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Climate Change Awareness, Impacts, and Adaptation Measures among Rural Agroforestry Farmers in Guma LGA, Benue State, Nigeria

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ABSTRACT
Climate change is impacting agriculture in Benue State, prompting farmers in Guma LGA to adopt agroforestry for adaptation and mitigation. This study surveyed 118 farmers across four council wards to assess their perceptions, awareness, and strategies for coping with climate-related challenges such as droughts, floods, and pests. A semi-structured questionnaire was administered online using Google Forms to collect data. The demographic profile revealed a predominantly male (64.4%) and married (65.3%) farming population, with most aged between 18 - 20 years and 75.4% classified as low-income earners. Agroforestry practices were widespread, with 47.4% of farmers having 6–15 years of experience. Agri-silviculture (100%) and alley cropping (98.3%) were the most practiced systems. While 55.9% of respondents were aware of climate change, only 23.7% understood its causes, indicating a significant knowledge gap. Community members (45.8%) and radio (39.8%) were the main sources of climate change information. Deforestation (91.5%) and bush burning (61.0%) were perceived as the primary causes of climate change, with extreme heat (98.3%) and floods (65.3%) being the most recognized indicators. Pests (86.3%) were the most common adverse factor affecting farms. Adaptation measures favored included changing crop sowing times (96.6%), access to irrigation (100%), and market access (79.7%), while technological and financial interventions faced notable resistance. The major reported impact of climate change was decreased crop yield (91.5%) and changes in planting days (75.4%). The findings highlight the need for targeted educational programs, diversified mitigation strategies, and enhanced infrastructural support to improve climate resilience among farmers in Guma LGA.

Keywords:
Climate change adaptation,
Perceptions,
Impacts,
Agroforestry practices,
Mitigation strategies,
Guma LGA.

INTRODUCTION

Climate change is increasingly recognized as a critical threat to agricultural productivity and rural livelihoods in Nigeria, particularly among smallholder and agroforestry farmers (Nzeh *et al.*, 2016; Ayanlade *et al.*, 2023). The sector faces mounting challenges from erratic rainfall, extreme heat, drought, flooding, and pest outbreaks, all of which have led to declining crop yields, soil degradation, and heightened food insecurity (Tajudeen *et al.*, 2022; Agbola and Fayiga, 2016). Despite the spread of information about climate change, rural farmers often have limited access to timely and practical knowledge, partly due to insufficient extension services and trained change agents (Nzeh *et al.*, 2016).

Climate change has emerged as a major challenge for agricultural productivity and food security in Nigeria, with Benue State-renowned as the "Food Basket of the Nation"-being particularly vulnerable due to its reliance on rain-fed farming systems (Onyeneke *et al.*, 2023; Aye & Haruna, 2017; Banke, 2023). Multiple studies have documented the adverse effects of climate change in the region, including erratic rainfall, increased temperatures, drought, floods, and pest and disease outbreaks, all of which disrupt crop and livestock production and threaten rural livelihoods (Onyeneke *et al.*, 2023; Banke, 2023; Abaje *et al.*, 2013; Tiwo, 2023). Farmers in Benue State have reported declining yields, food shortages, and increased poverty, with climate variability undermining both the stability and sustainability of agricultural systems (Onyeneke *et al.*, 2023; Aye & Haruna, 2017). Although adaptation strategies such as mixed cropping, use of early-maturing crop varieties, and organic/inorganic fertilizers have been adopted to enhance resilience recent research highlights persistent gaps in farmers' knowledge of climate change causes and limited adoption of climate-smart and diversified practices, such as agroforestry and improved access to information and credit (Onyeneke *et al.*, 2023; Ubong *et al.*, 2022). Moreover, most existing studies focus on general adaptation strategies without specifically examining the role of community-based information networks, the influence of demographic characteristics, or the effectiveness of specific mitigation measuresin the local context of Benue State (Onyeneke *et al.*, 2023; Ubong *et al.*, 2022).

To address this identified gap, this study adopts the Sustainable Livelihood Framework (SLF) to explore how local farmers respond to climate-induced livelihood shocks through knowledge, social capital, and resource accessthe main objective of this study is to assess farmers' perceptions, awareness, and adaptation strategies to climate change in Guma LGA of Benue State, with particular emphasis on the sources of climate change information, perceived impacts on crops and livestock, and the adoption of agroforestry and other mitigation measures. This research aims to provide evidence-based insights to inform targeted interventions that can strengthen climate resilience and enhance food security among smallholder farmers in the region.

MATERIALS AND METHODS

Study area

The study was conducted out in Guma Local Government Area (LGA) is in the northern part of Benue State, North Central Nigeria, with its administrative Headquarters in Gbajimba. Covering a land area of 2,882 km². It is geographically located between latitudes 7°40′N and 8°20′N and longitudes 8°30′E and 9°00′E (Musa *et al.*, 2023). Guma is characterized by a tropical climate with an average annual temperature of 29°C and about 1,850 mm of rainfall, making it highly suitable for agriculture. Guma LGA is divided into 10 council wards, which include Nyiev, Mbayer-Yandev, Mbawa, Mbabai, Uvir, Abinsi, Kaambe, Saghev, Nzorov, and Mbadwem (Dibal *et al.*, 2020). It is predominantly inhabited by the Tiv people, though other ethnic groups such as Jukun, Hausa, and Kabuwa are also present. Agriculture forms the backbone of Guma's economy, with residents primarily engaged in the cultivation of crops like rice, yams, cassava, maize, and groundnuts, as well as livestock farming. Guma River and fertile soils further enhance its agricultural potential, while local markets like Abinsi and Agasha serve as important commercial hubs (Egbeadumah and Tubasen, 2024). Despite its rich agricultural resources, Guma LGA faces challenges such as flooding, soil erosion, and limited rural infrastructure, which affect both farming and rural livelihoods. The area is also notable for its vibrant Tiv culture, marked by traditional festivals, music, and dance, and is governed by a combination of elected officials and traditional rulers who play key roles in community affairs (Ekhuemelo *et al.*, 2019). As a major agricultural hub in Benue State, Guma's development is crucial for sustaining the state's reputation as the "Food Basket of the Nation".

Experimental Design

A multistage sampling technique was adopted for the study. The sample size was surveyed from sampled Council Wards and communities within Guma LGA. Four Council Wards: Mbawa, Nyiev, Mbabai, and Uvirwere purposively selected, encompassing a total of 10 communities. Based on uneven population of the Council Wards, respondents were purposively selected as: Mbawa (30), Nyiev (23), Mbabai (34) and Uvir (31). A total of 118 responses were recorded across all sampled communities (Table 1).

Table 1: Sampled council wards and communities in Guma LGA

S/No.	Name of council ward	Name of Community	Frequency	Percentage (%)	Mean
1.	Mbawa	1. Tse Ukange village	10	8.5	30(25.4)
		2. Daudu community	10	8.5	
		3. Tse Ortaver village	11	9.3	
2.	Nyiev	1. Ortese Community	22	18.6	23(19.5)
		2. Umenger village	11	9.3	
3.	Mbabai	1. Ukpam community	10	8.5	34(28.8
		2. Tse Ayo`o` village	12	10.2	
4.	Uvir	1. Iye village	10	8.5	31(26.3)
		2. Imande-dem village	10	8.5	
		3. Anyiase village	12	10.2	
Total	**4**	**10**	**118**	**100**	**118(100)**

Data Collection Method

Data for this study were collected using a semi-structured questionnaire designed via Google Forms. The questionnaire captured information on demographic characteristics, agroforestry practices, awareness and perceptions of climate change, sources of climate information, perceived impacts, and adaptation and mitigation measures. A multistage sampling approach was employed, selecting four Council Wards (Mbawa, Nyiev, Mbabai, and Uvir) were purposively selected, encompassing ten communities. Respondents were selected purposively within each ward based on population distribution, yielding a total sample size of 118. The online format enabled efficient data collection and standardized responses.

Data Analysis

The data collected were analyzed using descriptive statistics, including frequencies and percentages, to summarize demographic profiles, awareness levels, perceptions, and adaptation responses. The results are presented in tables and figures. Microsoft 365 Excel was used for data analysis.

RESULTS AND DISCUSSION

Results

This study presents the demographic profile of 118 respondents from Guma LGA. The sample comprised 64.4% males and 35.6% females. Most respondents were aged between 18 and 50 years, with the largest age group being 18–25 years (26.3%). Christianity was the predominant religion (91.5%). Most respondents were married (65.3%) and engaged in farming as their primary occupation (78%), with a significant number also reporting farming as an alternative occupation (94.9%). Household sizes were generally large, with 28% of respondents living in households of more than ten members. Income levels were predominantly low, as 75.4% of respondents fell into the low-income category (Table 2).

Table 2: Demographic characteristics of respondents

Variables	Frequency	%
Sex		
Male	76	64.4
Female	42	35.6
Total	**118**	**100**
Age Range		
Below 18	1	0.8
18 – 25	31	26.3
26 – 35	20	16.9
36 – 45	28	23.7
46 - 50	24	20.3
51 – 55	4	3.4
56 - 60	8	6.8
61 Above	2	1.7
Total	**118**	**100**
Religion		
Christianity	108	91.5
Islam	1	0.8
Traditional1	1	0.8
Total	**118**	**100**
Marital status		
Single	21	17.8
Married	77	65.3
Divorced	11	9.3
Widow	9	7.9
Total	**118**	**100**
Primary Occupation		
Student	25	21.2
Farming	92	78
Tailoring	1	0.8
Total	**118**	**100**
Primary Occupation		
Civil Servant		
Tailoring	5	4.2
Farming	112	94.9
Teaching	1	0.8
Total	**118**	**100**
Household size		

1 - 4	27	22.9
5 -7	30	25.4
8 - 10	28	23.7
Above 10	33	28
Total	**118**	**100**
Income Category		
No income	12	10.2
Low Income	89	75.4
Medium Income	12	10.2
High income	5	4.2
Total	**118**	**100**

Results in Figure 1 indicate that most farmers have between 6 and 15 years of experience, accounting for 47.4% of respondents. Experience levels gradually decrease with increasing years, with only 6.8% of farmers having more than 30 years of experience. The findings suggest a relatively young but experienced agroforestry workforce, with the largest segment having 6–10 years of practice, highlighting ongoing adoption and sustained participation in agroforestry within the region.

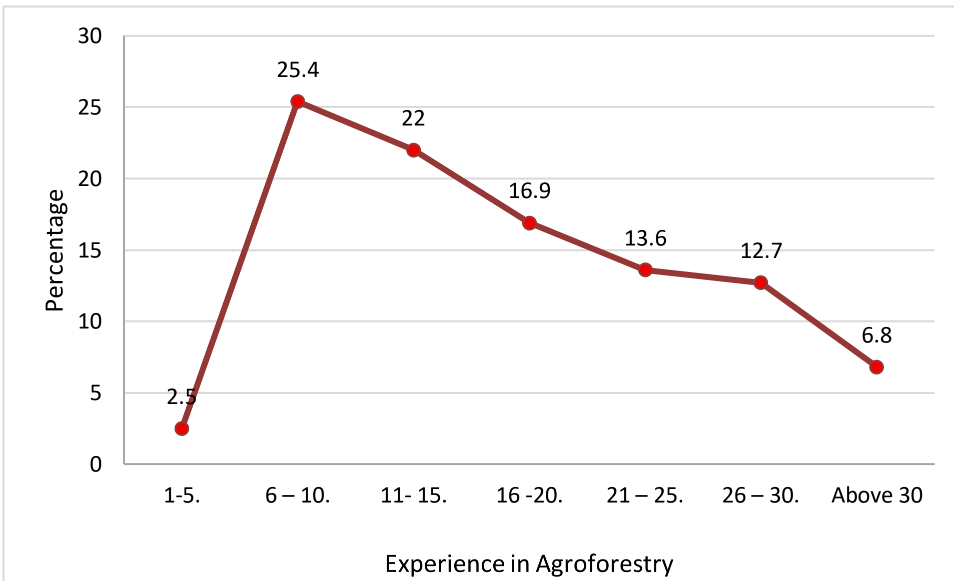

Figure 1: Distribution of farmers by years of experience in agroforestry practices in Guma LGA

Agri-silviculture was majorly practiced (100%) by respondents in Guma LGA, making it the most dominant system among farmers. Alley cropping also shows high adoption, with 98.3% of farmers engaged in this practice. In contrast, windbreaks and forest farming are minimally adopted, each accounting for only 0.8% of respondents (Figure 2). These results indicate a strong preference for agri-silviculture and alley cropping in the region, while other agroforestry practices remain largely underutilized. This pattern suggests opportunities for extension services to promote diversification and broader adoption of alternative agroforestry systems in Guma LGA.

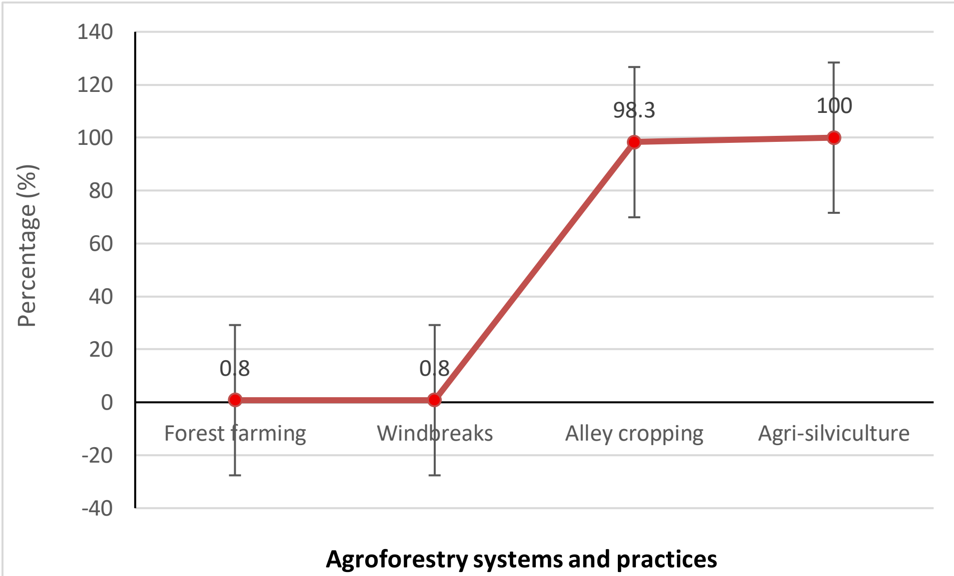

Figure 2: Adoption Rates of Agroforestry Systems among Farmers in Guma LGA

Majority (55.9%) of respondents were aware of climate change, but only 23.7% possess awareness of its causes. However, 29.6% of respondents were uncertain about climate change, while the majority (76.3%) were unaware of its causes. These findings highlight a gap between general awareness of climate change and understanding of its underlying causes, emphasizing the need for targeted educational and awareness programs in Guma LGA to enhance knowledge and promote informed action on climate issues.

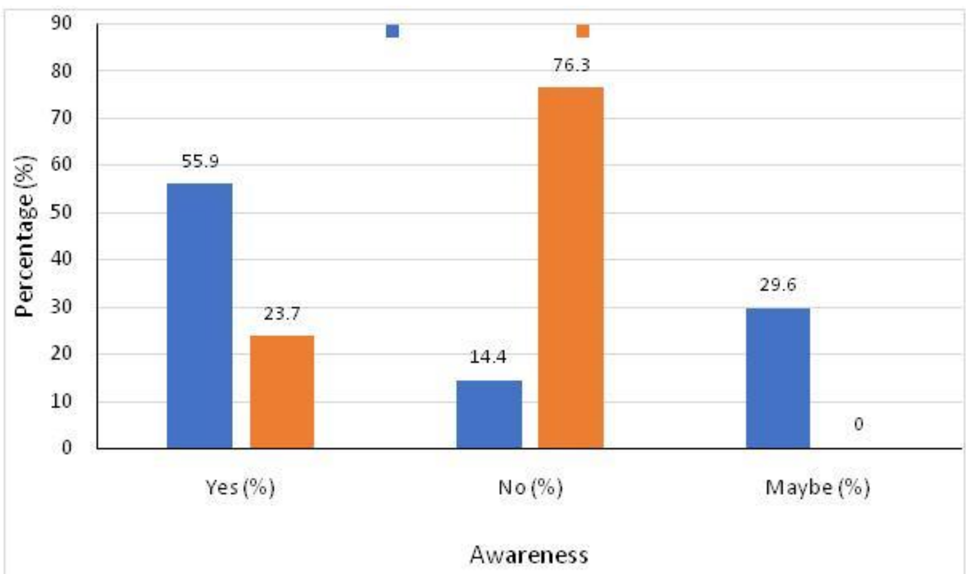

Figure 3: Awareness and understanding of climate change among respondents in Guma LGA

Results in Figure 4 revealed that community members (45.8%) and radio (39.8%) were the most channels for climate change information among farmers, indicating the importance of interpersonal networks and traditional media in information dissemination. Other sources such as the internet (7.8%), public squares (5.1%), and newspapers (1.7%) contribute less significantly. These findings suggest that climate change awareness initiatives in Guma LGA should prioritize leveraging community engagement and radio broadcasts to maximize outreach and effectiveness.

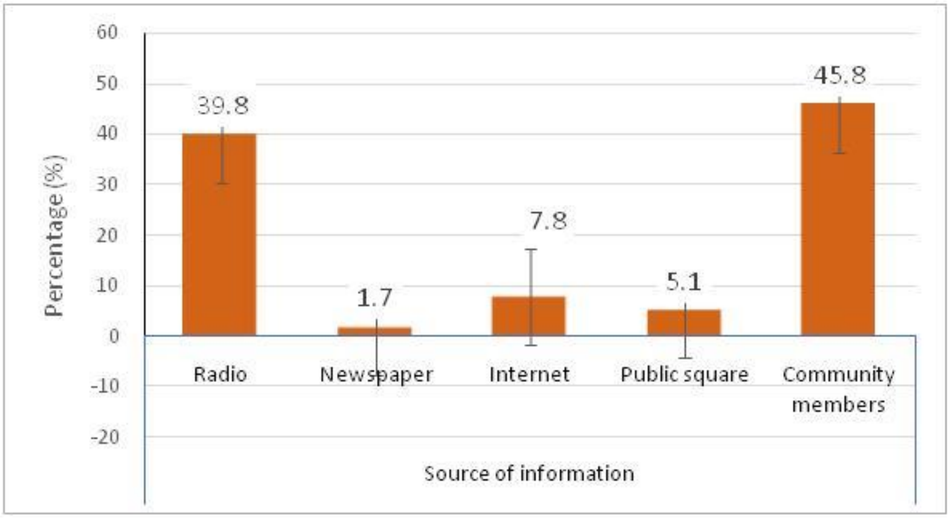

Figure 4: Distribution of respondents by sources of climate change information in Guma LGA

Table 3 summarized the perceptions of respondents in Guma LGA regarding the environmental impacts and causes of climate change. Deforestation (91.5%) and burning of bushes and forests (61.0%) were identified as the most perceived causes of climate change, while industrial emissions and vehicle emissions were less frequently mentioned. Extreme heat was the most widely recognized indicator of climate change (98.3%), followed by floods (65.3%). Over the past five years, pests (86.3%) have been the most common adverse factor affecting farms, with floods and diseases playing a lesser role. In response, the primary mitigation strategy adopted by respondents is changing crop sowing times (96.6%), while other measures such as changing crop cultivars, cultivation techniques, and irrigation practices are less commonly practiced. The findings highlight a strong awareness of deforestation and climate variability, prevalent pest impact on agriculture, and a preference for adaptive farming practices to mitigate climate risks in Guma LGA.

Table 3: Perceptions of environmental impacts, causes, and mitigation of climate change among respondents in Guma LGA

Indicators	Variables	Frequency (F)	Percentage (%)
Causes of climate change	Deforestation	108	91.5
	Industrial emissions	2	1.7
	Emission of greenhouse gases from vehicle	1	0.8
	Burning of bushes and forest	72	61
Climate change indicators	Temperature (extreme heat)	116	98.3
	Droughts	4	3.4
	Floods	77	65.3
Indicators affected farm adversely 5yrs	Flood	11	9.4
	Drought	2	1,7
	Pest	101	86.3
	Disease	3	2.6
Mitigation	Change crop cultivars (plant variety by selective breeding)	4	3.4
	Change crop sowing time,	114	96.6
	Change cultivation techniques	1	0.8
	Use irrigation practices.	2	1.7

Results in Table 4 show that access to irrigation was overwhelmingly supported, with 12 respondents (10.2%) strongly agreeing and 106 (89.8%) agreeing. Access to market was also highly rated, with 50 respondents (42.4%) strongly agreed and 44 (37.3%) agreed. Access to land and labour received strong support, with 51 (43.2%) strongly agreed and 11

(9.3%) agreeing, though 24 (20.3%) disagreed and 32 (27.1%) strongly disagreed. Access to information was widely acknowledged as important, with 17 (14.4%) strongly agreed and 86 (72.9%) agreed. In contrast, the availability and access to subsidy was viewed negatively, as 57 (48.3%) disagreed and 59 (50%) strongly disagreed, with only 1 respondent (0.8%) strongly agreed. Employment of modern technologies in farms faced significant resistance, with 14 respondents (11.9%) disagreed and 104 (88.1%) strongly disagreed. Access to agricultural extension services received mixed responses: 21 (17.8%) strongly agreed and 44 (37.3%) agreed, while 20 (16.9%) disagreed and 32 (27.1%) strongly disagreed. Access to credit/capital/funds was also contentious, with 32 (27.1%) strongly agreed, 6 (5.1%) agreed, but 46 (39%) disagreed and 33 (28%) strongly disagreed. These findings indicate that while infrastructural and informational supports were widely valued as adaptation measures, financial and technological interventions face substantial skepticism or barriers to adoption among respondents in Guma LGA.

Table 4: Respondents' perceptions of adaptation measures to climate change in Guma LGA

Variables	Strongly agree F(%)	Agree F(%)	Neutral F(%)	Disagree F(%)	Strongly disagree F(%)
Availability and access to credit/capital/funds	32(27.1)	6(5.1)	1(0.8)	46(39)	33(28)
Availability and access to subsidy	1(0.8)	0	1(0.8)	57(48.3)	59(50)
Access to information	17(14.4)	86(72.9)	0	12(10.2)	3(2.5)
Access to agricultural extension	21(17.8)	44(37.3)	1(0.8)	20(16.9)	32(27.1)
Access to land and labour	51(43.2)	11(9.3)	0	24(20.3)	32(27.1)
Access to irrigation	12(10.2)	106(89.8)	0	0	0
Access to market	50(42.4)	44(37.3)	0	17(14.4)	7(5.9)
Employment of modern technologies in farms	0	0	0	14(11.9)	104(88.1)

The most impact reported of climate change on crop production in Guma LGA was a decrease in crop yield, with 91.5% of respondents identifying it as a major consequence of climate change. Changes in planting days or times were also widely observed, affecting 75.4% of respondents. A considerable proportion (33.1%) experienced a shortage of food supply, while 13.6% noted an increased prevalence of insects. Moisture stress and an increase in crop diseases were less commonly reported, each affecting only 1.7% of respondents (Figure 5). These findings highlight that reduced crop yield and shifts in planting schedules were the most pressing challenges faced by farmers in Guma LGA because of climate change, underscoring the need for targeted adaptation strategies in agricultural planning and support.

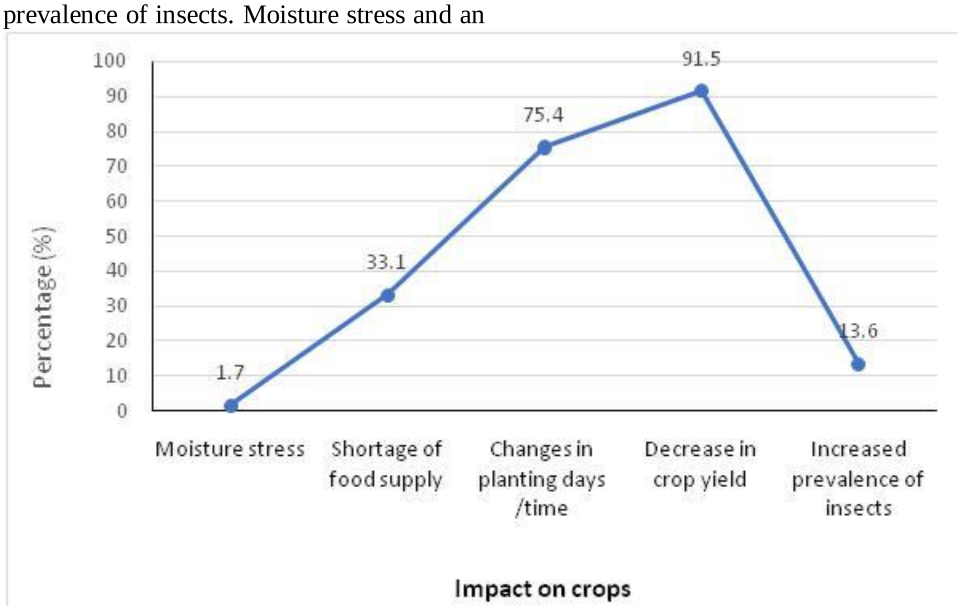

Figure 5: Perceived impact of climate change on crop Farming in Guma LGA

The results in Figure 6 indicate that heat waves are the most significant effect, reported by 94.1% of respondents, highlighting the vulnerability of livestock to rising temperatures. Other notable impacts include increased parasites and diseases (20.3%) and threats to pasture and feed availability (19.5%). These findings suggest that while heat waves are the predominant concern for livestock farmers in the region, issues related to animal health and feed resources are also emerging challenges. The results underscore the urgent need for adaptive strategies to mitigate heat stress and enhance the resilience of livestock systems in Guma LGA.

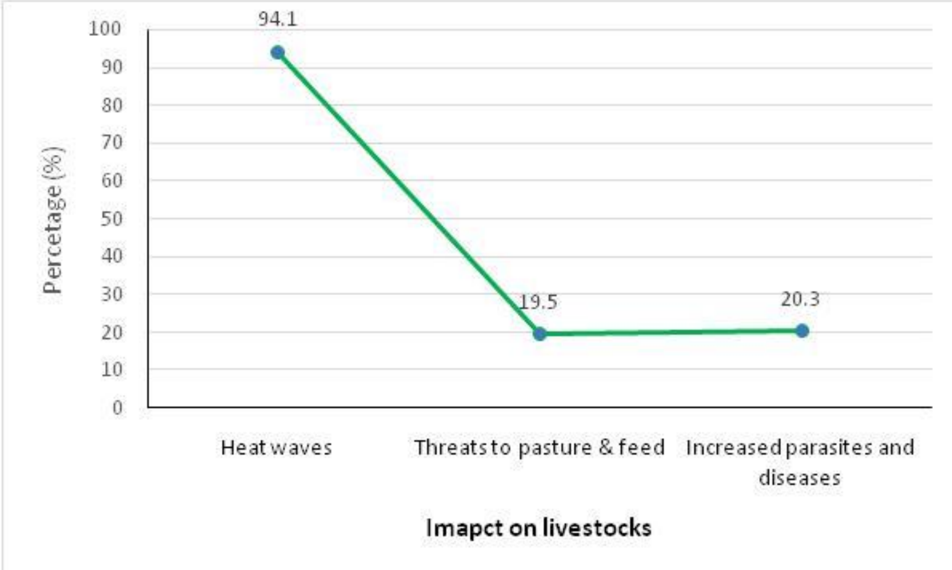

Figure 6: Perceived effects of climate change on livestock in Guma LGA

The results in Figure 7 reveal that most respondents (96.6%) consider changing crop sowing time as the most effective mitigation strategy. Other measures, such as changing crop cultivars (3.4%), using irrigation practices (1.7%), and changing cultivation techniques (0.8%), are far less commonly adopted. These findings suggest a strong reliance on adjusting planting schedules as the primary response to climate variability, while the adoption of other agronomic or technological practices remains limited. This highlights the need for increased awareness and support for a broader range of mitigation strategies to enhance agricultural resilience in the region.

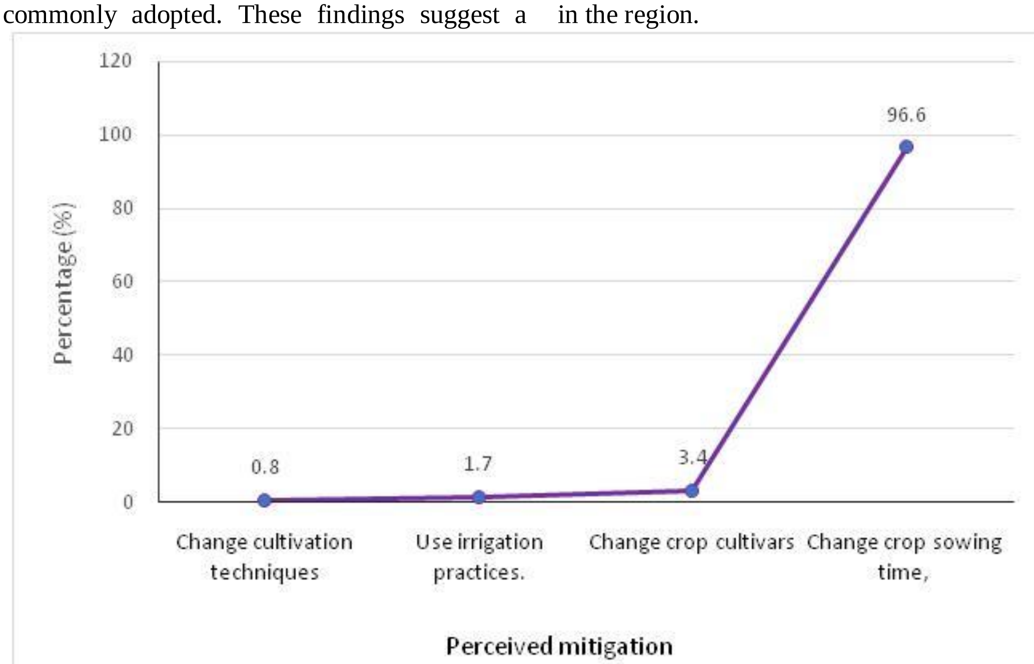

Figure 7: Perceived mitigation measures against climate change among respondents in Guma LGA

Discussion

Agroforestry farmers in this study were predominantly male, revealing a gender imbalance in agroforestry participation. Women do play an important role in agroforestry, but their participation is often limited to specific areas and faces challenges. According to Kiptot and Franzel (2011), women's participation is low in enterprises considered men's domain, such as timber production, but high in activities with little commercial value, like collecting indigenous fruits and vegetables. While women's involvement in technologies like soil fertility management and fodder production is relatively high in terms of female-headed households participating, it is low in terms of the area allocated and number of trees planted (Kiptot & Franzel, 2011). Fortmann and Rocheleau (1985) contradict the notion of male dominance, stating that women are traditionally important participants in both agricultural and forestry components of agroforestry production. However, they also notedthat women are frequently ignored in the design of agroforestry projects due to commonly held myths about their participation (Fortmann & Rocheleau, 1985).

Most agroforestry farmers in the study had between 6 and 15 years of experience. Experience levels gradually decrease with increasing years. Tega and Bojago (2023) noted that the experience of agroforestry positively affects the adoption of agroforestry practices and their contribution to household farm income (Tega & Bojago, 2023a). Darge *et al.*, (2023a) indicate that farming experience is one of the factors that significantly impact smallholder farmers' choice of adaptation options in agroforestry systems (Darge et al., 2023). Agri-silviculture emerged as the most widely practiced system among respondents in Guma LGA, making it the dominant approach among local farmers. Alley cropping also enjoys high adoption, with most farmers engaged in this practice. Agroforestry practices vary in adoption rates across different regions and contexts. In Ethiopia, a study found high adoption rates for several agroforestry technologies, with home-garden agroforestry being adopted by all respondents in the adopter group. Other technologies also showed significant adoption, with boundary planting and multipurpose woodlot at almost 60% and alley-cropping at 30% (Tafere & Nigussie, 2018). The adoption patterns can differ significantly between regions. For instance, in Flanders, the response to alley cropping subsidy programs was relatively low, with only around 30 farmers known to be consciously engaged in the practice (Borremans *et al.*, 2016). This contrasts sharply with the high adoption rates mentioned above.

Most agroforestry farmers in Guma LGA were aware of climate change, but only a small proportion understood its causes. Some respondents expressed uncertainty about climate change, and the majority lacked awareness of what contributes to it. Several studies indicate varying levels of climate change awareness among farmers. For instance, in Ethiopia, most farmers are aware of the significant differences in the sensitivity of water resources to climate change effects across different landforms (Tesfahunegn & Gebru, 2020). In Malaysia, 84% of rice farmers perceive a decrease in rainfall, while 75% perceive an increase in temperature due to climate change (Akhtar *et al.*, 2018). In Nigeria, farmers' perception of climate change is associated with their climate change knowledge, with those in dry agroecological zones being more aware and knowledgeable (Madaki *et al.*, 2023). There are contradictions in the level of awareness across different regions. In Egypt, 51.9% of investigated farmers had no knowledge about the climate change phenomenon (Kassem *et al.*, 2019), which contrasts with the higher awareness levels reported in other studies. This highlights the variability in climate change awareness among farmers in different geographical contexts.

Agroforestry farmers in Guma primarily receive climate change information from community members and radio, underscoring the key role of interpersonal networks and traditional media in spreading information. In contrast, sources like the internet, public squares, and newspapers are less influential in keeping farmers informed about climate change. Several studies indicate that interpersonal networks and traditional media play a significant role in disseminating agricultural and climate change information to farmers. For instance, Okoronkwo *et al.*, (2024) reported that farmers primarily rely on face-to-face discussions with neighbours (76.0%), fellow farmers (66.7%), and radio (54.7%) for climate change information (Okoronkwo *et al.*, 2024). Similarly, Opara (2008) highlights that agricultural extension agents (88.1%), fellow farmers (71.2%), and radio (63.2%) are important sources of agricultural information for farmers in Nigeria (Opara, 2008). While the results in Figure 4 suggest low internet usage (7.8%) for climate change information, Sen *et al.*, (2021) notes that farmers in Vietnam have access to devices like smartphones but prefer to use them for entertainment rather than climate information (Sen *et al.*, 2021). This indicates a potential gap between access to technology and its utilization for agricultural purposes.

Agroforestry farmers in Guma LGA reported that deforestation and the burning of bushes and forests were most identified as causes, while industrial and vehicle emissions were mentioned less frequently. Extreme heat was widely recognized as a key indicator of climate change, with floods also noted by many respondents. In recent years, pests have been the most common adverse factor affecting farms, while floods and diseases have had a lesser impact. To mitigate these effects, most farmers have adopted the strategy of changing crop sowing times. This aligns with findings from other studies, such as the one conducted across Nigeria's agroecological zones, which revealed that most farmers recognize deforestation and land clearance by bush burning as contributors to climate change (Madaki *et al.*, 2023). While industrial and vehicle emissions were less frequently mentioned in Guma LGA, studies in other regions have shown that farmers' perceptions of climate change are influenced by factors such as information received from government extension services, environmental NGOs, and radio, as well as experiencing extreme weather events (Madaki *et al.*, 2023). The high recognition of extreme heat as a climate change indicator in Guma (98.3%) is consistent with the general trend observed in other studies, where farmers perceive changes in temperature-related events and precipitation (Dey *et al.*, 2017). The adoption of changing crop sowing times as a mitigation strategy by 96.6% of farmers in Guma LGA demonstrates their proactive approach to adapting to climate change. This aligns with findings from other regions, where farmers employ various adaptation strategies such as crop diversification, integrated crop-livestock systems, and contingency crop planning (Reddy *et al.*, 2022). The high adoption rate of this strategy in Guma LGA suggests that farmers are actively seeking ways to enhance their resilience to climate change impacts, which is crucial for maintaining food security and improving livelihoods in the face of changing environmental conditions.

Most agroforestry farmers in Guma reported that irrigation wasthe most important adaptation measure to climate change in their area. Access to markets, land, labour, and information were also highly valued by most farmers. However, the majority viewed the availability and accessibility of subsidies negatively, indicating dissatisfaction with current support in this area. Several studies highlight the importance of various adaptation strategies for smallholder farmers facing climate change. For instance, in the Sissala West District, agroforestry practices, drought-resistant crops, and mulching were the most preferred methods (Fagariba *et al.*, 2018). In Nepal, farmers adopted strategies such as off-farm activities, temporary migration, small-scale irrigation, and agroforestry, depending on their agro-ecological zone and social group (Kandel *et al.*, 2023). In Ethiopia's Gedeo zone, farmers employed methods including expanding agroforestry systems, implementing modern agriculture techniques, conserving soil and water, and diversifying livelihoods (Darge *et al.*, 2023b). While irrigation is not specifically mentioned as the most important adaptation measure in these studies, access to water for irrigation was found to be a significant factor in farmers' perception of climate change in the Philippines (Lasco *et al.*, 2015). The importance of institutional support, access to information, and financial resources in adopting climate change adaptation strategies is emphasized in multiple studies (Darge *et al.*, 2023b; Datta & Behera, 2022; Fagariba *et al.*, 2018).

Agroforestry farmers in Guma LGA reported that the most significant impact of climate change on crop production is a decrease in crop yield. Many farmers also observed changes in planting periods, which have disrupted traditional farming schedules. Some respondents experienced food shortages and an increase in pest prevalence, prompting them to adopt strategies such as adjusting crop sowing times to cope with these challenges. Multiple studies have predicted substantial reductions in crop yields due to climate change. For instance, research on maize production in China projected yield decreases of 2-32% for potential maize yield and 0-24% for rainfed maize yield during 2010-2099 compared to the baseline period (Lv *et al.*, 2019). Similarly, a study in the Niger Basin estimated yield reductions of 2-20% for maize and sorghum in certain agro-ecological zones (Akumaga *et al.*, 2018). Some studies have found that adopting farming practices can help mitigate these negative impacts. Adjusting sowing dates has been identified as a crucial adaptation strategy. In China's Maize Belt, optimizing sowing dates and cultivar selection could potentially increase maize yields by 11.1-53.9% under future warming scenarios (Huang et al., 2020). Similarly, in the North China Plain, delaying both wheat sowing and maize harvesting led to a 4-6% increase in total grain yield of the wheat-maize system (Wang *et al.*, 2012).

Results from Guma show that heat waves are considered the most significant effect of climate change, underscoring the vulnerability of livestock to rising temperatures. Other impacts reported by farmers include an increase in parasites and diseases, as well as threats to the availability of pasture and feed. Heat waves are indeed a significant threat to livestock and agriculture due to climate change. Multiple papers highlight the negative impacts of rising temperatures on animal productivity and welfare. For example, Ortiz-Colón *et al.*, (2018) state that high temperatures and heat stress reduce animal productivity, increase parasites and disease pathogens, and lower conception rates in cattle (Ortiz-Colón *et al.*, 2018). This aligns with the question's mention of increased parasites and diseases as a notable impact. Interestingly, while heat waves are a major concern, some studies suggest that certain species or breeds may have greater resilience to high temperatures. Catry *et al.*, (2015) found that European rollers exhibited greater heat tolerance than lesser kestrels, surviving nest temperatures up to

50°C (Catry *et al.*, 2015). This indicates that species-specific responses to heat should be considered in climate change assessments.

Most respondents in Guma identified changing crop sowing times as the most effective strategy for mitigating the effects of climate change. Other measures, such as adopting different crop varieties, using irrigation, and altering cultivation techniques, were much less commonly practiced. The findings from Guma contrast with the broader trends observed in other studies on climate change adaptation strategies among smallholder farmers.

While changing crop planting dates is indeed a widely adopted strategy in many regions, as seen in the central highlands of Ethiopia (89% of respondents) (Alemayehu & Bewket, 2017) and Indonesia (94% of farmers) (Sekaranom *et al.*, 2021), the extremely high percentage (96.6%) reported in Guma for this single strategy is unusual. Most studies indicate a more diverse range of adaptation measures being employed by farmers.

For instance, a systematic review of adaptation measures in Africa found that crop diversification (51.5%), planting drought-tolerant varieties (45%), changing planting dates (42%), and planting early maturing crops (22%) were the dominant strategies (Magesa *et al.*, 2023). Similarly, in the eastern highlands of Ethiopia, farmers employed a variety of practices including adjusting planting dates, using improved maize varieties, intercropping, using recommended mineral fertilizers, supplementary irrigation, and soil and water conservation measures (Teshome *et al.*, 2021). The extremely low adoption rates for other strategies in Guma, particularly irrigation (1.7%) and changing cultivation techniques (0.8%), are concerning. Many studies highlight the importance of these strategies. For example, in West Africa, optimized planting dates combined with climate-resilient crop varieties could offset the negative effects of climate change on crop yields (Carr *et al.*, 2022). The limited adoption of diverse strategies in Guma may leave farmers vulnerable to climate change impacts and may indicate the presence of significant barriers to adaptation, such as lack of access to resources, information, or technology (Teshome *et al.*, 2021).

CONCLUSION

This study offers a comprehensive assessment of farmers' perceptions, awareness, and adaptation strategies to climate change in Guma LGA, Benue State, Nigeria.The respondent population was predominantly male, revealing a gender imbalance in agroforestry participation. While most farmers were aware of climate change, few understood its underlying causes, with deforestation and bush burning most frequently identified. Major impacts reported included extreme heat, floods, and pest outbreaks, which have prompted most changes in farming practices, especially shifting sowing times and using irrigation. However, the adoption of agroforestry and modern technologies remains low despite their potential benefits. Farmers highly valued access to information, markets, and irrigation, but faced challenges in obtaining subsidies, credit, and new technologies. Community networks and radio emerged as the main sources of climate change information. These findings underscore the need for targeted, gender-sensitive interventions, greater support for agroforestry adoption, and improved access to resources and information to strengthen farmers' resilience and food security in Guma LGA.This study aimed to evaluate not only awareness but also the behavioral responses of farmers in the context of a changing climate. In Guma LGA, despite its contributions, this study is limited by its reliance on self-reported data and its focus on a single LGA, which may affect generalizability. Future research should consider longitudinal studies and include multiple regions to assess trends and variations in adaptation strategies over time. Policymakers and stakeholders are encouraged to use these insights to design localized, inclusive climate adaptation programs.

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