AGRICULTURE GREENHOUSE GAS EMISSIONS AND MITIGATION: ASSESSING THE DISPOSITION OF NIGERIAN URBAN FARMERS

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Abstract: Agriculture is the sector most vulnerable to climate change (CC), yet it contributes significantly to the problem, directly accounting for approximately 13.5% of global greenhouse gas emissions. Although CC mitigation has gained a lot of attention in research, there is a notable lack of understanding regarding Nigerian farmers' awareness and perception of greenhouse gas (GHG) emissions mitigation strategies. This study aimed to explore the knowledge of CC and disposition towards adoption of GHG emissions mitigation measures among 358 urban farmers in Nigeria. The participants were randomly selected for online survey questions to ascertain their awareness and dispositions towards agricultural GHG emissions and mitigation. Descriptive statistics and Analysis of Variance (ANOVA) were used to analyze the data. The study found that farmers possess a moderate level of awareness about CC. Motivation of the farmers to adopt strategies for mitigating GHG emissions was moderately high but not as high as expected. No significant difference between the motivations of urban farmers to mitigate GHGs from different states. Urban farmers were willing to adopt climate-friendly practices to reduce GHG emissions. Urban farmers are encouraged to reduce the rate at which they use chemical fertilizers and implement sustainable livestock management practices while the government provide training and extension services for them.

Keywords: *Urban farmers; Emissions; Nigeria; Greenhouse Gas; Climate change; Agriculture; Mitigation.*

1. INTRODUCTION

Climate change (CC) is a significant threat to the achievement of sustainable development goals (SDGs) worldwide, with Nigeria being one of the developing nations facing high vulnerability due to its weak economy and inadequate adaptation strategies [1]. All aspects of Nigeria's economic and physical sectors are highly susceptible to the impact of CC [2, 3, 4]. CC is caused by the Greenhouse Gases (GHGs). GHGs are made up of 76% carbon dioxide (CO_2), 6% nitrous oxide (N_2O); 16% methane (CH_4) and 2% combination of other gasses [5].

Agriculture is an important sector of the economy that plays an important role in human-driven CC. However, the sector is also affected by CC severely which therefore requires adaptation strategies [6]. Globally, agriculture accounts for 13.5% of GHG emissions and approximately 20% of global CO_2 [7] The agriculture sector in Nigeria alone was responsible for approximately 34.9 million tonnes of carbon dioxide equivalent in GHG emissions by 2010. A significant 69.2% of these emissions were from livestock production alone. According to [8], these levels are expected to increase by 94% in 2050. The intensification of agricultural practices and other human activities contributes to CC, leading to alterations in temperatures, rainfall, storminess, sea levels, and more. It has been projected that sea level rise by 2100 may be higher than the occurrence since 1900. It was specifically stated by [9] and [10] that the sea level rise by 2100 may be larger than 4-8 inches that had occurred since 1900.

Most states in Nigeria are agricultural states producing mainly food crops, few cash crops and raising animals. Although most of these farmers are subsistence farmers while others engage in commercial agriculture. Adoption of innovative agricultural practices in the country is relatively low, the majority of the farmers still depend on nitrogen-rich fertilizers leading to the release of nitrous oxide and methane. Majority of the farmers in Nigeria engage in rice production in flooded soil while others embark on livestock production. These activities contribute significantly to the level of greenhouse gas (GHG) emissions released in the country [11]. They further stated that the indiscriminate use of agro-chemicals like herbicides and pesticides also increases the greenhouse gas emission and depletion of soil carbon in Nigerian farm soil.

To avert the looming environmental disasters, mitigating greenhouse gas emissions especially in agricultural sector is a most considering the significant contribution of the sector to greenhouse gas emissions. Incorporating environmentally friendly crop cultivation, environmentally friendly animal husbandry approaches, improved efficiency of fertiliser use, exploration of genetic and biodiversity, soil fertility integration, the use of soil methane-producing bacteria and improved livestock production through feed efficiency can effectively reduce agricultural GHG emissions. Studies like that of [12] have also identified various strategic approaches to mitigate GHG emissions in agriculture.

Some of the strategies proposed include fertilizer optimization and construction and usage of material lifespan in plastic greenhouse gasses.

While looking for unconventional approaches to mitigate greenhouse gas emission from the agricultural sector, [13] advocated for smart farming practices such as precision agriculture using IoT technologies to offer innovative strategies like resource management, emission reduction in agriculture, promoting sustainability and long-term environmental supervision. The use of organic amendments like biochar, bio-digestate combined with inorganic manure can enhance carbon sequestration and reduce GHG emission on the farm. Bioresources management have been found to be environmentally sustainable. It cuts the amount of greenhouse gas emission and can store carbon in the soil. Through genetic engineering, mitigation efforts of greenhouse gas emission can be further enhanced. For example, the use of aerobic rice varieties and alternating wetting and drying can be deployed to further reduce greenhouse gas emission from paddy rice fields.

Strengthening agricultural extension services especially in the rural area of the country while adopting carbon pricing, mitigation policies and sustainable farming practices can assist in the mitigation efforts [14]. Moreover, the efforts of the government of Nigeria investing in renewable energy sources must be commended. There are recent efforts also recorded in climate change education and sustainability by non-government organizations in the country. The effort is being taken to schools and colleges to educate the youths about sustainable practices and behavior. [15] commended the efforts of the government in engagement in international collaborations for climate financing and carbon trading. [15] believed that doing these will reduce global warming effects and ensure a green climate future for Nigeria.

Nigeria is a country with rich cultural values and indigenous knowledge that can be tapped in climate change mitigation, reduction of carbon and other greenhouse gas emissions. [16] stressed that IKS can play an important role in adaptation efforts of Nigeria to climate change. They identified various indigenous knowledge practices that the farmers in the country had used to respond to CC challenges of temperature fluctuations, erratic rainfall patterns among others. Some of the indigenous practices they identified in their study that Nigerians farmers are using include making mounds and heaps, crop rotation, mulching and making of compost from household waste for water conservation.

To further mitigate effects of climate change on farm crops, [16] reported that farmers from Nigeria following their indigenous knowledge system can alter the time of planting as they can accurately predict weather patterns. These farmers have knowledge of how-to diversity crops varieties to enhance resilience to climate variability. [17] concluded that integration of IKS into climate-smart agricultural activities can enhance agricultural development, food production, food security and importantly help agriculture build resilience.

In another perspective, [18] was of the opinion that Indigenous knowledge practices in Nigeria are significantly important as they enable farmers in the country to enhance their farm productivity and ensure food security for all. They assert that farmers see indigenous knowledge practices as a positive and effective activity to engage in when considering reducing greenhouse gas emission in agriculture. [19] also acknowledged that water management, and building resilience against CC related disaster can be enhance in agriculture through strategic combination of indigenous knowledge practices with modern technologies like artificial intelligence, satellite remote sensing, GPS, Web-GIS, artificial intelligence and the Internet of Things can bring about unprecedented revolution to farming in Nigeria by improving dissemination of information, resource management, real-time analysis and decision-making processes.

The impact of CC is already causing irreversible damage to ecosystems and animals. This global issue could lead to the disappearance of serious and irreversible changes in ecosystems, such as the ongoing damage to coral reefs [20]. The contributing factors are numerous such as increasing global temperatures, droughts and floods. The changes will also affect water resources, and grazing lands, depending on the management systems in use and their adaptive capacities. Recent studies have shown that some regions are already experiencing discernible effects on agriculture, economy, biodiversity, and human health due to warming trends [21; 22; 23].

Nigeria is one of the countries that will be severely affected by CC, according to CC impact projections. From CC impact projection, Nigeria is among the countries that will be worst hit by CC impact. Although CC mitigation has gained attention in Nigeria and research, there is a paucity of knowledge regarding the awareness and deposition of Nigerian farmers towards Agricultural GHG emissions and mitigation strategies. Therefore, this study assessed Nigerian urban farmers' knowledge and disposition to GHG emissions and strategies for the reduction of GHG emissions. The study also examined the motivations of urban farmers for reducing GHG emissions and their acceptance of potential regulation schemes, as well as their preferred sources of information on the topic.

2. MATERIALS AND METHODS

The study was conducted in Nigeria to determine the knowledge of urban farmers regarding CC and their willingness to reduce agricultural GHG emissions using a

quantitative research design. The study included the six states in Southwest Nigeria: Lagos, Osun, Ondo, Ekiti, Oyo and Ogun. A total of 360 urban farmers were contacted through an online survey, with 358 responses suitable for further analysis. It is important to note that Nigeria, where the study was carried out is in West Africa and shares borders with Benin Republic in the West, the Niger Republic in the North, Cameroon in the East, and the Atlantic Ocean in the South.

Data were collected using both secondary and primary sources. The secondary source of data collection was through literature review. Literature was reviewed on the climate change mitigation and adaptation strategies in agriculture. Primary data were collected through questionnaires. Survey questions were developed and checked by experts from social science and education before they were distributed to urban farmers in the southwest (Lagos, Osun, Ondo, Ekiti, Oyo and Ogun States) from April to July 2023. The first section of the survey gathered sociodemographic information about urban farmers. The other three sections were Likert type formats of strongly agree, agree, disagree, strongly disagree and undecided. In the second section, participants were asked to express their opinions on CC and agriculture through multiple-choice statements. The third section focused on GHG emissions and agriculture. The fourth section aimed to determine the farmers' readiness to reduce GHG emissions and their source of information about CC. Data were scored in this order. Strongly agree = 5, agree = 4 disagree = 3 strongly disagree =2 while undecided was rated 1.

Data was collected using the Agricultural Greenhouse Gas Emission (AGGE) questionnaire. The instruments were validated through face, content and construct validity testing. Cronbach's alpha coefficient test was used to determine the reliability and internal consistency of the subscales in the questionnaire. Questionnaire data was supplemented with literature review. Quantitative data were analyzed using frequency count with percentages and analysis of variance (ANOVA) statistical tools.

Research ethics as approved by Osun State University and Lagos State University were followed in carrying out this study. The consent of the respondents was obtained before participation in the study. All the participants were assured of the anonymity and confidentiality of their responses and were allowed to opt out of the study at any time they wish to.

3. RESULTS

3.1 Demographic characteristics of the respondents

In this study, we analyzed the demographic characteristics of urban farmers who participated in the study. The results are presented as follows. The majority (84%) of the participants were male while 16% were female. The age distribution of farmers was as follows: 32% were between ages 26 to 35, 24% were between 36 and 45 years, 40% were between ages 46 to 55 years and only 4% were 56 years old or older. Less than 16% of the farmers cultivated less than one hectare of land, while 45 % cultivated 1-2 hectares of land. More than half (over 50%) of the farmers cultivated 3 or more hectares of farmland. More than half (54 %) of the urban farmers practice mixed farming, combining animal and crop production. Another 38% focused solely on crop production, while only 8% involved animal husbandry.

Out of the participants, 65% worked full-time on their farms, 30% of them worked part-time and only 5% of the respondents were irregular farmers. Most of the farmers had received primary school education with 45% having only secondary education. 20% of the farmers had tertiary education meaning they had university degrees. Another 30% had only primary education, while only 5% of the respondents did not have any form of education. 7% of the respondents had an income of less than one hundred thousand Naira while 35% earned between one hundred thousand and five hundred thousand Naira. Another 35% of the respondents earned between five hundred thousand and one million Naira with only 23% earning above one million Naira annually.

3.2 Respondents' Knowledge and Disposition about CC:

According to Table 1, out of the total of 358 respondents, 312 (88 %) agreed that CC is the biggest threat to agriculture. Only 45 (12%) of the respondents were not convinced of this fact. Additionally, 358 (90%) respondents agreed that the impact of CC on agriculture is already noticeable on a global scale (Table 1). Only 33 (10%) of the respondents' believed CC does not affect agriculture. According to the survey results, most of the participants do not think that the effect of CC was overblown. Out of the total respondents, only around 74 (21%) believed that the consequences were exaggerated, while a majority of about 230 (62 %) of the respondents disagreed with this statement (as shown in Table 1).

From Table 1, 57% of the respondents agreed that individual actions against CC were useful, while 43 % of the respondents did not believe that individual actions against CC are useful in fighting CC and emissions of GHGs.

Table 1: Respondents knowledge and disposition about CC

	Item	*SA*		*A*		*D*		*SD*		*UD*	
		Fre	*%*	*Fre*	*%*	*Fre*	*%*	*Fre*	*%*	*Fre*	*%*
1.	CC is the largest threat to agriculture	193	54	119	33	30	8.4	15	4.4	01	0.2
2.	CC effects on agriculture are already noticeable today	120	34	200	56	15	4.2	18	5.8	0	0
3.	The consequences of CC are exaggerated.	40	11	34	10	100	28	130	36	54	15
4.	Individual actions against CC are useful	119	33.8	83	23	80	22	75	21	01	0.2
SA: Strongly Agree; A: Agree; D: Disagree; SD: Strongly Disagree; UD: Undecided											

3.3 Disposition of the respondents about GHG emissions:

According to our survey, slightly above half (44 %) of the respondents feel that the public blames agriculture for GHG emissions. On the other hand, 54% of the respondents believed that agriculture is responsible for GHG emissions. Interestingly, one-third of the respondents think of respondents that agriculture has the potential to reduce GHG emissions while only 109 of the respondents believed agriculture cannot reduce GHG emissions (Table 2). Out of the total respondents, 62% believed it was economical to reduce GHG emissions while only 29% of the total respondents disagreed. On the topic of climate-friendly agriculture practices, 46% believed that the risk of adopting climate-friendly management practices in agriculture would benefit both farming and farmers (Table 2). In terms of income opportunities, 63% of the respondents believed that farmers could benefit from adopting climate-friendly practices, while only 33% did not see any positive outcomes. Additionally, 50% of the respondents believed that the use of mineral fertilizers was a primary source of GHG emissions in agriculture (Table 2).

3.4 GHG Emission Reduction

Over half (58%) of the respondents had average knowledge regarding GHG emissions from the agricultural sector. Only 8% and 16% of the respondents rated their knowledge of CC as very high and high. Most respondents obtained their knowledge of CC and GHG emissions from the internet, followed by television, radio, agricultural associations and newspapers.

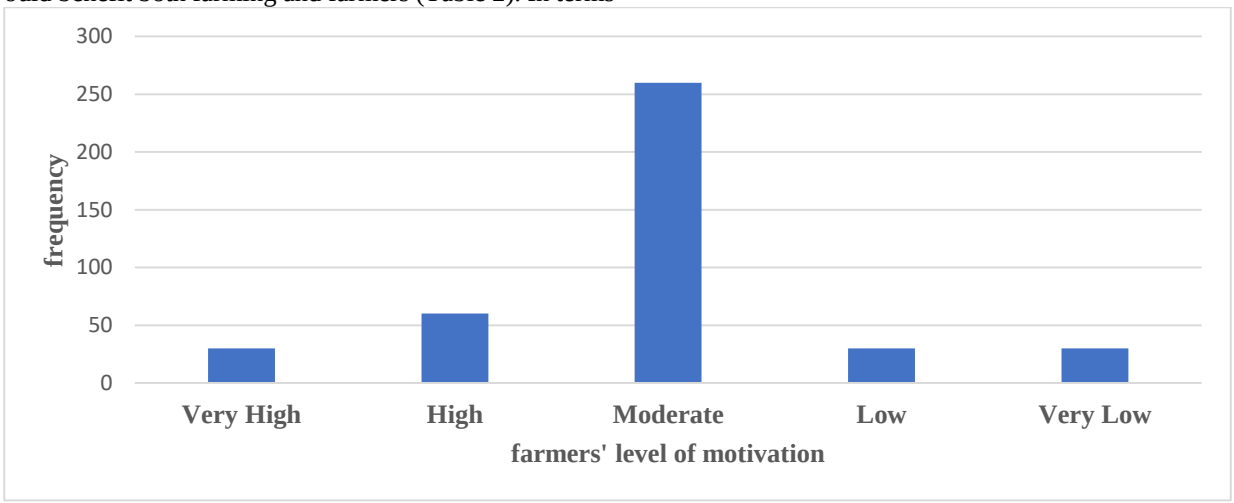

Fig. 1. Chart showing level of motivation for GHG emissions reduction

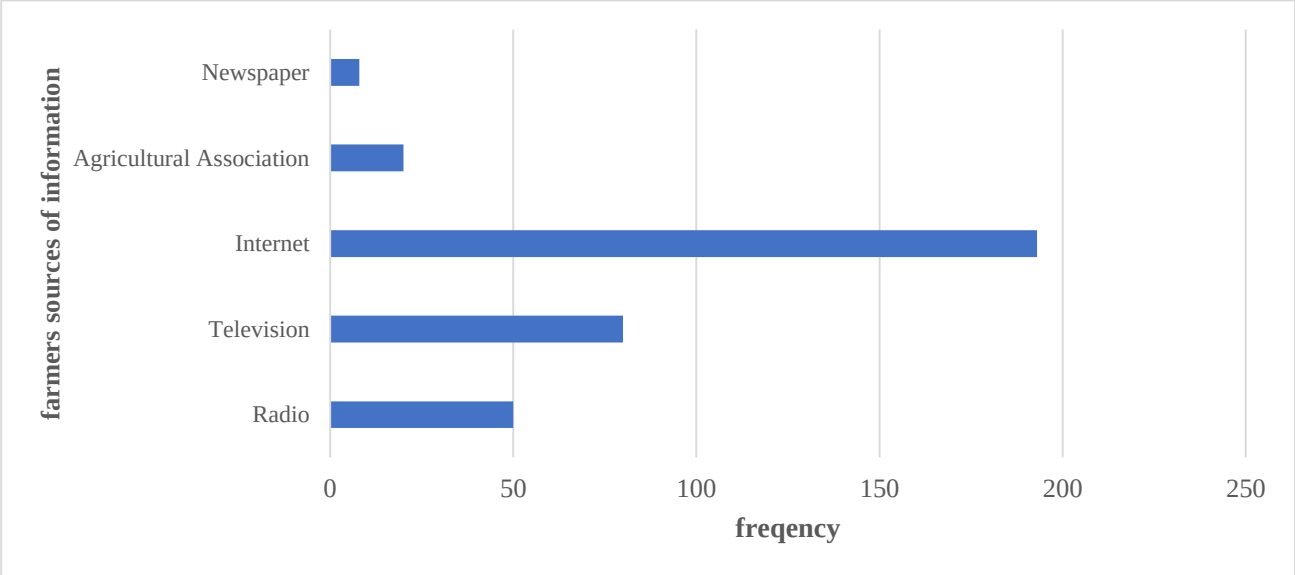

Fig. 2. Sources of information about GHG Emission

3.5 Respondents Motivation for GHG Reduction:

Out of the total respondents, 283 (79%) expressed their willingness to adopt emission-friendly practices, but only if they received subsidies from the government for emission-friendly farm management. Additionally, 30 (8%) of the respondents stated that they would be willing to adopt climate-friendly practices if they witnessed other examples of such practices around them. Another 45 (13%) respondents indicated that they would need training opportunities before they can incorporate climate-friendly practices on their farms. Out of the respondents, 8% (30 people) expressed their willingness to adopt eco-friendly practices on their farms when they see others doing it. Meanwhile, 13% (45 people) said they would need some training before implementing such practices.

When asked about their stance on reducing GHG emissions on their farms, 50% (179 people) said they needed more information on the subject. Only a small number of respondents (8%) stated that they would adopt eco-friendly agricultural practices if they reduced their costs. Another 8% said they would only reduce GHG emissions if the state or federal government compensated them for any additional costs. Around 25% (90 people) were willing to dedicate extra time to learn more about CC and GHG emissions in agriculture. These respondents were also open to working with agricultural extension agents to learn more about reducing GHG emissions if they didn't have to pay for the services.

Out of the respondents, 8% (30 people) expressed their willingness to adopt eco-friendly practices on their farms when they see others doing it. Meanwhile, 45 people (13%) expressed they would require training opportunities before they can adopt climate-friendly practices on their farms.

Describing the present position of the respondents towards reducing GHG emissions on the farms, 179 (50%) of the respondents needed more information about GHG emissions in agriculture. Only a few respondents (8%) would adopt climate-friendly agricultural practices if the practice could reduce their costs. Another 8% stated that they would be willing to reduce GHG emissions on their farms if the state or federal government compensates for the additional costs. Around 25% (90 people) of the respondents were willing to take some extra time to learn more about CC and GHG emissions related to agriculture. The respondents have expressed their willingness to work and learn more about GHG emissions and ways to reduce them from agricultural extension agents, provided they don't have to pay for the services.

In terms of the disposition of farmers towards GHG emissions in agriculture, there was no significant difference observed among farmers in the six states of southwest Nigeria, as indicated in Table 3.

Table 2: Disposition of the Respondents about Agriculture and GHG emissions

Item	*SA*		***A***		***D***		*SD*		*UD*	
	Fre	*%*	*Fre*	*%*	*Fre*	*%*	*Fre*	*%*	*Fre*	*%*
The public is blaming agriculture for GHG emission	85	24	70	20	100	28	93	26	10	2
The agriculture sector has the potential to reduce GHG emissions	200	56	24	7	15	4	104	29	15	4
GHG emission reduction not economically feasible	50	14	54	15	135	38	90	24	29	8
Risk of adopting climate-friendly agricultural management practices outweighs farming benefits	64	18	100	28	104	29	60	17	30	8
There are positive income opportunities in agricultural climate-friendly management	124	35	100	28	15	4	104	29	15	4
Application of mineral fertilizers is a major source of agricultural GHG emissions	100	28	79	22	75	21	75	21	30	8

Table 3: Analysis of variance

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	649.1575	356	1.823476	0.953139	0.674428	1.190916
Within Groups	679.16	355	1.913127			
Total	1328.318	711				
SS: Sum of Squares; DF: degree of freedom; MS: mean square						

4. DISCUSSION

In the southwestern region of Nigeria, most farmers were young and actively engaged in both crop and animal farming. They worked full-time on their farms, were literate, and were open to changing practices that were not environmentally friendly. Young people were increasingly taking up farming as a means of sustainable livelihood possibly due to unemployment and the good income that farming can provide [24]. Technology has also made farming easier. These young farmers are willing to adopt new climate-friendly practices that can reduce GHG emissions on their farms. They understand that CC is the greatest threat to agriculture, impacting crop and animal production.

These effects of CC on crops and animal production are already noticeable today globally. However, many urban farmers in southwestern Nigeria like in some other countries still believe that the effect of CC is an exaggeration [25]. However, Southwestern Nigerian urban farmers like other farmers in other countries have witnessed cases of drought, farmland flooding and increased temperature which were not favorable to crop production, affecting their income negatively [26]. Some of the urban farmers in southwestern Nigeria believe that there are things they can do to fight CC and reduce GHG emissions on their farms [27,28].

The beliefs of Nigerian farmers regarding GHG emissions were investigated. Some Nigerian urban farmers believe that agriculture is responsible for GHG emissions and application of fertilizer is a major source of GHG emissions on the farm [6]. Various factors influence the emission of greenhouse gas in urban farming. These factors include socio-economic factors and farming practices like method of soil tillage, types of manure used, and management strategies for keeping livestock. Application of nitrogen-rich fertilizers has been found to significantly contributes to methane and nitrous oxide emissions in rich field. Poor farm waste management practices can increase greenhouse gas emissions in livestock farming. Rich urban farmers who adopt commercial farming system are sometimes responsible for high level of greenhouse gas emission as most of them do not adopt climate-smart practices like organic manuring and zero tillage. However, farmers believed

that agriculture has the potential to reduce GHG emissions and is economically feasible. Some climate-smart farm practices that can help to reduce GHG emissions on the farms include rotational grazing and the use of quality feeds. In addition, manure should be managed to reduce methane and nitrous oxide on the farm and crop diversities [29]. Many farmers in southwestern Nigeria believe that the benefits of farming outweigh the costs. They are open to participating in activities that reduce GHG emissions if it increases their income. Most of the southwestern Nigeria urban farmers requested payment of subsidies for them to engage in emission-friendly farm management practices on their farms. If they must reduce GHG emissions on their farms. They needed more information and services of extension agents for information on GHG emission reduction. Climate-smart agriculture holds the key to reducing greenhouse gas emission in agriculture. Adopting climate-smart agriculture has the potential to increase farm productivity. Educating farmers about improved agricultural practices, efficient waste management, climate-smart livestock infrastructure, feeds and feeding are important for reducing greenhouse gas emissions and improved farm productivity among urban farmers in Nigeria.

5.CONCLUSION AND RECOMMENDATIONS

Urban farmers in southwestern Nigeria were young and they were moderately informed about CC. They rely on the internet, television, radio, farmers' associations, and newspapers for information on CC, with the internet being the most popular source. These farmers are willing to adopt climate-friendly practices and reduce GHG emissions, but they require proper training and support to do so.

It is recommended that farmers should be trained, provided with subsidies and consider implementing climate-friendly practices that can reduce GHG emissions on their farms. They should explore options such as using renewable energy sources, improving soil health and reducing fertilizer use, and implementing more sustainable livestock management practices. These actions can not only benefit the environment but also have economic and social benefits for farmers and their communities.

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Conflict of interest: The authors confirm that there is no conflict of interest concerning this study

Ethics Consideration: Farmers' consent was sought before the questionnaire was administered.

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