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ORIGINAL ARTICLE

Climate Change Effects: Insights from Agroforestry Farmers in Gwer East, Benue State, Nigeria

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ABSTRACT This study explored farmers' awareness of climate change impacts on agroforestry farms in Gwer East, Benue State, Nigeria. Using a multi-stage sampling method, four council wards and fifteen villages were selected. A total of 292 farmers were interviewed using a semi-structured questionnaire via Google Forms. Results showed that most respondents were male (90.4%), aged 36-45 years (29.5%), Christian (99.7%), and married (94.2%). Farming was their primary (88.4%) and secondary occupation (82.2%), with average household sizes of 5-7 members (34.6%). Most earned no income (87.7%) and had undergraduate-level education (42.8%). The farmers practiced alley cropping (95.9%) and a crops-and-trees system (94.9%), with 57.5% having over 15 years' experience. There was a significant positive correlation between educational status and both awareness of climate change ($\rho = .338$, $p < .01$) and knowledge of its causes ($\rho = 0.406$, $p < 0.01$). Most (58.9%) farmers were aware of climate change, with awareness higher among females (71.4%) than males (57.6%), while more males (42.4%) than females (28.6%) reported no awareness. Males made up most of the sample (90.4%). Chi-square analysis showed no statistically significant association between gender and climate change awareness (Pearson Chi-square = 2.007, df = 1, $p = 0.157$). Farmers mainly got climate change information from public gatherings (33.6%) and linked it to natural causes, observing extreme heat (89.7%) and drought (80.8%). Key impacts included reduced crop yields (84.6%) and pasture loss (96.6%), with tree planting (96.9%) as the top mitigation strategy. Modern technologies and better access to credit (90.1%) were widely recommended for adaptation.

Keywords: Agroforestry, adaptation, Climate change, Farmers, Gwer East, mitigation

1. Introduction

This study focused on perceived climate change awareness among agroforestry farmers in Gwer East, Benue State, Nigeria**.** Climate awareness encompasses our understanding and recognition of climate change. It serves as the foundation for effective solutions and involves identifying its causes, risks, and consequences, including global warming (IPCC, 2023). Farmers' perceptions of climate change vary widely, with many recognizing changes in temperature and precipitation patterns over time. Studies have shown that a majority of farmers perceive warming temperatures and decreasing rainfall trends, which often align with local meteorological records (Hou et al., 2015; Roco et al., 2014). For instance, in Central Chile, about 62% of farmers perceive increased average temperatures, 93% note decreased precipitation, and 87% observe more frequent droughts (Roco et al., 2014).

Remarkably, farmers' perceptions about past climate do not always reflect their anticipations about the future. A substantial number of farmers' future climate anticipations are less consistent with climate model projections (Habtemariam et al., 2016). Moreover, there are diverging views about the long-term consequences of climate change among farmers (Takahashi et al., 2016). The study in China revealed three distinct types of farmers' attitudes towards climate change which include: fatalism, support seekers, and technocrats (Zobeidi et al., 2016).

Farmers in Nigeria generally perceive climate change through its observable effects on their agricultural activities and local environment. Studies show that rural farmers are aware of increased temperatures, prolonged dry seasons, floods, and droughts, which lead to lower harvests and reduced income (Abraham and Fonta, 2018). Farmers also notice impacts like increased weed infestation, drying up of streams/rivers, and decreased soil moisture (Olumba et al., 2023). Furthermore, farmers' perceptions of climate change vary across different agroecological zones in Nigeria. Those in drier regions tend to be more aware and knowledgeable about agricultural practices contributing to climate change (Madaki et al., 2023). Besides, there appears to be a significant relationship between the length of farming experience and farmers' perceptions of climate change adaptation techniques (Ayanlade et al., 2017).

Farmers' perceptions and attitudes play a crucial role in their decision-making processes and the adoption of conservation practices in agroecosystems. Research indicates that farmers' environmental attitudes, risk perceptions, and views on profitability significantly influence their willingness to implement sustainable farming practices and participate in conservation efforts (Cary and Wilkinson, 1997; Nastis et al. , 2019; Thompson et al., 2014). Studies have shown that farmers' decision-making is influenced by multiple factors, including their perceptions of technical feasibility, profitability, and environmental concerns. Perceived profitability has been identified as the most important factor influencing the use of conservation practices (Cary & Wilkinson, 1997). However, farmers' environmental attitudes and risk perceptions also play a significant role in their choices. For instance, farmers with higher risk perceptions tend to diversify their land use, contributing to local environmental conservation and agrobiodiversity (Min et al., 2017).

Interestingly, there are often contradictions between farmers' and scientists' perceptions of biodiversity, ecosystem services, and conservation measures. This highlights the need for enhanced communication and cooperation between agricultural stakeholders to promote biodiversity-friendly

farming practices (Maas et al., 2021). Additionally, factors such as age, education, farm size, and the existence of a farm succession plan can influence farmers' preferences for environmentally sustainable strategies (Nastis et al. , 2019; Spina et al., 2023).

Farmers in different regions have shown awareness of climate change and its impacts on agriculture. In Nigeria, rural farmers in the central agricultural zone of Delta State were aware of climate change and identified various causes and effects on crops and livestock (Ofuoku, 2011). Also, farmers in Nigeria generally perceive climate change through various environmental indicators and impacts on their agricultural practices. Studies conducted in different regions of Nigeria reveal that farmers observe increased temperatures, prolonged dry seasons, floods, droughts, and changes in rainfall patterns (Abraham and Fonta, 2018; Jellason et al. 2019). These perceptions align with scientific observations and contribute to farmers' awareness of climate changeThe aim of this study was to investigate perception of climate change effect on agroforestry practices in Gwer East LGA.

2. Materials and methods

2.1. Study area

This study was conducted in Gwer East Local Government Area (LGA), Benue State, Nigeria, with its headquarters located in Aliade. The LGA covers an area of 2,294 km² and had a population of 163,647 as recorded in the 2006 census. Geographically, Gwer East lies between Latitude 7.3° - 7° 18' north and Longitude 8.4833° - 8° 29' east, at an elevation of 166 meters (545 feet) above sea level. The area falls within the wet and dry savannah climate zone (Aw) and has an average temperature of 28°C. Mean monthly temperatures show December as the coolest month (26°C) and March as the hottest (31°C) (Tyubee, 2008).

Gwer East LGA, hosts diverse ecosystems and agro-ecosystems that shape its socio-economic dynamics, particularly for its rural majority (Onah et al., 2023). The region's fertile soils sustain intensive agriculture, with approximately 75% of the population engaged in farming activities, primarily cultivating Yams (*Dioscorea spp.*), rice (*Oryza sativa*), beans (*Phaseolus spp.*), cassava (*Manihot esculenta*), sweet potatoes (*Ipomoea batatas*), maize (*Zea mays*), soybeans (*Glycine max*), sorghum (*Sorghum bicolor*), millet (*Panicum miliaceum*), sesame (*Sesamum indicum*). River Benue bolster irrigation and fishing, critical for livelihoods and food security. Environmental challenges, including deforestation and land degradation, have spurred interventions such as Forest User Groups (FUGs), which promote reforestation and sustainable land management practices. Urban centers like Aliade remain limited in scope, functioning primarily as administrative hubs, while local markets dominate trade networks for agricultural goods. The socio-economic fabric of Gwer East is deeply rooted in natural resource dependence, underscoring the need for sustainability initiatives to preserve ecological integrity and livelihood systems (Ekhuemelo et al., 2017).

2.2. Sampling strategies

A multi-stage sampling technique was employed to select respondents from four Council Wards: Gee, Aliade/Mbalav, Ikyonov, and Mbabur. From each ward, five villages engaged in agroforestry farming were purposively chosen from each ward (Table I). The choice of selection of the Council Wards and villages sampled was based on their active involvement in agroforestry practices in the LGA and the insecurity in the area. From each Ward, 73 respondents were selected, resulting in a total of 292 participants who were directly interviewed.

Table I

Sampled council wards and communities in Gwer East LGA

S/ No.	Name of council ward	Villages	Participants	Percentage (%)
1	Gee	Mbada	14	4.79
		Mbashir	14	4.79
		On-mbanyan	15	5.14
		Mbakor	15	5.14
		Mbatyor	15	5.14
2	Aliade/ Mbalav	Mbakose	14	4.79
		Mbalav	14	4.79
		Mbamune	15	5.14
		Mbagar	15	5.14
		Mbayongo	15	5.14
3	Ikyonov	Mbachor	14	4.79
		Mbachingh	14	4.79
		Mbakaa	15	5.14
		Mbaafa	15	5.14
		Mbakuna	15	5.14
4	Mbabur	Mba-Agayo	14	4.79
		Mba-Abese	14	4.79
		Mbayakar	15	5.14
		Mbachor	15	5.14
		Mbakia	15	5.14
Total			**292**	**100**

2.3. Collection Techniques

Data were collected through personal interview and a semi-structured questionnaire via Google Forms. This method was used because it provides valuable insights into the process of answering questions, which may not be possible with traditional paper-based surveys (Hohwü et al., 2013). Besides, the ease of use and accessibility of Google Forms make it an attractive tool in this study. The use of personal interview allows researchers to develop positive relationships with participants and can lead to improved quality of data collection (Musselwhite et al., 2006). Google Forms was used to administer the questionnaire in this study, following the approach of Salem et al. (2022) in similar research. This approach was chosen because the researcher could directly interview respondents using a semi-structured questionnaire

on Google Forms, which ensured consistent question delivery and minimized interviewer bias. Additionally, automated data storage and analysis tools streamlined the research process, allowed respondents to complete the survey at their convenience, and helped avoid the insecurity challenges prevalent in Gwer East LGA. The questionnaire was developed to collate information on different aspects of agroforestry among farmers. It focused on their demographic characteristics, the agroforestry systems they practice, and their awareness and experience with agroforestry. Also, it examined farmers' awareness of climate change, their sources of information on the topic, and their understanding of its causes, indicators, mitigation measures, and effects. Besides, it explored how agroforestry farmers adapt to climate change and their perceptions of its impact on livestock and crops.

2.4. Data analysis

Responses to questions were manually coded or checked on Google Forms. The data generated from the digital form were automatically registered on excel data sheet. The data was transformed, sorted analysed on 2016 version of Excel and presented in Tables and charts. The study utilized quantitative analysis to explore the relationships between agroforestry farmers' educational status, climate change awareness, and understanding of its causes. Educational status was transformed into ordinal numerical codes for analysis: non-formal education = 0, Primary = 1, Secondary = 2, Undergraduate = 3, and Postgraduate = 4. Awareness of climate change and knowledge of its causes were coded as binary variables (Yes = 1, No = 0). Using IBM SPSS statistics 17 software, Spearman's Rho correlation was used to assess the relationships between agroforestry farmers' educational status, climate change awareness, and knowledge of its causes because these variables are ordinal or not normally distributed. Chi-square test was used to examine the association between gender and awareness of climate change among agroforestry farmers. Pearson correlation coefficients were used to assess the relationships among adaptation measures among agroforestry farmers in Gwer East LGA, as the variables are continuous, and the data were assumed to be normally distributed and linearly related. Calculation of mean scores involves assigning numerical weights to each response category as: Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly Disagree = 1. These are used as approximate indicators of agreement intensity, acknowledging that Likert-type data are ordinal in nature. The mean score for each variable was calculated as follows:

$$Mean\ Score = \frac{(5 \times \%Strongly\ Agree) + (4 \times \%Agree) + (3 \times \%Neutral) + (2 \times \%Disagree) + (1 \times \%Strongly\ Disagree)}{100}$$

3. Results

3.1. Demographic characteristics of Agroforestry Farmers in Gwer East LGA

The reported predominantly male (90.4%) dominance, with females accounting for only 9.6%. This gender imbalance suggests potential societal roles or cultural norms influencing participation in the survey or community activities. The mean age of respondents was 46 years, with the largest groups falling within the 36–45 (29.5%) and 46–50 (26.0%) age ranges. A smaller percentage was under 35 years (15.4%), indicating an aging population with a concentration in middle-aged adults, potentially affecting the labour force's sustainability and productivity. Religion was overwhelmingly Christian (99.7%), with only 0.3% practicing traditional beliefs, highlighting a homogeneous religious composition that could facilitate culturally cohesive interventions. Marital status data showed that 94.2% of respondents were married, with a small proportion single (5.1%) or divorced (0.7%), reflecting strong family structures and social stability that could influence household decision-making and resource allocation (Table II). The strong social cohesion, evident in marital stability and shared religious beliefs, provides a solid foundation for community-based programs aimed at enhancing economic resilience and sustainable development.

The primary occupation was farming, which accounted for 88.4% of respondents, emphasizing the agrarian nature of the community. Other occupations, such as tailoring (4.8%), civil service (3.8%), and student (2.7%), were minimally represented, indicating limited occupational diversity. The reliance on farming and the prevalence of low or no income despite educational achievements call for strategies to improve agricultural productivity, create alternative livelihood opportunities, and align education with market demands. Despite relatively high educational attainment, 42.8% had undergraduate degrees, 37.7% had completed secondary education, and 15.8% held postgraduate qualifications. Income levels were notably low, with 87.7% reporting no income.

This disparity suggests underemployment and a mismatch between educational qualifications and available job opportunities, underlining the need for economic and occupational diversification. Household sizes varied, with the majority comprising 5 - 7 members (34.6%) or 1 - 4 members (29.1%). Larger households (above 10 members) accounted for 15.8%, reflecting a mix of nuclear and extended family systems. Such household structures impact resource distribution and dependency ratios. Furthermore, income levels were predominantly low, with 87.7% of respondents reporting no income and only 12.0% falling into the medium-income category, underscoring economic challenges despite the community's educational achievements (Table II).

3.2. Agroforestry System, Awareness and Experience among Farmers in Gwer East LGA

The Majority of farmers had limited experience in agroforestry, with 57.5% having between 1 to 5 years of farming experience in this system; 30.1% of the farmers had between 6 to 10 years of experience, while only a minimal number (2.4%) had more than 15 years of experience. On types of agroforestry systems employed, most 94.9% of farmers in Gwer East LGA utilize a combination of crops and trees, demonstrating a strong preference for this integrated approach to land management. Conversely, only 3.4% engage

in systems that incorporate animals with trees. Awareness of specific agroforestry practices was very high among the farmers surveyed, particularly regarding alley cropping, which is recognized by 95.9% of respondents as a viable practice. However, awareness of windbreaks is significantly lower, with only 4.1% acknowledging their use (Figure 1).

Table II

Demographic characteristics of Agroforestry Farmers in Gwer East LGA

Variables	Frequency	Percentage
Sex		
Male	264	90.4
Female	28	9.6
Total	**292**	**100**
Age Range		
Below 18		
18 – 25	1	0.3
26 – 35	44	15.1
36 – 45	86	29.5
46 - 50	76	26.0
51 – 55	30	10.3
56 - 60	38	13.0
61 - 65	10	3.5
66 – 70	5	1.7
Above 70	2	0.7
Total	**292**	**100**
Mean	**46**	
Standard deviation	**9.53**	
Religion		
Christianity	291	99.7
Traditional	1	0.3
Total	**292**	**100**
Marital status		
Single	15	5.1
Married	275	94.2
Divorced	2	0.7
Total	**292**	**100**
Primary Occupation		
Student	8	2.7
Farming	258	88.4
Tailoring	14	4.8
Civil servant	11	3.8
Total	**292**	**100**
Secondary Occupation		
Civil Servant	10	3.4
Tailoring	10	3.4
Farming	240	82.2
Teaching	29	9.9
Transportation	11	3.8
Civil servant	2	0.7
Total	**292**	**100**
Household size		
1 - 4	85	29.1
5 -7	101	34.6
8 - 10	60	20.5
Above 10	46	15.8
Total	**292**	**100**
Income Category		
No income	256	87.7
Medium Income	35	12
Total	**291**	**100**
Education Status		
Primary	9	3.1
Secondary	110	37.7
Undergraduate	125	42.8
Postgraduate	46	15.8
Non-formal	2	0.7
Total	**292**	**100**

3.2. Agroforestry System, Awareness and Experience among Farmers in Gwer East LGA

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3.3. Correlations analysis between agroforestry farmers' educational status, climate change awareness, and knowledge of its causes

The results in Table III reveal a statistically significant positive correlation between educational status and awareness of climate change ($\rho = 0.338$, $p < 0.01$), as well as between educational status and knowledge of the causes of climate change ($\rho = .406$, $p < 0.01$). Furthermore, a strong positive correlation was observed between awareness of climate change and knowledge of its causes ($\rho = 0.620$, $p < 0.01$) (Table III).

3.4. Gender differences in awareness of climate change among agroforestry farmers

Crosstabulation results revealed that 58.9% of respondents were aware of climate change, with a higher proportion of awareness among females (71.4%) compared to males

(57.6%). Conversely, a greater percentage of males (42.4%) than females (28.6%) reported no awareness of climate change. Despite these differences, males constituted most of the sample (90.4%) (Table IV). This finding is limited by the fact that 90.4% of the sample consisted of male respondents, resulting in a marked gender imbalance. This imbalance may reduce the statistical power of the chi-square test to detect significant differences.

Figure 1.

Agroforestry System, Awareness and Experience among Farmers in Gwer East LGA

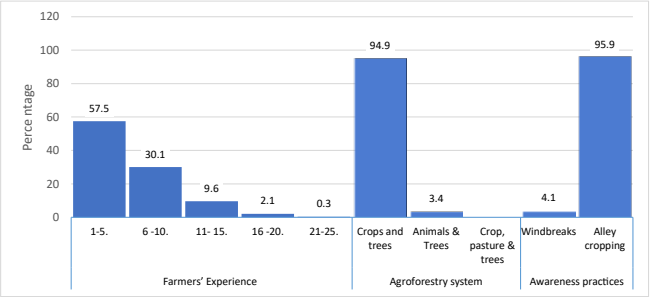


Table III

Spearman's Rho correlations between agroforestry farmers' educational status, climate change awareness, and knowledge of its causes

	Educational Status	Awareness of climate change	Knowledge of the causes of climate change
Educational Status	1.000	.338**	.406**
	.	.000	.000
	292	292	292
Awareness of climate change	.338**	1.000	.620**
	.000	.	.000
	292	292	292
Knowledge of the causes of climate change	.406**	.620**	1.000
	.000	.000	.
	292	292	292

Note: ***. Correlation is significant at the 0.01 level (2-tailed) (ρ ≈ 0.10 - 0.29 - weak; ρ ≈ 0.30 - 0.49 – moderate, ρ ≥ 0.50 – strong)*
ρ = 0.620 (strong positive correlation, since ρ ≥ 0.50)
ρ = 0.338 (moderate positive correlation, since 0.30 ≤ ρ ≤ 0.49)
ρ = 0.406 (moderate positive correlation, since 0.30 ≤ ρ ≤ 0.49)

Chi-square analysis indicated that the association between gender and climate change awareness was not statistically significant (Pearson Chi-square = 2.007, df = 1, p = 0.157) (Table V). These findings suggest that while female farmers demonstrated greater awareness of climate change, gender was not a significant factor influencing awareness levels in this population. The results suggest the relevance of inclusive climate education strategies.

Figure 2.

Source of information on climate change among Farmers in Gwer East LGA

Table IV

Gender differences in awareness of climate change among agroforestry farmers

Gender	Not Aware (n, %)	Aware (n, %)	Total (n)
Male	112 (42.4%)	152 (57.6%)	264
Female	8 (28.6%)	20 (71.4%)	28
Total	120 (41.1%)	172 (58.9%)	292

Table V

Chi-square test results for gender and climate change awareness

Test Statistics	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.007	1	0.157

3.5. Source of information on climate change among Farmers in Gwer East LGA

The most significant source of information for these farmers is the public square, with 33.6% relying on this platform for climate-related knowledge. This suggests that community gatherings and public discussions play a crucial role in disseminating information about climate change. Following closely, 29.5% of farmers obtain information from community members, indicating the importance of interpersonal communication and local networks in spreading awareness about climate issues. Radio is another notable source, with 19.9% of farmers tuning in for updates and information. In contrast, more traditional media such as television (5.1%), newspapers (5.5%), and the internet (6.5%) are less utilized as sources of information among this demographic (Table III). This pattern may reflect limited access to technology or preferences for more immediate, community-based communication methods.

3.6. Awareness of the Causes, indicators, Mitigation and Effect of Climate Change in Gwer East LGA

The study revealed that natural phenomenon (53.1%), deforestation (47.6%) and industrial emissions (27.1%) were prominent causes of climate change, while burning of bushes/forest (31.2%), Industrial emissions (27.1%), burning of hydrocarbons (25.3%), and emission of greenhouse gases from vehicles (23.3%) were also identified as contributing factors. Most respondents observed extreme heat (89.7%), droughts (86%), water scarcity (83.6%), floods (64.4%), and torrential rainfall (45.5%) as current climate indicators in the area. Many have personally experienced drought (80.8%), disease (11.6%), pest infestation (6.5%), floods (0.7%), and forest fires (0.3%) in the last five years. To mitigate these effects, respondents adopted measures such as planting tree crops (96.9%), employing selective breeding techniques (3.1%), changing cultivation methods (2.1%), adjusting crop sowing times (1.7%), and utilizing irrigation practices (1.7%) (Table VI).

Table VI

Perceived awareness of the causes, indicators, mitigation and effect of climate Change in Gwer East LGA

Category	Item	n	%
Perceived causes of climate change	Natural phenomena	155	53.1
	Deforestation	139	47.6
	Burning of bushes and forests	91	31.2
	Industrial emissions	79	27.1
	Hydrocarbon combustion	74	25.3
	Vehicle emissions (greenhouse gases)	68	23.3
Observed indicators	Extreme heat	262	89.7
	Drought	251	86.0
	Water scarcity	244	83.6
	Floods	188	64.4
	Torrential rainfall	133	45.5
Experienced impacts (last 5 years)	Drought	236	80.8
	Disease outbreaks	34	11.6
	Pest infestations	19	6.5
	Floods	2	0.7
	Forest fires	1	0.3
Mitigation strategies used	Planting of tree crops	283	96.9
	Selective breeding (plant varieties)	9	3.1
	Changes in cultivation techniques	6	2.1
	Adjusting crop sowing time	5	1.7
	Use of irrigation	5	1.7

3.7. Prioritization of farmers' adaptation measures to climate change in Gwer East LGA

The findings in Table VII reveal that the application of modern technologies was the most generally agreed upon adaptation measure, with a mean score of 4.29 (10.3% strongly agree, 70.5% agree). This was followed by availability and access to credit or capital (mean score: 4.17; 27.1% strongly agree, 63.0% agree), and provision of infrastructure (mean score: 4.07; 11.6% strongly agree, 65.4% agree). Other important factors included access to market (mean score: 4.06), access to irrigation (4.01), and availability of subsidies (4.00). Access to information (3.96), land and labour (3.94), and agricultural extension services (3.84) were rated lower, indicating potential areas for improvement. Across all measures, disagreement and strong disagreement were minimal, suggesting broad consensus on the importance of these adaptation strategies. The results highlight the critical role of modern technologies, financial resources, and infrastructure in enhancing farmers' adaptive capacity to climate change.

3.8. Perceived impacts of climate change on livestock and crops in Gwer East LGA

Among livestock, high impact of climate change was identified as threat of drought to pasture and feed supplies, affecting 96.6% of respondents. Also, 19.2% respondents reported an increase in the prevalence of parasites and diseases, while 2.7% cited heat waves as a concern. For crops, the primary impact was a decrease in crop yields reported 84.6% respondents. Other major issues included moisture stress (74.3%), food supply shortages (68.8%), and changes in planting times (68.8%). Furthermore, 45.2% observed an increase in insect prevalence, 37.7% reported a rise in crop diseases, and 4.5% noted soil infertility (Figure 3). These findings underscore the diverse and serious impacts of climate change on both livestock and crop farming in the region.

Figure 2.

Source of information on climate change among Farmers in Gwer East LGA

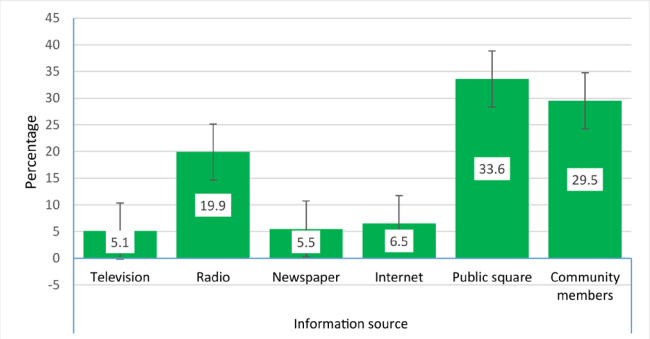
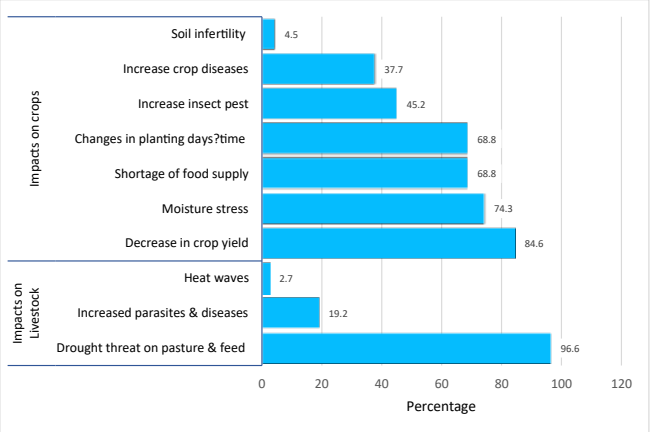


Figure 3.

Impacts of climate change on Livestock and crops in Gwer East LGA



3.9. Correlation matrix of adaptation measures among agroforestry farmers in Gwer East LGA

Using Pearson correlation analysis on survey data from 292 respondents, significant positive correlations were found among all adaptation strategies, indicating that farmers who prioritize one adaptation measure are likely to prioritize others as well (Table VIII). Spearman's ρ; all correlations significant at the 0.01 level (2-tailed); N = 292.The strongest correlations were observed between availability and access to information and agricultural extension services ($r = 0.584$, $p < .01$), and between provision of infrastructure and provision of modern technologies ($r = 0.534$, $p < .01$). Access to irrigation and access to market were also highly correlated ($r = 0.586$, p

Table VII

Prioritization of farmers' adaptation measures to climate change in Gwer East LGA

Adaptation Measure	Strongly Agree n(%)	Agree n(%)	Neutral n(%)	Disagree n(%)	Strongly Disagree n(%)	Mean Score	Rank
Application of modern technologies	30 (10.3)	206 (70.5)	53 (18.2)	3 (1.0)	0 (0.0)	4.29	1
Access to credit or capital	79 (27.1)	184 (63.0)	27 (9.2)	2 (0.7)	0 (0.0)	4.17	2
Provision of infrastructure	34 (11.6)	191 (65.4)	63 (21.6)	4 (1.4)	0 (0.0)	4.07	3
Access to markets	37 (12.7)	183 (62.7)	68 (23.3)	4 (1.4)	0 (0.0)	4.06	4
Access to irrigation	31 (10.6)	181 (62.0)	74 (25.3)	6 (2.1)	0 (0.0)	4.01	5
Access to subsidies	56 (19.2)	184 (63.0)	49 (16.8)	3 (1.0)	0 (0.0)	4.00	6
Access to information	53 (18.2)	177 (60.6)	60 (20.5)	2 (0.7)	0 (0.0)	3.96	7
Access to land and labour	36 (12.3)	177 (60.6)	77 (26.4)	2 (0.7)	0 (0.0)	3.94	8
Access to agricultural extension services	44 (15.1)	165 (56.5)	77 (26.4)	6 (2.1)	0 (0.0)	3.84	9

Table VIII

Correlation matrix of adaptation measures among agroforestry farmers in Gwer East LGA

	Credit	Subsidy	Information	Extension	Land	Irrigation	Market	Infrastructure	Technology
Credit	1.000	0.367	0.343	0.400	0.285	0.259	0.238	0.234	0.281
Subsidy	0.367	1.000	0.522	0.442	0.374	0.341	0.259	0.312	0.300
Information	0.343	0.522	1.000	0.584	0.386	0.351	0.258	0.303	0.303
Extension	0.400	0.442	0.584	1.000	0.542	0.473	0.308	0.387	0.413
Land	0.285	0.374	0.386	0.542	1.000	0.529	0.418	0.363	0.347
Irrigation	0.259	0.341	0.351	0.473	0.529	1.000	0.586	0.388	0.426
Market	0.238	0.259	0.258	0.308	0.418	0.586	1.000	0.483	0.379
Infrastructure	0.234	0.312	0.303	0.387	0.363	0.388	0.483	1.000	0.534
Technology	0.281	0.300	0.303	0.413	0.347	0.426	0.379	0.534	1.000

< .01), highlighting the interconnectedness of market access and water resources in farmers' adaptation strategies. These results suggest a holistic approach to adaptation, where improvements in one area, such as infrastructure or extension services, may positively influence the adoption of other adaptation measures. The findings underscore the need for integrated policy interventions that simultaneously enhance access to credit, information, infrastructure, and modern technologies to effectively strengthen the adaptive capacity of agroforestry farmers facing climate change challenges in the region.

4. Discussion

4.1. Socio-demographic factors and perceptions of climate change

The demographic characteristics of agroforestry farmers in Gwer East LGA revealed a stark gender disparity, with more males involved in farming and fewer females. This may be attributed to several socio-cultural and economic factors in the study area. Traditionally, farming is a male-dominated activity, with women expected to focus on household responsibilities. In Gwer East LGA, women have less access to farmland and decision-making in agricultural activities. Women are also limited in labour-intensive nature of agroforestry like land preparation, tree planting, and maintenance. Furthermore, women are often burdened with domestic work and childcare. Disparities in education and access to agricultural training reduce women's awareness and participation in agroforestry in the study. This finding in similar studies where men predominantly engage in agricultural activities, particularly in agroforestry, while women often participate less due to sociocultural norms or lack of resources. Study by Diawuo *et al.* (2019) in Ghana has shown that men tend to dominate agroforestry systems, despite women playing key roles that often go unrecognized. The finding aligns with the study of Faulkner *et al.* (2014) that reported that participants in agroforestry technologies were primarily older male farmers, highlighting the need to attract more females to adopt these practices. Kiptot et al., (2013) reported that women's involvement in agroforestry was significant, but often constrained by cultural norms and lack of resources. In a related study, Kiptot and Franzel (2012) noted that in terms participation, women are actively involved in agroforestry practices, but their level of engagement varies across different activities. Kiptot and Franzel, (2012) also reported that 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. To promote

gender equity in agroforestry and ensure women benefit fully, Kiptot and Franzel, (2012) and Kiptot et al. (2013) recommended intervention such as women's associations, to assist women to improve productivity and marketing of products in their domain and improving women's access to information through targeted training and representation in all activities which was not seen in this study.

The results of this study indicate statistically significant positive correlations between educational status and both awareness of climate change and knowledge of its causes. Multiple studies indicate a positive correlation between educational level and climate change awareness or knowledge. Incesu and Yas (2023) reports that nursing students had high levels of awareness of global climate change and environmental literacy. Cornejo et al. (2024) found that most agronomy students had a medium level of perception (55.85%) and knowledge (54.25%) regarding climate change. Gaber et al. (2023) revealed that faculty members had a medium level of AI awareness, which could be related to their educational background (Gaber et al., 2023). Also, Selm et al. (2019) observed an interaction between education and gender in self-perceived climate change knowledge. Women's self-perceived knowledge was higher than men among those with low educational attainment, but lower among those with high educational attainment. Respondents reported lower perceived climate change knowledge than white respondents, regardless of educational attainment (Selm et al., 2019).

This study indicates that although most respondents were aware of climate change, with females exhibiting greater awareness than males, the Chi-square analysis revealed no statistically significant association between gender and climate change awareness.Several studies indicate that most respondents were aware of climate change, with varying levels of knowledge across different populations. For instance, Ajuang et al. (2016) reports that 90.9% of respondents in Kenya had observed changes in the overall climate (Ajuang et al., 2016). Similarly, Ofori et al. (2023) found that a strong majority of undergraduate students in Ghana believed climate change is real and human-induced (Ofori et al., 2023). Regarding gender differences, the results are somewhat contradictory. Clayton et al. (2023) reports small but consistent gender differences, with female respondents expressing greater levels of concern and negative emotions about climate change (Clayton et al., 2023). This aligns with the statement that females exhibited greater awareness than males. However, Selm et al. (2019) presents a more complex picture, showing an interaction between education and gender where women's self-perceived knowledge was higher than men among those with low educational attainment, but lower among those with high educational attainment (Selm et al., 2019). Ajuang et al. (2016) found that the sex of the household head significantly influenced respondents' awareness of climate change markers in Kenya (Ajuang et al., 2016). However, Sraku-Lartey et al. (2018) contradicts this, stating that perception of climate change is not influenced by gender in Ghana (Sraku-Lartey et al., 2018).

The perceived awareness of climate change among Gwer East farmers shows a mixed picture. This indicates some progress in climate literacy, though the gap in understanding the suggests the need for more targeted educational initiatives. Increasing knowledge about climate change causes could help empower farmers to adopt sustainable practices and adapt better to its impacts, as recommended in other studies examining climate change awareness in rural Nigerian communities (Aimua *et al*., 2024). Studies across different countries show varying levels of climate change awareness among farmers (Akhtar *et al*., 2018; Ayanlade *et al*., 2017; Oduniyi *et al*., 2018). The findings from this study highlight a moderate level of awareness regarding the causes of climate change, with natural phenomena, deforestation, and industrial emissions being identified as major contributors. This aligns with other studies by Madaki *et al*. (2023), which also note deforestation and industrial activity as prominent causes of climate change. Interestingly, the agroforestry farmers identified both local and global factors, showing some awareness of the broader climate crisis.

The awareness of climate indicators such as extreme heat, drought, and water scarcity suggests that farmers in Gwer East LGA are acutely aware of local manifestations of climate change. Similar finding was reported by Mamun *et al*., (2021) that droughts and erratic rainfall patterns are increasingly recognized as primary climate change indicators. However, the lack of awareness regarding windbreaks and other advanced mitigation strategies, which was found in some studies, indicates the need for more education on comprehensive mitigation techniques. For adaptation, agroforestry farmers in Gwer East primarily employed tree planting to combat climate change.

Finding from this study shows that a mean age of 46 years was more involved in agroforestry in Gwer East LGA. This population is mainly middle-aged adults with young growing families to carter for-. The result aligns with studies showing that middle-aged individuals were highly active in farming, as they are typically more experienced and resourceful compared to younger farmers (Kughur *et al*., 2018). The predominance of Christianity and high marriage rates reflect the cultural landscape of the region, consistent with other rural areas where marriage and religion play critical roles in community structure. The primary occupation of farming for of respondents emphasizes the reliance on agriculture for livelihoods, though the high percentage of farmers without income highlights significant economic challenges. Comparatively, other studies in Gwer-West LGA also show similar trends where agriculture dominates livelihoods, but income generation remains a challenge due to factors like land fragmentation and limited market access (Shabu *et al*., 2020).

4.2. Adaptation practices and climate resilience

Regarding agroforestry practices, a majority of Gwer East farmers combine crops and trees, which is consistent with global agroforestry practices favoring integrated land management to optimize resources. However, the low use of animal-tree systems suggests limited diversification, which could be enhanced through awareness campaigns. Awareness of alley cropping was high, while windbreaks

were significantly less recognized, indicating a need for broader education on diverse agroforestry practices. These findings are consistent with similar studies in Benue State, where awareness of modern techniques like alley cropping is growing, but traditional practices like windbreaks receive less attention (Tokede *et al*., 2021).

This preference for agroforestry reflects a reliance on tree crops for long-term resilience, which has been similarly noted in other agroforestry practices across Nigeria. However, less widespread techniques like selective breeding and irrigation indicate limited adoption of more diverse or advanced climate adaptation methods. The study reveals a strong dependency on financial support systems to enhance adaptation capacity, which aligns with broader research showing that access to credit and subsidies is crucial for building climate resilience. The finding from this study shows that mitigation practices overwhelmingly focused on tree planting (96.9%), illustrating the community's strong reliance on agroforestry to combat climate change. This practice has significant implications for both environmental and agricultural resilience. Trees provide multiple ecosystem services, such as improving soil fertility, reducing erosion, sequestering carbon, and creating favorable microclimates that protect crops from extreme weather conditions.

The study also highlights severe impacts on both livestock and crops. Drought was particularly damaging to livestock through reduced pasture, while moisture stress and crop yield declines underscore the vulnerability of agriculture. Other studies by Drugova *et al*., (2022) and Martins *et al*., (2016) corroborate these findings, showing that livestock feed and crop productivity are consistently hampered by climate change across Nigeria. However, the limited use of diverse mitigation and adaptation strategies suggests a need for improved access to resources and education to enhance farmers' resilience.

Modern technologies emerged as the most highly prioritized adaptation measure among agroforestry farmers; followed by the availability and access to credit or capital, and the provision of infrastructure, which were also rated as important strategies for adapting to climate change. Several papers highlight the importance of traditional and indigenous practices in climate change adaptation. For instance, Okoronkwo et al. (2024) noted that traditional adaptation practices such as organic manure use, traditional organic composting, afforestation, and agroforestry were the topmost agricultural practices used to cushion the effect of climate change (Okoronkwo et al., 2024). Similarly, Biggs et al. (2013) emphasized the role of indigenous knowledge in successful climate change adaptation in Nepal (Biggs et al., 2013). Access to credit and financial support are indeed mentioned as important factors. Ojo and Baiyegunhi (2020) reported how credit constraints can limit farmers' ability to adopt climate change adaptation strategies (Ojo & Baiyegunhi, 2020). Jiri et al. (2017) also noted that access to credit significantly enhanced adaptation (Jiri et al., 2017).

On adaption to climate change by agroforestery farmers, the strongest relationships were found between access to information and agricultural extension services, as well as between the provision of infrastructure and the use of modern technologies. Access to information and agricultural extension services are consistently highlighted as crucial factors influencing farmers' adaptation strategies. Darge et al. (2023) emphasized the importance of access to climate change information and agricultural extension contacts in farmers' decision-making processes. Jiri et al. (2017) noted that households with increased access to climate information through extension services were likely to have better adaptation abilities (Jiri et al., 2017). Popoola et al. (2020) identified the lack of access to agricultural extension services as the most critical constraint to climate change coping and adaptation (Popoola et al., 2020). Asare-Nuamah et al. (2019) elaborated on how extension services enhance smallholder farmers' adaptive capacity through the transfer of skills, knowledge, technology, and innovations (Asare-Nuamah et al., 2019). Regarding infrastructure and modern technologies, several papers highlight their significance. Jiri et al. (2017) mentioned that younger farmers are more likely to adapt due to their access and use of modern information and technology. Abid et al. (2017) emphasized the importance of financial services and farm equipment in supporting adaptation efforts (Abid et al., 2017). Tambo and Abdoulaye (2011) identified access to the technology and complementary inputs as key determinants of adoption for drought-tolerant maize (Tambo & Abdoulaye, 2011).

5. Conclusion

Agroforestry experience was limited among most farmers in Gwer East LGA who were practicing crop-tree systems, while climate change awareness was very high among them. The perceived causes of climate change among farmers were deforestation and industrial emissions. Farmers reported challenges such as drought and extreme heat, responding by planting tree crops and adjusting farming methods. Climate change significantly affected livestock by reducing pasture availability and increasing disease incidence, while crop yields declined due to moisture stress and shifts in planting schedules. Adaptation efforts were bolstered by access to credit, subsidy information, and modern technologies.

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