0.45). Our findings confirmed the incidence of GHG emissions in rice fields and that farmers have started practicing GHG mitigation strategies to reduce emissions from rice in the area. However, among various constraints, our study observed that inadequate technical know-how is negatively challenging rice farmers' capacity to implement and scale-up GHG emissions mitigation strategies. Therefore, our study recommends that the government should strengthen and support agricultural extension service systems to enable them to visit farmers' farms regularly to transmit and build farmers capacity in the use of recent GHG emission mitigation strategies and innovations in rice fields.

Keywords: Rice; GHG emission; CH_4, N_2O; GHG mitigation strategies; AWD; knowledge level; Nigeria.

1. INTRODUCTION

Millions of families throughout the world depend on rice (*Oryza spp*.), the second-most popular food crop (behind wheat) to meet their dietary calorie needs [1]. To projections, the demand for rice would increase by 56% by the end of 2050 compared to the production level of 25.1 million tons in 2001 as a result of the population growth rate [2]. A large increase in rice production is required to supply this need on a worldwide scale. In Nigeria, rice is a primary staple grain and is consumed in large quantities by all households including the affluent and poor [3].The structural rise in rice consumption over the years, with consumption spreading across all socioeconomic strata, including the poor, appears to have been caused by a confluence of many variables [4]. The rise in demand could be a result of rising income levels and population increase as well as the food's convenience in terms of preparation, storage, and calorie availability. Rice is critical in Nigeria from separate vantage points: first, in terms of the number of calories (2.06kg) it provides per person and day; 24.80 kg of calories per annum [5] and second, based on the value of income it generates through its various local production value chains. Meeting the increased demand for rice consumption in Nigeria requires increased production. Also in Nigeria, the growing demand for rice exceeds supply, resulting in a rice deficit, with smuggled rice filling the expanding gap between domestic production and consumption, with about 2.0 million metric tons smuggled into Nigeria by the end of 2022 [5,6]. The efforts of the most populous nation in Africa to provide food security will be jeopardized by any reduction in rice output brought on by climate change impact and global warming. Therefore, describing how climate change affects rice production, GHG emissions mitigation strategies and farmers' knowledge are the kernels of this study. The Southeast region of Nigeria, the most populous nation in Africa, produces a significant amount of rice. The majority of the households in

the area rely on rice farming as their main source of nutrition and agricultural revenue to survive [7]. Despite the fact that rice is crucial to the rural economy of Southeast Nigeria, GHG emission from rice fields is endangering its production, health and environment. Currently, due to the present Federal Government of Nigeria Objective on diversification of the economy, reducing food insecurity and import restriction, rice is grown in almost 36 States in Nigeria including Federal Capital Territory (FCT) under diverse production systems and agro-climatic conditions [8,6]. Rice is traditionally produced in soggy paddy soils. Scientific communities have been quite concerned about rice paddies because they create dangerous and persistent GHGs, primarily CH_4 and N_2O [9]. Rice fields release around 30% and 11% of the world's agricultural emissions of CH_4 and N_2O, respectively [10]. CH_4 global warming potential (GWP) is 34 while N_2O is 298 which is more than carbon dioxide (CO_2).In addition, anthropogenic N_2O is thought to be the main cause of acid rain [11]. Understanding farmers' knowledge of GHG emissions and mitigation strategies is among the crucial starting points for deciding what steps should be made to mitigate emissions from rice fields and produce rice in a cleaner environment. Some of the GHG emission mitigation strategies in rice field includes; alternate wetting and drying (AWD); system of rice intensification (SRI); changing tillage operations (CTO); Nitrogen Fertilizer Management (NFM); residue management (RM) and aerobic rice varieties (ARV) [12,13,14]. Substantial empirical evidence [9,11,13] exists on measuring and mitigating GHG emissions in rice fields in developed and developing countries and different researchers have analyzed the likely effects on rice production with various parameters. Reducing GHG emissions and water use in rice fields is critical for combating climate change, and increasing the yield, income and standard of living of the farmers. A key factor in deciding what steps should be made to mitigate the adverse impacts of climate change on rice productivity and the environment is the amount of awareness that rice farmers have regarding GHG emissions. Studies on the link between GHG emissions in rice fields are increasing. However, there remains a dearth of empirical evidence on the farmers' knowledge of GHG emissions and the different mitigation strategies they practice. Therefore, the absence of this study creates a void in research and makes it increasingly pertinent that the study is systematically undertaken. Hence, the specific objectives of the study were to (i) describe the socio-economic characteristic of the rice farmers in the area and (ii) ascertain rice farmer's knowledge level of GHG mitigation strategies.

2. MATERIALS AND METHODS

The study was carried out in the Southeast agricultural zone of Nigeria from January through March, 2023. The zone is made up of five States, namely, Abia, Anambra, Ebonyi, Enugu and Imo. It has an estimated land mass of 32,610 km^2 and a population of 22,583,076 [15].The area lies between longitude 2^o61^1 and $6^0.32^1$ East and latitudes 6^o74^1 and 8^o15^1 North of the Equator with the mean annual temperature ranging from 21.6°C to 32.4°C while the annual rainfall ranges from 720 mm to 1440 mm in the rainforest region [16,17]. The State has good climatic conditions suitable for rice farming and a good proportion of the population are essentially rice farmers. In the selection of respondents who are rice farmers, the study used multistage and purposive random sampling techniques. Selecting farmers who are primarily engaged in rice cultivation in the region was done through purposive sampling. One hundred and fifty-two (150) rice growers made up the samples. The sample proportion and the map of the study were shown in Table 1 and Fig.1 respectively.

In addition, data collected were analyzed using descriptive statistics such as mean, percentage and mean score of likert scale type. The study used descriptive statistics to describe the socio-economic characteristics of rice farmers and mean score of likert scale type to evaluate rice farmer's knowledge level on GHG emission strategies in rice fields. The primary instrument used to gather data was a structured questionnaire. The Likert scale type rating method was used to examine the data. The weighted mean (X_w) calculation methodology was given below [18];

$$X_w = \frac{\sum_{j=1}^{5} ni(5i)}{n}$$

Where X_w = Weighted Mean Score
n = Number of rice farmers selected
Σ = Summation

The various attributes (GHG emission strategies) were rated using mean score of a 4-point Likert scale type rating model for rice farmers

Table 1. Sampling proportion for the rice farmers

Southeast Agricultural Zones of Nigeria	Total Number of Local Government	Total Number of Communities	Total number of Villages	Total Number of Farmers	Total number of farmers per zone
Ebonyi	5	5	10	5	50
Imo	5	5	10	5	50
Anambra	5	5	10	5	50
Total	15	15	30	30	150

Source: Field survey data, 2023

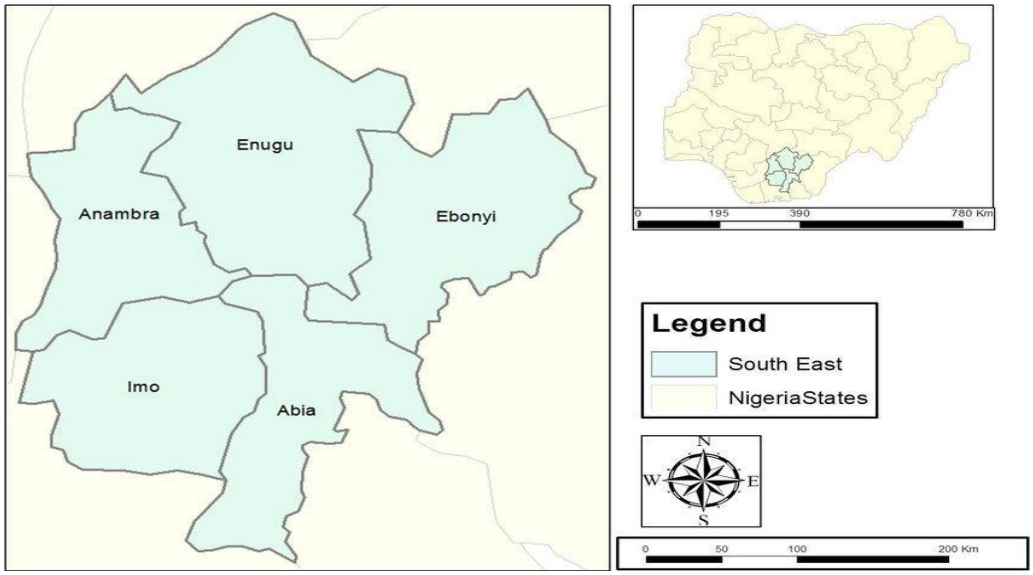

Fig. 1. Map of Southeast Nigeria showing the five various States [19]

perceived level of knowledge on various GHG emission strategies and then divided by the number of scales to obtain the discriminating index, for example, (4+3+2+1)/4 = 2.50 cut-off point. It was stated as follows;

SA = Strongly agreed (4)
A = Agreed (3)
D = Disagreed (2)
SD = Strongly Disagreed (1)

2.1 Decision Rule

0.1-1.99= No Knowledge;
2.0-2.49= Moderate Knowledge;
2.50 and above = High Knowledge
The level of Significance is 0.05%

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of Rice Farmers

The socio-economic characteristics of the rice farmers in the area were shown in Table 2. The farmers were 45 years old on average. This suggested that the region's rice farmers were still relatively young and in the prime of their lives, giving them more chances to apply various GHG emission tactics to increase their rice output, as seen in Table 2. Age is particularly important in rice farming since it significantly impacts farmers' access to and acceptance of new ideas their need for energy, and their overall production objectives [7]. Greater proportions 0.72 (72%) of the farmers were males. This implied that both sexes (male and female) are involved in rice farming but males were more in number. Nigeria practices a more paternalistic culture, making it easier for males than for women to obtain and possess agricultural productive inputs including lands, financing facilities, better seedlings, and labour. Additionally, male farmers could be able to withstand the stress and strains involved in rice farmers, and the negative impact of climate change and are able to practice more GHG mitigation strategies than their female counterparts. The average household size in the area was 8 persons, suggesting that the rice producers had quite high households, some of

which may have included direct family, relatives, or extended dependents who surely could help with rice production and practice more GHG mitigation strategies in the area. The result was in consonance with the study of Olugbenga *et al.* [20] who found that household size could be a proxy for labour to increase and enhance their farming activities, expansion of farm income and standard of living. The average length of time spent in school was 12 years, which suggests that the rice farmers in the region had at least a secondary education. Education could be very vital in positively influencing rice farmers' GHG mitigation strategies in increasing rice yield and reducing emissions in rice fields in the area. The finding was consistent with the result of Esiobu *et al*. [12] who asserted that higher education influences farmer's decision making positively, acceptance of innovation, better access and utilization of productive input in reducing GHG emission and climate change impact in rice fields. The extension values of 0.31 (31%) and 2.11 revealed that about 51% of the rice farmers accessed extension services and were visited at least 2 times per year by the extension agents in the area. This is quite poor and could negatively affect rice farmers' adaptation to climate change and mitigation of GHG emission in rice fields in the area. Improved and steady contact of farmers with extension agents is critical in improving farmers' access to input, innovation, high yield and income. The result supported the findings of Esiobu *et al.* [12] who reported that extension contact improves farmers' access to recent information and expertise of contemporary farming techniques to raise their yield, income and standard of living. The average experience in farming was 16 years. This is a strong indication that rice farmers have reasonable years of experience in rice farming and may have been adapting to climate change and mitigating GHG emission in rice fields in the area. A unit increase in farming experience is anticipated to boost farmers' practical expertise in resolving difficulties specific to rice farming and their ability to handle both internal and external obstacles influencing rice yield particularly related to climate change and GHG emission. The mean farm size of the rice farmers in the area was 1.53 hectares. This is characteristic of rural farmlands, which are frequently dispersed, fragmented, and small in size. This small farm size could also be attributed to the system of land tenure and urbanization predominant in the area.

Land is one of the important productive inputs in rice farming and when farmers have limited size of it, increased farm production and mitigating GHG emission may be unattainable. The finding tallies with the studies of Abdulwahab *et al.* and Tobi & Edgeweblimel [21,22] who found that large farm size increases yield, farmers adaptation to climate change, mitigating GHG emission and income of the farmers. Additionally, research shows that 0.75 (or 75%) of the rice farmers belonged to farmer clubs or associations. This suggests that rice farmers might have access to current research on climate change adaptation and GHG mitigation in rice fields through the association. Cooperative membership is seen to be a helpful tool for members to manage risks, exchange knowledge, labour, and pool their limited resources to boost yield, income and standard of living [23]. Finally, finding from Table 2 indicates that the mean annual farm income from rice production was ₦480,000 ($626.76). This is an indication that farmers have a relatively high annual farm income which could positively affect farmer's adaptation to climate change and mitigation to GHG emission in the area. Most GHG emission strategies are costly [12] and farmers with sizable and sustainable farm income would be able to adapt and mitigate adequately.

Table 2. Socio-economic characteristics of rice farmers

S/No	Variables	Mean (x̄)/Percentage (%)
1	Age (years)	45.00
2	Sex (percentage of male)	0.72
3	Household size (number of persons)	8.00
4	Education (years spent in school)	12.00
5	Extension contact (percentage of access)	0.31
6	Number of extension visits (number of visits per season)	2.11
7	Farming experience (years)	16.00
8	Farm size (hectares)	1.63
9	Membership of farmer groups (percentage of members)	0.75
10	Annual Farm income (Nigerian Naira)	₦480,000 ($626.76)

Source: Field survey data, 2023

3.2 Rice Farmer's Knowledge Level on GHG Mitigation Strategies

The outcome of rice farmers' distribution based on knowledge level of GHG mitigation strategies in the area was shown in Table 3.The various attributes were rated on a 4- point Likert type scale rating questions of Strongly Agreed (4); Agreed (3); Disagreed (2) and Strongly Disagreed (1). The values of standard deviation (σ) denote the degree of variation in the responses of the rice farmers on their knowledge level in mitigating GHG emission in rice fields in the area. Reducing GHG emissions from paddy rice production is a critical target for many African countries (of which Nigeria is included) in order to comply with their climate policy commitments [12]. However, understanding farmers' knowledge on GHG mitigation strategies is key to achieving community, regional, and global climate policy commitments. Therefore, results revealed that rice farmers had high knowledge in the use of Aerobic Rice Varieties (ARV) ($\bar{x}$ = 3.61; σ = 0.87); Residue Management (RM) ($\bar{x}$ = 3.42; σ = 0.60); and Changing Tillage Operations (CTO) ($\bar{x}$ = 3.60; σ= 0.85). The incorporation of rice residues contributes toward long-term nutrient cycling but may be due to high carbon-to-nitrogen ratio (C/N ratios), causing short-term Nitrogen (N) immobilization and thus affecting N availability for subsequent crops [24]. Meanwhile, aerobic rice varieties (ARV) is a production system in which specially developed "aerobic rice" varieties are grown in well-drained soils that are neither waterlogged nor puddled [25]. The technique targets yield of at least 4-6 tons per hectare with careful management [26,27,28,29,30]. Rice farmers' high knowledge of these strategies is expected as they may not require so much technical know-how and capital for their overall implementation. Similarly, rice farmers stated that they have moderate knowledge in the use of Nitrogen Fertilizer Management (NFM) ($\bar{x}$ = 2.38; σ = 0.60) in mitigating GHG emissions in rice fields in the area. Differentiated emissions are produced as a result of nitrogen fertilizers' major influence on N_2O emissions [31,32]. Rational nitrogen fertilizer use may both encourage good rice yields and lower greenhouse gas emissions [33]. Therefore, to ensure yield and minimize N_2O loss due to nitrification and denitrification of excess nitrogen in soil, nitrogen reduction and appropriate application can significantly increase the nitrogen usage efficiency of rice. The timing and kind of fertilization have a significant impact on the amount of CH_4 and N_2O emissions in paddy fields [34]. Ultimately, finding shows that the rice farmers have low knowledge on the use of Alternate Wetting and Drying (AWD) ($\bar{x}$ = 1.88; σ = 0.45); and System of Rice Intensification (SRI) ($\bar{x}$ = 1.85; σ = 0.48) in mitigating GHG emission in rice field in area. The low knowledge of farmers on AWD and SRI GHG emission mitigation strategies could be associated with poor extension contact earlier found in the study. Extension agents are charged with transmitting recent innovation to farmers in their farmland to help increase their yield, income and standard of living. However, when the extension system is not well strengthened, it creates a gap between extension agents and farmers. The finding is in line with the studies of Esiobu *et al.* [12,26] who reported that extension contact improves farmers' access to recent information and expertise of contemporary farming techniques to raise their yield, income and standard of living. Also the low use of AWD and SRI could also be associated with Nigeria's unsustainable rice production practices and high import dependent on rice commodity to meet demand deficient. Although the recent Federal Government of Nigeria intervention has banned rice import to boost local production [6], this ban has not yet achieved the desired result. Nigeria is still not yet self-sufficient in rice. Meanwhile, the SRI is a comprehensive strategy for sustainable rice farming. Instead of planting them by the fistful and bunched closely together, it called for planting a single seedling with more space between them [35]. Additionally, it calls for spot irrigation and the tolerance of dry spells as opposed to constant flooding and the use of organic input. The SRI has the potential to reduce energy use, GHG emissions and global warming potential (GWP) in rice-growing areas of Nigeria. The AWD was developed by IRRI in 2002 and it is one of the most significant GHG emission mitigation strategies used by farmers across Southeast Asia [36]. Farmers can use the water-saving technique of AWD to decrease irrigation water usage in rice fields without lowering production. AWD applies irrigation water a few days after the ponded water has disappeared. As a result, the field is periodically inundated and unflooded. For irrigated rice, alternate wetting and drying (AWD) is a management technique that has been developed to minimize water input [28]. AWD incorporates a number of dry spells during the course of the rice growth cycle as opposed to continually flooding the fields while the rice is being grown [37]. However, field water is maintained at a level that allows rice plants to get enough water and avoid

Table 3. Rice farmers knowledge level on GHG Mitigation strategies

n =150

S/No	Items	SA	A	D	SD	Mean (x̄)	SD (σ)	Decision
1	Changing Tillage Operations (CTO)	102 (68.00)	40 (26.67)	6 (4.00)	2 (1.33)	3.60	0.85	High Knowledge
2	System of Rice Intensification (SRI)	3 (2.00)	13 (8.67)	92 (61.33)	42 (28.00)	1.85	0.48	Low Knowledge
3	Aerobic Rice Varieties (ARV)	99 (66.00)	44 (29.33)	6 (4.00)	1 (0.67)	3.61	0.87	High Knowledge
4	Residue Management (RM)	92 (61.33)	33 (22.00)	22 (14.67)	3 (2.00)	3.42	0.60	High Knowledge
5	Alternate Wetting and Drying (AWD)	3 (2.00)	9 (6.00)	106 (70.67)	32 (21.33)	1.88	0.45	Low Knowledge
6	Nitrogen Fertilizer Management (NFM)	16 (10.67)	28 (18.67)	104 (69.33)	2 (1.33)	2.38	0.60	Moderate Knowledge
	Aggregate Mean Score					2.79	0.64	Accepted

*Key; SA: Strongly Agreed; A: Agreed; SD: Strongly Disagreed; D: Disagreed; SD (σ); Standard Deviation; Discriminatory index: Cut off point x̄ Key; SA: Strongly Agreed; A: Agreed; SD: Strongly Disagreed; D: Disagreed; SD (σ); Standard Deviation; Discriminatory index: Cut off point x̄≥2.50 Accepted; 0.1-1.99= Low Knowledge; 2.0-2.49= Moderate Knowledge; 2.50 and above = High Knowledge; *Figures in parenthesis are percentage; Field Survey Data, 2023*

experiencing water stress and use of "safe" or moderate AWD has no negative effects on grain output [38,39]. From the aggregate mean ($\bar{x}$ = 2.79; σ = 0.64) which is above the discriminatory score ($\bar{x} \geq 2.50$), it shows that the rice farmers perceived rightly their knowledge level on GHG mitigation strategies and the result was therefore accepted. Finally, there is no doubt that the relative level of knowledge of rice farmers is responsible for low practices of GHG emission mitigation strategies in the area. Addressing these challenges will be critical in improving rice farmer's knowledge on GHG emission mitigation strategies, GHG mitigate emission from rice fields and producing rice in a cleaner environment.

Rice is critical to Nigeria from separate vantage points: first, in terms of the number of calories it provides per person and day; and second, based on the value of income it generates through its various local production value chains. Sustainable rice production offers promising opportunities for ensuring safe food, high yield, and income. Most of the farmers have limited knowledge of AWD. AWD is one of the major GHG mitigation strategies developed by IRRI in 2002, and has been adequately studied and propagated globally by various scholars and institutions. AWD is a promising technique that involves intermittently flooding and drying rice fields. When compared to continuous flooding, it has the potential to cut CH_4 emissions by an average of 48%. The study also found that rice farmers complained of limited capital. since member of cooperatives, they are encouraged to take advantage of their strength and shared common purpose to collectively project a common demand in obtaining funds and other necessary inputs for the implementation and scaling–up of GHG emission mitigation strategies in the area. From the limitation of the study, only one hundred fifty (150) rice farmers from the study region had to be chosen for the study due to time and resource constraints on the researcher. Therefore, the findings were generally relevant to other parts of the State that were not chosen. Also, the questionnaire and in-person interviews used to acquire the data require the rice farmers to recollect past activities related to farming and GHG emissions. Therefore, the results might be affected by respondents' memory errors. Ultimately, although the GHG emission mitigation techniques farmers utilized varied from one responder to the next, they were all quantified and used to arrive at the study's conclusive findings. Therefore, the results might be inconsistent in different regions where the same situation is present. Further studies should look at the cost-benefit of utilization of each of the rice farmers GHG Emission Mitigation options. It is possible that farmers are utilization these GHG Emission strategies because of the economic gain they receive for using it than the aim of reducing GHG emissions in rice fields.

4. CONCLUSION

The GHG emissions from rice fields contribute significantly to global warming and climate change. Therefore, mitigating emissions from rice fields is very critical to limit global warming, increasing yield, and income, and ensuring food security and improving the standard of living for farmers and all. Understanding farmers' knowledge of GHG emissions and mitigation strategies is among the crucial starting points for deciding what steps should be made to mitigate emission from rice fields and produce rice in a cleaner environment. Some of the GHG emission mitigation strategies in rice fields identified in the study include alternate wetting and drying (AWD); system of rice intensification (SRI); changing tillage operations (CTO); Nitrogen Fertilizer Management (NFM); residue management (RM) and aerobic rice varieties (ARV). The mean age of the farmers was 45 years. Most were male with an average farm size of 1.53 hectares. The land is one of the essential productive inputs in rice farming and when farmers have a limited size of it, increased farm production and mitigating GHG emission may be unattainable. Most of the rice farmers were visited at least twice per year by the extension agents in the area. This is quite poor and could negatively affect rice farmers' mitigation effort to GHG emission in the area. Extension contact improves farmers' access to recent information, expertise and knowledge on contemporary farming techniques to raise their yield, income and standard of living.

5. RECOMMENDATIONS

The low knowledge of farmers on the use of AWD and SRI GHG emission mitigation strategies could be associated with poor extension contact earlier found in the study. AWD is a promising technique that involves intermittently flooding and drying rice fields. When compared to continuous flooding, it has the potential to cut CH_4 emissions by an average

of 48%. Extension agents are charged with transmitting recent innovation to farmers in their farmland to help achieve farmer's production objectives. However, when the extension service system is not well strengthened, it creates a gap between extension agents and farmers. Rice farmers are therefore encouraged to constantly seek information on GHG emission mitigation strategies before embarking on rice production, this will without doubt position them to overcome any adverse effect of global warming. Additionally, the government should assist farmers in implementing climate change and GHG policies to reduce the challenges they face and increase rice production in a clean environment. The study recommends that the government should strengthen and support agricultural extension service systems so as to enable extension personnel to visit farmers farms regularly to transmit recent innovations related to GHG emission mitigation strategies as these would increase yield, income and standard of living of the farmers. Ultimately, since rice farmers are members of cooperatives, they are encouraged to take advantage of their strength and shared a common purpose to collectively project a common demand in obtaining funds and other necessary inputs for the implementation and scaling–up of GHG emission mitigation strategies in the area.

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SIGNIFICANCE STATEMENT

Rice is critical to Nigeria from separate vantage points: first, in terms of the quantity of calories it provides per person and per day; and second, based on the value of income it generates through its various local production value chains. However, rice production in Nigeria is vulnerable to climate change and associated with greenhouse gas (GHG) emissions, mainly anthropogenic methane (CH_4) and nitrous oxide (N_2O). Understanding farmers' knowledge on GHG emission mitigation strategies would be crucial in reducing emission from rice fields, producing rice in a cleaner environment. An essential first step in evaluating what steps should be implemented to combat the detrimental impacts of climate change on rice output and the environment is assessing the degree of GHG emission knowledge among rice farmers. Most rice farmers in the region have limited knowledge on AWD. AWD is one of the major GHG mitigation strategies developed by IRRI in 2002, has been adequately studied and propagated globally by various scholars and institutions. AWD is a promising technique that involves intermittently flooding and drying rice fields. When compared to continuous flooding, it has the potential to cut CH_4 emissions by an average of 48%. The study recommends that the government should strengthen and support agricultural extension service systems so as to enable extension personnel to visit farmers farms regularly to transmit recent innovations related to GHG emission mitigation strategies as these would increase yield, income and standard of living of the farmers. The study also found that rice farmers complained of limited capital. Therefore, as members of cooperatives, the rice farmers are encouraged to take advantage of their strength and shared common purpose to collectively pool productive resources together and project a common demand in obtaining funds and other necessary inputs for the implementation and scaling–up of GHG emission mitigation strategies in the area. Finally, further studies should look at cost benefit of utilizing each of the rice farmer's GHG emission mitigation options. It is possible that rice farmers are utilizing these GHG emission strategies because of the economic gain they receive for using it rather than the aim of reducing GHG emissions in rice fields.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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