Climate Change Knowledge and Perception among Farming Households in Nigeria

Mustapha Yakubu Madaki
Czech University of Life Sciences Prague: Ceska Zemedelska Univerzita v Praze
Steffen Muench
Czech University of Life Sciences Prague: Ceska Zemedelska Univerzita v Praze
Harald Kaechele
ZALF: Leibniz-Zentrum fur Agrarlandschaftsforschung (ZALF) e V
Miroslava Bavorova (bavorova@ftz.czu.cz)
Czech University of Life Sciences Prague https://orcid.org/0000-0001-8102-9304

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Abstract

Nigeria is committed to achieving a 20% unconditional and 45% conditional reduction of GHGs emissions by 2030 through a strong focus on awareness and preparedness for climate change impacts via the mobilization of local communities for climate change mitigation actions. As land use and forestry contribute 38% and agriculture contributes 13% of the country's GHGs, farmers are among the stakeholders to be aware and prepare for climate change mitigations and adaptations. This study assessed the knowledge of agriculturally related practices associated with climate change and its relation to their climate change perception. 1,080 smallholder farmers were interviewed across six agroecological zones of Nigeria using a semi-structured questionnaire. Results of regression models revealed that most farmers know that deforestation and land clearance by bush burning contributes to climate change. However, many farmers did not know that methane emissions from livestock (enteric fermentation) can cause climate change. Our results further show that the farmers' perception of climate change is associated with climate change knowledge. Factors affecting the climate change knowledge of farmers include information received from government extension services and environmental NGOs, radio, as well as experiencing extreme weather events. Farmers of dry AEZs were more aware and knowledgeable of the agricultural practices contributing to the changing environment. Increased exposure to climate change events thus appears to elevate the knowledge on the topic. Using extension and environmental NGOs and radio to disseminate climate change information will help further in guiding and shaping farmers' perceptions towards scientific findings for appropriate actions.

1. Introduction

Nigeria is committed to reduce GHGs emission as the country identified as a climate change hotspot (UN 2018). The country faces the deleterious effects of climate change such as changes in rainfall patterns, desertification, flooding and drought (IPCC, 2014). These will negatively have an impact on the environment and result in a loss to Nigeria's GDP of 1.27% by 2027 and 3.42% by the year 2037 (Kompas et al. 2018). As a condition of the Paris Agreement, Nigeria formulated an Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) with the objective of achieving a 20% unconditional and 45% conditional reduction of GHGs-emissions by 2030. This includes a strong focus on awareness and preparedness for climate change impacts via the mobilization of local communities for climate change adaptation action (Li et al. 2017). In addition, it is intended to integrate climate change mitigation and adaptation into national, sectoral, state and local government planning as well as into the plans of universities, research and educational organizations, civil society organizations, the private sector and the media (UNFCCC 2015).

Experience demonstrates that small-scale farmers are not so much concerned with questions related to causes and effects but rely more on their own perception and awareness of changes, (FAO 2014). Farmers respond to climate change according to their perception of the causes of the environmental changes rather than scientific facts and evidence as conventional media trust is not guaranteed among farmers (Hyland et al. 2015; Arbuckle et al. 2015). The actions taken towards climate change mitigation and adaptation thus implies, that the farmers experience the negative effects of climate change on their farm operations. The awareness of climate change among farmers has been a focus of interest in recent scientific discussions (Bryan et al. 2013; Ibrahim et al. 2015; Kutir et al. 2015; Keneilwe et al. 2018; Oduniyi and Tekana 2019; Abdallah et al. 2019 and Mahamadou et al. 2019). However, studies that investigate how the knowledge of climate change is associated with the farmers' climate change perception are scanty despite its paramount importance, as it can be used to guide and shape the farmers' climate change for appropriate mitigation and adaptation decisions. This research gap served as motivation for our study.

While up to 37% of global GHG emissions are caused by the global food system (Mbow et al. 2019), almost 24% of the total global greenhouse gas emissions were caused by the agricultural sector in 2010 alone (EPA 2018). In Nigeria, land use and forestry contribute 38.2% and agriculture contributes 13% and the emissions increased by 25% between 1990 and 2014, (USAID 2019). Investigating not only farmer awareness but also knowledge of the causes of climate change in the context of the need for appropriate mitigations, is of the utmost relevance, but very few studies elicit such information (Madhuri and Sharma 2020). According to the knowledge gap theory, which hypothesized that when an information is disseminated to a social system increases, segments of the population with higher socioeconomic status tend to acquire this information at a faster rate than the lower status segments so that the gap in knowledge between these segments tends to increase rather than decrease (Tichenor et al. 1970). In this way, farmers with high social status will be likely to be more knowledgeable on climate change as they have access to a variety of information sources/channels that broadcast or publish governmental and non-governmental programs on climate change. This indicates the effect of socio-economic variables such as education, income, etc. as well as the role of information sources and channels on the knowledge of climate change of farmers.

However, some authors found out that people with low socioeconomic status are more knowledgeable about local issues that affect them directly than their counterparts (Hwang and Jeong 2009; Madhuri, & Sharma 2020). In this way, farmers that experienced climate risk events are assumed to be more knowledgeable on climate change. This particularly applies to small-scale farmers with poor coping strategies and financial shock absorbers and this, depicts the effect of climate risk experience in climate risk-prone agroecological zones such as dry agroecology (arid, semi-arid, savannah zones, etc.). Based on these previous findings, our study analyzed the climate change knowledge of farmers and its association with their perception and provides answers to the following research questions: i. is the climate change knowledge of farmers associated with their climate change perception? ii. which factors affect the awareness of climate change and the farmers' knowledge of the causes of climate change?.

2. Methodology

2.1 Study area

Nigeria has a total land area of 910,768km^2, a water area of 13,000km^2 (World Bank, 2018). The country is characterized by a tropical climate, with six distinctive AEZs. These AEZs can be categorized into i. the Semi-arid zone, ii. the Sudan savanna, iii. the Guinea savanna, iv. the Swamp forest, v. the Mangroves, and vi. the Rainforest ecological zones. Rainfall is bimodal in the humid/southern (freshwater swamp, Mangroves and Rainforest) part, while unimodal in dry/northern part (the Semi-arid zone, the Guinea and Sudan savannas) of the country (World Climate Guide, 2019). Annual rainfall varies significantly from about 500mm/year in the north (the Semi-arid zone) to 3,000mm/year in the extreme south (the Mangrove and Rainforest ecological zones). The humid climate is a result of the proximity to the Gulf of Guinea. Seasonal temperature differences range from 40˚C at the extreme north (the Semi-arid zone) around April and May to only 12˚C in the central part of the country (the Mangrove/drive savannah agro-ecological zones) around December and January (World Climate Guide 2019). The mean temperature of the country keeps increasing in the last 30 years and the mean precipitation of the country decreases (World Bank 2020). The drought occurrences is more pronounced in the dry AEZs (Eze 2018) and floods affect almost all part of the country to a high extent in the dry AEZs of the country (Usigbe 2021).

2.2 Sampling procedure and sample size

Multi-stage sampling was used to select the respondents for this study. In the first stage, we applied a convenient sampling of one state from each AEZs (figure 1), followed by the random sampling method (a lottery), which was used to select a total of 12 local government areas. Based on these specifications, two wards were selected randomly from each local government area making a total number of 24 wards. Lastly, 45 farming households were drawn randomly (again using a lottery) from each selected ward, reaching a total of 1,080 farming household for the study (Table 1). In cases where random sampling was not possible because of missing lists of farmers (about 20% of wards), snowball sampling was used.

Table 1: Sampling and sample size

Area	Agro-ecological zone	State	No. of farming households
Dry part	Semi-arid	Jigawa	180
	Sudan savannah	Gombe	180
	Guinea savannah	Kaduna	180
Humid part	Mangrove	Ondo	180
	Freshwater swamp	Imo	180
	Rainforest	Ogun	180
		Total	**1,080**

2.3 Data collection

Primary data were collected with the help of 12 trained enumerators using a questionnaire/pen and paper survey between October 2020 and February 2021. Household heads or their representatives (less than 10% of respondents) were interviewed. Most of the interviews were made in native languages (Hausa, Yoruba and Igbo) and responses were translated into English on the spot.

A pre-test survey was conducted with 40 farmers and modifications were made based on the pre-test outcome prior to data collection. A semi-structured questionnaire was used, in which most questions were derived from the knowledge-gap theory as used in the literature (Abdallah et al. 2019; Keneilwe et al. 2018; Oluwaseun et al. 2019 and Sonam et al. 2017) and adjusted to suit regional differences accordingly. The questions included respondents' weather information sources (e.g. extension agent, NGOs, research institutions, farmers' colleagues), information channels (e.g. radio, television, newspapers, internet), their climate risk event experience (e.g. drought, flooding) and their socio-economic characteristics (e.g. household, farm and institutional characteristics), climate change awareness/knowledge of causes and indicators of climate change such as increases in temperature and evaporation, or rainfall variability.

2.4 Data analysis

2.4.1 T-test statistics

T-statistics were used to assess the relationship between the climate change knowledge and climate change perception of farmers. A mean climate change knowledge score (ranges between 0-7) of farmers was compared to the two groups of farmers, based on those that perceived the changes (Yes) in climate change indicators in the study area such as an increase in temperature, decline in the amount of annual rainfall, delay in coming of rainfall etc, and those that do not perceive the changes (No). The t-statistic equation is:

$$t = \frac{X_1 - X_2}{\sqrt{S_1^2 - S_2^2}} \quad \dots (1)$$

t is a t-statistics, $X_1 - X_2$ is climate change knowledge mean scores of those that perceived the changes and those that do not perceive the change respectively, $S_1^2 - S_2^2$ is a variance of the climate change knowledge score of those that perceived the changes and those that so not perceive it.

2.4.2 Logit model: CC awareness

To examine the factors influencing climate change awareness, a binary response (Logit) model was used. Following previous studies, we considered that a farming household head was aware of climate change if he heard the word climate change from information sources and channels or if the farmer experienced changes in their farming operations due to climatic variations (Oduniyi and Tekana 2019; Abdallah et al. 2019 and Mahamadou et al. 2019).

$$y_{i1} = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon \quad \dots (2)$$

In equation 2, y_{i1} is a probability that farming household head i will be aware of climate change by getting climate information or climate variability experience is greater than zero ($y_i > 0$). α is a constant, $\beta_1 \beta_n$ is the regression coefficients, X_i -X_n denotes the set of explanatory variables or factors that influence climate change awareness ε is the error term.

Factors that affect climate change awareness were identified according to the reviewed literature as shown in Table 2. Gender, farming experience and information usage showed a varying effect in previous research, indicating the importance of considering regional differences within this context (Bryan et al. 2013; Ajuang et al. 2016). Education and farming experience are found to influence climate change awareness of farmers (Ajuang et al. 2016; Bryan et al. 2013; Oduniyi and Tekana 2019). However, extension services show mixed effects on the degree of climate change awareness among farmers (Bryan et al. 2013; Oduniyi and Tekana 2019; Mahmood et al. 2021; Shi-yan et al. 2018; Trinh et al. 2018). Access to credit has an association with awareness of climate change causes (Ibrahim et al. 2015; Menike and Arachi 2016; Masud et al. 2018). The most reliable sources of farmers' climate change awareness were extension agents, radio, internet, magazines, newspapers and television (Agwu and Adeniran 2009; Junsheng et al. 2019; Ali et al. 2021; Mudombi et al. 2014).

Table 2: Description of variables imported into the models (N=1,080)

Variable	Description	Mean and standard deviation
Dependent variables		
Climate change awareness	Yes= 1, otherwise= 0	0.72 (0.44)
Knowledge of climate change causes	Farmer's quiz score 0-7	2.62 (1.56)
Independent variables		
Socio-demographic characteristics		
Gender	Male= 1, female= 0	0.78 (0.41)
Age	Years	48.15 (13.30)
Years of education	Years of formal education	8.24 (5.59)
Farming experience	Years of being in farming	22.61 (12.18)
Farmers group membership	Yes= 1, no= 0	0.82 (0.37)
Farm size	In hectare	3.44 (3.45)
Credit	Access to credit (Yes= 1, No= 0)	0.32 (0.46)
Livestock ownership	Yes= 1, No=0	0.56 (0.49)
Agricultural income	Annual agricultural income (Naira)	7,563.60 (5,249.34)
Non-agricultural income	Annual non-agricultural income (Naira)	86.99 (96.78)
Dependency ratio	Number dependent/number of active labourers	1.13 (1.70)
Climate change information sources		
Government extension agent (GEA)	Receiving weather information from GEA (Yes= 1, No=0)	0.69 (0.45)
Environmental NGOs	Receiving weather information from NGOs (Yes= 1, No=0)	0.22 (0.42)
Farmers' cooperatives	Receiving weather information from farmers' cooperatives (Yes= 1, No=0)	0.37 (0.48)
University and research institution (URI)	Receiving weather information from URI (Yes= 1, No=0)	0.10 (0.31)
Farmers' friends	Receiving weather information from farmers' friends (Yes= 1, No=0)	0.40 (0.49)
Climate change information channels		
Radio	Number of times receiving climate-related information via radio in a month	9.84 (9.37)
Television	Number of times receiving climate-related information via television in a month	1.63 (4.75)
Newspaper	Number of times receiving climate-related information via newspapers in a month	0.49 (2.37)
Internet	Number of times receiving climate-related information via the internet in a month	1.10 (4.46)
Climate change experience		
Extreme temperature	Number of extreme temperature experiences by farmer in the last 10 years	0.71 (0.45)
Flooding	Number of flood experiences by farmer in the last 10 years	0.73 (0.43)
Drought	Number of drought experiences by farmer in the last 10 years	2.15 (2.23)
Dry agroecological zones	If a farmer is from one of the three dry zones = 1 otherwise= 0	0.5 (0.50)

2.4.2 Multiple linear regression: CC knowledge

Multiple linear regression was used to analyze the factors affecting knowledge of agricultural practices contributing to climate change. Farmers were asked seven quiz questions on farming practices that related with climate change mitigation to indicate their level of climate change knowledge. Table 3 shows the score distribution of farmers in the following seven dimensions:

i. Deforestation: this is the process of cutting down plants and crops. This breaks the carbon cycle by stopping the CO_2 absorption function of plants. Between 2015-2017, the global loss of tropical forests contributed to about 4.8 billion tonnes of CO_2 per year (or about 8-10% of annual human emissions of carbon dioxide) (Climate Council 2018).

ii. Land clearance by bush burning: this is a process where farmers clear their farmlands using fire to prepare for the rainy season. Bush burning can deplete top-soils nutrients, potentially causing crop yields to decrease (Hassan et al. 2019). Furthermore, it changes organic nitrogen into mobile nitrates which makes it very volatile, causes air pollution through the release of carbon stored in plant leaves, stems and branches into the atmosphere (Sciencing 2017).

iii. Fossil fuel use: is the primary source of CO_2 that is emitted directly from human-induced impacts. The total CO_2 contribution from fossil fuel use and other industrial processes alone contribute 65% of the global greenhouse gas emissions (EPA 2018).

iv. Methane (CH_4) from livestock production: methane makes up the majority of emissions that come from farmed livestock, such as sheep and cattle; animals naturally produce methane as a by-product of their digestive processes and release it into the air (NIWA 2018). Between 1970 and 2010, emissions of CH_4 from enteric fermentation and rice cultivation increased by 20 % (IPCC 2014).

v. Use of manure: inappropriate manure handling and application lead to the emission of CH_4 and Nitrous Oxide (N_2O) this agricultural activity contributes to climate change (EPA 2018).

Table 3: Farmers' scores on quiz questions of causes of climate change (N=1,080)

Quiz mark	Score distribution of farmers (%)	Cumulative frequency
0	10.11	10.11
1	9.46	19.57
2	29.13	48.70
3	25.88	74.58
4	14.01	88.59
5	6.40	94.99
6	2.88	97.87
7	2.13	100.00

vi and vii. Use of chemical fertilizer and other agrochemicals: agricultural activities contribute approximately 30% of total greenhouse gas emissions, mainly due to the intensive use of chemical fertilizers and other agrochemicals (IAEA 2020).

$$y_{i2} = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots \quad + \beta_n X_n + \varepsilon \quad \ldots (3)$$

In equation 3, y_{i2} is the number of questions a farmer answered correctly (table 3) with answer options of yes and no. A correct answer attracted 1 point and a wrong answer 0 points resulting in a total score ranging from 0 to 7 points. α is a constant $\beta_1 \beta_n$ is the regression coefficient, X_i -X_n represents the explanatory variables (table 2), ε is the error term. Logit and the Multiple linear models were tested for multicollinearity and homogeneity by using the Variation Inflation Factor (VIF) (table 7) and normality of the residuals; no signs for homogeneity and multicollinearity were found, as no value exceeded the threshold of VIF>5, which would be a sign of multicollinearity among the explanatory variables (Akinwande et al. 2015).

3. Results

3.1 Farmers' socio-economic characteristics

Table 4a presents the Chi-square result of the discrete socio-economic characteristics of the farmers. The majority (88.89%) of the farmers in dry and humid AEZs were male. There is a significant difference between the two AEZs as females constituted 32.22% of respondents in humid

AEZs, while in dry AEZs females represented only 11.11%. In general, farmers with secondary school education constituted 31.1% of the respondents while 29.6% had primary education. Furthermore, we identified a significant difference between the two zones in terms of education. Farmers with non-formal education in dry AEZs constituted 36.11% and only 7.59% in humid AEZs. This could partially be attributed to the fact that political unrest and insurgency in the dry zones in the northern Nigeria lead to the destruction of schools and displaced people from their hometowns (UNICEF 2021).

The majority (88.2%) of the farmers in this study possessed farmland. The differences between the AEZs are significant. Only 0.93% of farmers from dry AEZs had no farmland as opposed to 22.59% of farmers from humid AEZs. Most farmers (82.4%) had access to extension services with no significant difference between the AEZs. 82.68% of the farmers were members of farmers' groups/cooperatives with a significant difference between the two AEZs. 85.19% of farmers from the dry AEZ were members of farmers' groups as against 80.19% of farmers of humid AEZs. In addition, we identified a significant difference in livestock ownership between the dry and humid AEZs. 73.70% of farmers of dry AEZs reared animals while only 39.07% had livestock in humid AEZs.

Table 4a: Socioeconomic characteristics of farmers (N=1,108) [categorical variables]

Variables	*Category*	*Dry part (%) N=540*	*Humid part (%) N=540*	*Sig*[1]	*Total sample (%)*
Sex	Female	11.11	32.22	**0.000**	21.7
	Male	88.89	67.78		78.3
Level education	Non-formal	36.11	7.59	**0.000**	21.9
	Primary	27.96	31.30		29.6
	Secondary	21.67	40.56		31.1
	NCE/Diploma	9.82	10.00		9.9
	Graduate	3.89	9.81		6.9
	Postgraduate	0.56	0.74		0.6
Land ownership	No	0.93	22.59	**0.000**	11.8
	Yes	99.07	77.41		88.2
Extension contacts	No	16.11	19.07	0.201	17.6
	Yes	83.89	80.93		82.4
Farmers' group membership	No	14.81	19.81	**0.030**	17.32
	Yes	85.19	80.19		82.68
Livestock ownership	No	26.30	60.93	**0.000**	43.69
	Yes	73.70	39.07		56.31

[1] Significant level of X^2 result

Table 4b presents the t-test result of the continuous socio-economic characteristics of the farmers. There is a significant difference in farmers' age between the two AEZs. The mean age of farmers in the dry AEZs is 42.66 while the mean age in the humid AEZs is 53.63. Farmers in the dry AEZs have a larger family size compared to in the humid AEZs. 11 members is the average household size of farmers in the dry AEZs while the average family size is 6 members in the humid AEZs. This may be attributed to the polygamous family setting of dry AEZs (northern part) of the country compared to the dominant monogamous family setting of the humid AEZs (southern part) of the country (Kramer 2020).

Table 4b: Socio-economic characteristics (N=1,080) [continues variables]

Variable	*Dry part*[1]	*Humid part* [1]	*Sig*	*Total*[1]
Age	42.66 (11.85)	53.63 (12.38)	**0.000**	48.15 (0.40)
Household size	11.44 (6.97)	6.38 (2.64)	**0.000**	8.89 (0.17)
Farm size	3.93 (3.97)	2.87 (2.60)	**0.000**	3.44 (3.45)
Farming experience	23.98 (12.11)	22.61 (12.18)	**0.000**	22.61 (12.18)
Agric income ($)[2]	1,493.28(127.83)	1,350.90 (708.66)	**0.000**	7,563.60 (5,249.34)
Non-agric income ($)[2]	76.63 (61.80)	97.32 (5.24)	**0.000**	86.99 (96.78)

[1] Mean and standard deviation (in parenthesis) are reported. [2]original value was in Naira ($1=381 Naira)

Average farming experience in the dry AEZs was 24 years and was thus significantly higher than that of the humid AEZs of 22.61. This is because agricultural activities in the dry AEZs zones are more predominant as an occupation than in the humid AEZs. Farmers in the dry AEZs earn more than the farmers of the humid AEZs from agriculture. The agricultural income varies significantly with an average of $1,493 in dry AEZs in contrast to an average of $1,350 in humid AEZs. However, in terms of non-agricultural income, farmers in the humid AEZs earn more than the farmers in dry AEZs. The average non-agricultural earnings of farmers in the humid AEZs is $97.32 and $76.63 for the farmers in the dry AEZs. This result is not surprising, as agricultural activities are the main occupation in the dry AEZs, while business activities are more predominant in the humid AEZs of Nigeria. In addition, the level of investment is higher in the humid AEZs (southern part) of the country (World Bank 2016).

3.2 Climate change perception in dry and humid zones

Table 5 presents the farmers' climate change perceptions based on indicators of climate change and risk occurrences (five-point from strongly disagree to strongly agree (1-5) scale). Perceived increases in temperature has a mean of 4.03, indicating that most farmers perceived some temperature increases in the last 10 years. These findings agree with NiMet (2020) and BNRCC (2011). Farmers also perceived a decrease in rainfall and a delay in the onset of rainfall. The perception values of the dry AEZs farmers was 3.82 while the mean perception of the humid AEZs farmers was 3.72.

Table 5: Climate change perception of indicators and risk occurrences in last 10 years

Indicator[1]	*Dry AEZs*[2]	*Humid AEZs*[2]	*Sig*	*Mean and standard deviation*[1]
Climate change indicators perception				
Increase in temperature	4.02 (0.98)	4.04 (0.77)	0.647	4.03 (0.88)
Decrease in rainfall (amount)	3.9 (1.07)	3.85 (1.00)	0.241	3.77 (1.10)
Delay in coming of rainfall	3.81 (1.22)	3.72 (1.07)	**0.083**	3.88 (1.04)
Climate risk occurrence perception				
Increase in frequency of drought	3.83 (1.07)	3.88 (0.87)	0.780	3.85 (0.98)
Increase in frequency of flooding	3.84 (0.99)	3.87 (1.04)	0.715	3.86 (1.01)
Increase in evaporation/rapid dry of soil	3.82 (1.02)	3.89 (0.84)	0.857	3.86 (0.93)
Increase in crop pest and disease outbreak	4.18 (0.91)	3.95 (0.84)	**0.000**	4.07 (0.88)

[1] five-point from strongly disagree to strongly agree (1-5) scale. [2]Mean (Std Dev.)

Furthermore, farmers perceived an increase in drought, evaporation, and frequency of floods in the last 10 years. These perceptions are in conformity with BNRCC (2011) and Montcho et al. (2022) In addition to climatic conditions, farmers perceived an increase in crop pest and disease outbreaks in the last 10 years. A significant difference between the zones is observed, as 4.18 was the mean perception of farmers of increases in crop pest and disease outbreaks in the dry AEZs while 3.95 was the mean perception of farmers of increases in crop pest and disease outbreaks in the humid AEZs. Further results revealed no significant differences between the two AEZs on the climate change indicators perceptions except for the delay in coming rainfall. Within the climate risk occurrence perception a significant difference was only observed on increase in crop pest and disease outbreak. These findings clearly show, that the farmers in this study are strongly perceiving negative climate change effects despite the varying climatic conditions in the selected AEZs of Nigeria.

3.3 Description of farmers' knowledge of farming practices related to climate change

Table 6 reports a chi-square test of farmers' knowledge of causes of climate change comparing dry and humid AEZs. Farmers in dry AEZs are more aware on deforestation being a cause of climate change than farmers of the humid AEZs. In the dry AEZs 78.70% of farmers knew deforestation could cause climate change while 52.89% of farmers in humid AEZs were aware of this. Although many of the farmers were aware, it did not stop them from engaging in deforestation because they also consider it as a drought coping strategy (Hassan et al., 2019; Asfaw et al. 2019). 72.96% of the farmers in dry AEZs were aware of land clearance by bush burning causing climate change as opposed to 47.41% of the farmers in the humid AEZs. This corroborates with Hassan et al. (2019) who reported that farmers had no knowledge of the negative impacts of bush-burning. Also, they believe this traditionally used method is the most cost-effective way of land clearance (Hassan et al. 2019).

Table 6: Farmers' knowledge of farming practices causes climate change (N=1,080)

Causes	*Item*	*Dry AEZs (%) N=540*	*Humid AEZs (%) N=540*	*Sig*	*Total % (of knew)*
Deforestation	No	21.30	47.11	**0.000**	69.67
	Yes	78.70	52.89		
Land clearance by bush burning	No	27.04	52.59	**0.000**	60.1
	Yes	72.96	47.41		
Fossil fuel emissions	No	56.48	65.37	**0.000**	39.0
	Yes	43.52	24.62		
Methane from livestock	No	79.26	89.44	**0.000**	15.57
	Yes	20.74	10.56		
Inappropriate manure management	No	78.15	87.04	**0.000**	17.41
	Yes	21.85	12.96		
Excessive use of chemical fertilizer	No	63.52	88.52	**0.000**	24.0
	Yes	36.48	11.48		
Use of chemical plant protection and pesticides	No	58.34	61.67	0.264	40.0
	Yes	41.66	38.33		

Simultaneously, 39% of all respondents were aware that fossil fuel emissions from agricultural machinery can cause climate change. However, there is a significant difference between the farmers of the two AEZs. In dry AEZs 43.52% of farmers knew fossil fuel emissions can cause climate change while in humid AEZs only 24.62% were aware of this. Farmers thus appear to have relatively low knowledge of this issue. Previous research in Malaysia showed, that 85% of the public identified fossil fuel emission as a major cause of climate change and is converse with the knowledge in developed countries, where most farmers know about the effect of fossil fuel emissions on global warming (McCright et al. 2013).

Our results further indicate that farmers have low knowledge on methane emission from livestock production is contributing to climate change. On average, only 15% of the farmers knew about this, with 20.74% in dry AEZs and 10.56% in humid AEZs knew that methane emission from livestock production can cause climate change. This differs from developed countries, for example New Zealand, where many farmers were not only aware but also looking for feed management from different type of plants with low impacts on the amount of methane produced by an animal (NIWA 2018).

Only 17% of farmers knew that inappropriate manure management can cause climate change because of methane and nitrous oxide emissions. We identified a significant difference between the farmers in dry AEZs with 21.85% being aware while only 12.96% being aware in humid AEZs. 24% of farmers knew about the intensive and indiscriminate use of chemical fertilizer contributing to climate change. Again, we found a significant difference between the dry and humid AEZs. 36.48% of the dry AEZs farmers knew that excessive use of chemical fertilizer can cause climate change while only 11.48% of humid AEZs were aware of this issue. This is in line with finding of Environmental Protection (2017), in which most respondents were not aware that N_2O is one of the harmful GHGs. 40% of the farmers were aware that the use of chemical plant protection and pesticides contributed to climate change with no significant difference between the two AEZs. In a related study, Bhandari (2014) reported that farmers generally tend to be unaware of the negative effect of agrochemicals on the environment. The result depicted the farmers having very low knowledge that Methane from livestock and inappropriate manure management contributed to climate change irrespective of their AEZs. Although the respondents in the dry AEZs had a lower level of education compared to their counterparts in the humid AEZs, we could uncover that the farmers in the dry AEZs had significantly more knowledge on climate change causes in almost all dimensions. This would also go in line with previous findings indicating that social status and education might not necessarily lead to more knowledge on a specific subject (Hwang and Jeong 2009).

3.4 Climate change knowledge and its relation to the perception of climate change

There is a relationship between farmers' knowledge of the causes of climate change and their perceptions of several climate indicators (Table 7). Farmers that perceived an increase in temperature (yes) also achieved a higher knowledge score (average score of 2.85 on a scale from 0-7). This is significantly higher than the 1.84 mean knowledge score of farmers who did not perceive an increase in temperature. Similarly, farmers perceiving a decrease in rainfall had a higher knowledge mean score of 2.80 compared to farmers who did not perceive a decrease (score 2.3). If farmers perceive a delay in the coming of the rains, they have a higher knowledge mean score (2.77) than farmers who do not perceive this delay (2.31). Similar observations were made with the perceived increase in the frequency of drought and an increase in the frequency of flooding. If farmers perceived an increase, they had a higher knowledge mean score compared to farmers that did not perceive it. Overall, these findings show that perception and knowledge of the effects of climate change seem to be positively correlated to each other. This indicates that climate change knowledge can be used to guide and shape the climate change perception of farmers which will result in appropriate climate mitigation and adaptation decision.

Table 7: Relationship between the perception of climate indicators and knowledge of causes (N=1,080)

Perception	**Yes**	**No**	**Sig.**
	Knowledge Mean and Std.	Knowledge Mean and Std.	
Increase in temperature	2.85[1] (1.45)	1.84 (1.73)	**0.000**
Decrease in rainfall (amount)	2.80 (1.46)	2.32 (1.73)	**0.000**
Delay in coming of rainfall	2.77 (1.46)	2.31 (1.79)	**0.000**
Increase in frequency of drought	2.89 (1.49)	2.31 (1.66)	**0.008**
Increase in frequency of flooding	2.77 (1.38)	2.39 (1.89)	**0.000**
Increase in evaporation	2.89 (1.49)	2.17 (1.60)	0.173
Increase in crop pest and disease outbreaks	2.85 (1.52)	2.17 (1.50)	0.629

[1] knowledge score in a range from 0-7

3.5 Factors influencing awareness of climate change and knowledge of the causes of climate change

The factors that influence the general climate change awareness and the knowledge of agricultural practices contributed to climate change are shown in Table 8. Members of farmers' groups are significantly more likely to be aware of climate change ($p<0.05$) and are more knowledgeable about the causes of climate change compared to farmers not members of such a group (Table 8). Similar observations have been made by studies (Hasan and Kumar 2021; Huong et al. 2017; Mango et al. 2017 and Mudombi et al. 2014). A higher share of non-agricultural incomes of a farmer significantly increased the probability of climate change awareness and knowledge of climate change causes ($p<0.01$). Ibrahim et al.

(2015) also recorded a significant positive influence of non-agricultural income on both the causes and effects of climate change in southwestern Nigeria.

Farmers who received weather information from government extension agents were more likely to be aware of climate change. While this is in line with some studies (Ali et al. 2021; Ibrahim et al. 2015), it contrasts with findings of other literature (Bryan et al. 2013; Elum et al. 2017; Oduniyi and Tekana 2019) in which extension contact affected climate change awareness *negatively*. We thus see varying effects of extension service provision and how the quality of these facilities can have an influence on their effectiveness. Farmers receiving weather information from environmental NGOs are significantly more likely to be aware of climate change and have more knowledge of the causes of climate change. Similar results were reported in Mali and South Africa, where environmental NGOs were identified as the most important source of climate change information among farmers (Mahamadou et al. 2019; Mudombi et al. 2014). These findings indicate the need for closer collaboration between the public and private sector concerning the provision of information on climate change issues.

Table 8: Double hurdle model of drivers of climate awareness and knowledge (N=1080)

Variable	*Logistic regression[1] (Awareness)*	*Linear regression[2] (Knowledge)*	*VIF[3]*	*1/VIF*
Socioeconomics				
Sex	0.0818 (0.128)	0.0957 (0.119)	1.15	0.867
Age	0.0050 (0.006)	0.0057 (0.005)	2.94	0.340
Years of education	0.0132 (0.009)	0.0137 (0.009)	1.46	0.686
Farming experience	0.0094 (0.006)	0.0069 (0.005)	2.55	0.392
Farmers group membership	0.3322 (0.136)**	0.2471 (0.125)**	1.16	0.865
Farm size	0.0113 (0.015)	0.0093 (0.0141)	1.23	0.813
Credit	-0.1516 (0.118)	-0.1373 (0.109)	1.38	0.726
Livestock ownership	0.0505 (0.111)	0.1055 (0.104)	1.33	0.750
Agricultural income	-0.0003 (0.00)	-0.0014 (0.007)	1.05	0.953
Non-agricultural income	0.0834 (0.028)***	0.0748 (0.026)***	1.16	0.864
Dependency ratio	0.0349 (0.028)	-0.009 (0.026)	1.10	0.908
Weather information sources				
Government extension agent	0.5744 (0.118)***	0.4713 (0.108)***	1.26	0.794
Environmental NGOs	0.2465 (0.124)**	0.2332 (0.115)**	1.20	0.834
Farmers’ cooperatives	0.1913 (0.109)*	0.2464 (0.100)**	1.25	0.799
University and research institution	-0.0295 (0.171)	-0.0467 (0.157)	1.21	0.824
Farmers friends	0.6389 (0.108)***	0.6136 (0.100)***	1.22	0.820
Weather information channels				
Radio	0.0255 (0.005)***	0.0273 (0.005)***	1.36	0.736
Television	0.0091 (0.010)***	0.0054 (0.009)	1.22	0.823
Newspaper	-0.0030 (0.020)	-0.0098 (0.018)	1.15	0.867
Internet	0.01165 (0.011)**	0.0119 (0.010)	1.22	0.817
Climate risk experience in the last 10 years				
Extreme temperature	0.1679 (0.130)**	0.0517 (0.025)**	1.58	0.633
Flooding	0.0420 (0.123)	0.0499 (0.023)**	1.25	0.801
Drought	0.6640 (0.117)***	0.0802 (0.024)***	1.37	0.727
Windstorm	0.4384 (0.107)***	0.0656 (0.024)***	1.24	0.804
Dry agro-ecological zones	0.7535 (0.158)***	0.6309 (0.147)***	2.69	0.371
F-value	***0.000***	***0.000***		
Pseudo R^2/R^2	***0.1915***	***0.5231***		

[1]Marginal effect and standard error are reported. [2]Regression coefficient and std error is reported, *p<0.10, **p<0.05 and ***p<0.01, VIF= variance inflation factors.

Farmers receiving weather information from farmers’ cooperatives were significantly more likely to be aware of climate change and more knowledgeable of the causes of climate change. Other studies, such as from Muench et al. (2021), De Sousa et al. (2018) and Menike and Arachchi (2016), uncovered the positive effects agricultural cooperatives have on information access and awareness of climate change among farmers. Cooperatives serve as a common communication platform stimulate information exchange among farmers. Therefore, receiving weather information from fellow farmers significantly increased the likelihood for a farmer being aware of climate change, too. In addition, we observed an increase in knowledge of the causes of climate change due to access to information from other farmers. Farmer-to-farmer interaction was also identified as a highly important source of climate change information in Mali (Mahamadou et al. 2019) and Nepal (Muench et al. 2021). We can thus derive a generally close peer interaction in smallholder farming systems. As local farmer cooperatives are encouraging peer exchange, farmers in the study area should be motivated to join cooperatives. The importance of cooperatives, informal farmer groups and peer exchange as information sources among Nigerian farmers is evident. This revelation is particularly important because the dissemination rate in agriculture is comparably low (Fichter and Clausen 2021).

An increase in receiving weather information via radio significantly increased the likelihood of a farmer's awareness of climate change and knowledge of the causes of climate change. Similar findings were reported in the US and South Africa (Dorothee et al. 2011; Mudombi et al. 2014). Using television to access weather information had a significant effect on the likelihood of farmers being aware of climate change. This corroborated the findings of Junsheng et al. (2019), who reported the substantial contribution of television to climate change awareness. Mass media, such as television and radio clearly have a smaller effect on climate change awareness than the institutional factors reported in this study. Nevertheless, they should not be neglected as information sources, particularly in the light of the need for access to weather information in rural areas and in communicating with farmers during emergencies such as pest and disease outbreaks, expected flooding, windstorms or wildfires.

Receiving and searching for weather information primarily from the internet positively influenced the likelihood of farmers being aware of climate change. This effect of internet usage on climate change awareness agrees with the findings of Dorothee et al. (2011). Experiencing extreme temperatures more often increased both the perception and knowledge of the causes of climate change among our sample. An increase in the number of flood experiences had by farmers enhanced their knowledge of the causes of climate change significantly. Experience of droughts made farmers more likely to be aware of climate change while it also increased the farmer’s knowledge of the causes of climate change. Experiencing windstorms made farmers significantly more likely to be aware of climate change and increased the farmer’s knowledge of the causes of climate change.

An interesting revelation of this study was that farmers in the dry AEZs (the Semi-arid, Sudan savannah, and Guinea savannah zones) were more likely to be aware of climate change and have more knowledge on climate change compared to farmers in the humid AEZs (the Rainforest, Mangrove and Swamp Forest zones). This can be attributed to the fact that farmers living in vulnerable climate risk areas experience the effects of climate change more than those that are not living in climate risk areas, as depicted by the second argument of knowledge gap theory (Hwang and Jeong 2009; Madhuri and Sharma 2020). The location has been found to affect climate change knowledge, such as perceived changes in drought, flooding, temperature and rainfall patterns, as proxies (Huong et al. 2017). Similar findings, from Kenya and Bangladesh respectively, reported that farmers in arid and semi-arid areas perceived a decrease in rainfall and an increase in its variability, as well as an increase in temperature, more than their humid AEZs counterparts (Bryan et al. 2013; Ajuang et al. 2016; Abdallah et al. 2019). This result puts an emphasize on the importance of considering regional differences in the context of climate change awareness campaigns, policy formulation and mitigation efforts in agriculture. Climate change policies should thus not only be formulated on a national level but specified according to regional requirements.

4. Conclusion

This study, drawing on a primary data survey using a semi-structured questionnaire aimed to i. assess the knowledge of farmers on farming practices that are related to climate change and how its associated with climate change perception of farmers ii. the factors influencing awareness and knowledge of climate change. With respect to the causes of climate change attributed to agriculture, we were able to uncover varying degrees of knowledge in our sample. Most respondents know that deforestation and land clearance by bush burning contributes to climate change. However, many farmers did not know that methane emissions from livestock (enteric fermentation) can cause climate change, despite it being a major GHG contributor within the agricultural sector. This also holds for inappropriate use of manure, fossil fuel emissions from agricultural machinery and the excessive and indiscriminate use of agro-chemicals.

The climate knowledge of farmers was found to be positively associated with the climate perception of farmers. This finding serves as evidence that wrong or missing information can lead to distorted perception. Critical gaps in knowledge consequently lower the mitigation preparedness of farmers towards climate change. Given the mixed results in the level of knowledge about the agricultural causes of climate change among the respondents, we recommend policymakers to focus on educating farmers more about the effects of farm practices on the environment. A well-planned process of knowledge transfer would positively influence the degree of understanding of the subject matter.

Regarding the factors positively influencing the awareness of climate change and knowledge of its causes, contrary to the first aspect of knowledge-gap theory the socio-economic factors do not show much effect on farmers’ climate change awareness and knowledge of farm practices that mitigate climate change. This may happen because the smallholder farmers seem to be socio-economically homogenous. However, weather information sources, channels and climate risk experience of farmers show much significant influence on the farmers’ climate change awareness and knowledge of farm practices mitigate climate change. As cooperative membership, government extension agents, environmental NGOs and farmer-farmer climate change information sources influence the farmers’ climate change awareness and knowledge of farming practices that mitigate climate change. This indicates the importance of using subjected information sources in teaching farmers the effect farming practices, such as methane from livestock and inappropriate manure management, can have on the climate. As radio affects both the farmers' climate change awareness and knowledge of farming practices that mitigate climate change, this highlighted the vital of using radio in climate change awareness creation, guiding climate change perception of farmers toward scientific facts and findings for appropriate action.

Furthermore, as experiencing extreme temperatures, drought, flooding and windstorms were identified as positive drivers of climate change awareness and knowledge, we found farmers of humid AEZs were less knowledgeable about the farm practices that mitigate climate change than their peers in dry AEZs. Living in areas prone to a higher climate risk thus also increases the level of climate change knowledge. This holds particularly when there is not a large difference in income or education and access to the information sources and channels among the respondents as depicted by the knowledge gap theory. Therefore, we identified *location* as an important factor framing the perception and knowledge of climate change. These findings indicate that farmers of climate risk-prone areas are already ahead of their counterparts in terms of climate change perception and knowledge of farming practices that mitigate climate change that will ease the adaptation process what they need to be guided according to the scientific findings.

Climate change awareness and education schemes should be made available through farmers' cooperatives, radio, television and the internet. The better the farmers understand climate change issues and how they affect them, the more they will be ready to adapt to them accordingly. An increase in organizational involvement with farm-related associations and encouragement of farmers to participate in farmer-to-farmer extension and knowledge sharing networks could strengthen their climate change knowledge and shape their perceptions.

Declarations

Ethics approval and consent to participate

Not applicable (NA)

Consent to participate

Informed consent was obtained from all respondents.

Consent for publication

I Professor Miroslava Bavorova, the correspondent author of the paper "Climate Change Knowledge and Perception among Farming Households in Nigeria" and my co-authors (Mustapha Yakubu Madaki, Harald Kächele, and Steffen Muench) hereby declare our willingness and consent to publish the paper in the Journal Climatic Change with Springer publisher.

Competing Interests

There is no conflicting interest among the co-authors

Author contributions

Mustapha Yakubu Madaki (First author)

He carried out the literature review, designed the research, developed the survey questionnaire, carried out the data collection, analysed the data, and interpreted the result and wrote the first draft of the paper.

Miroslava Bavorova (Second author, corresponding author)

Coordinated the research and supervised the literature review, questionnaire design, data collection, analysis, and interpretation. Reviewed the paper.

Steffen Muench (Third author)

Supported the work on literature and theoretical background, results as well as the recommendation part.

Harald Kächele (Fourth author)

Contributed to the theoretical contribution of the paper, discussion of the result and conclusions.

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Availability of data and materials

Data is available on request. There is no other material to share.

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References

1. Abdullah AAKM, Tahmina A, Abu Hayat MSHJ, Hossain MJ, Masudul HPM, Mainuddin M, Kirby M (2019) An intra-household analysis of farmers' perceptions and adaptation to climate change impacts: empirical evidence from drought prone zones of Bangladesh. Climatic Change. https://doi.org/10.1007/s10584-019-02511-9.
2. Agwu AE, Adeniran AA, (2009) Sources of agricultural information used by arable crop farmers in Isale Osun farm settlement, Osogbo local government area of Osun State. Journal of Agricultural Extension 13 (1) 24-34.
3. Ajuang CO, Abuom PO, Bosire EK, Dida GO, Anyona DN (2016) Determinants of climate change awareness level in upper Nyakach Division, Kisumu County, Kenya. Springer Plus 5:1015. https://DOI.10.1186/s40064-016-2699-y
4. Akinwande MO, Dikko HG, Samson A (2015) Variance inflation factor: As a condition for the inclusion of suppressor variable(s) in regression analysis. Open Journal of Statistics 5, 754-767.
5. Ali S, Ying L, Nazir A, Abdullah IM, Shah T, Ye X, Ilyas A, Tariq A (2021). Rural farmers perception and coping strategies towards climate change and their determinants: evidence from Khyber Pakhtunkhwa Province, Pakistan. Journal of Cleaner Production. https://doi.org/10.1016/j.jclepro.2020.125250
6. Asfaw A, Simane B, Bantider A, Hassen A (2019) Determinants in the adoption of climate change adaptation strategies: evidence from rainfed-dependent smallholder farmers in north-central Ethiopia (Woleka sub-basin). Environ Dev Sustain 21:2535–2565. https://doi.org/10.1007/s10668-018-0150-y
7. Arbuckle JGJ, Morton LW, Jon Hobbs J (2015). Understanding farmer perspectives on climate change adaptation and mitigation: The roles of trust in sources of climate information, climate change beliefs, and perceived risk. Environment and Behavior 47(2) 205–234. https://doi/10.1177/0013916513503832
8. Bhandari G, (2014) An overview of agrochemicals and their effects on environment in Nepal. Applied Ecology and Environmental Sciences 2 (2) 66-73.
9. BNRCC (2011) National adaptation strategy and plan of action on climate change for Nigeria (NASPA-CCN). Prepared for the Federal Ministry of Environment Special Climate Change Unit http://csdevnet.org/wp-content/uploads/NATIONAL-ADAPTATION-STRATEGY-ANDPLAN-OF-ACTION.pdf.
10. Bryan E, Ringler C, Okoba B, Roncoli C, Silvestri S, Herrero M (2013) Adapting agriculture to climate change in Kenya: Household strategies and determinants. Journal of Environmental Management, 114, 26–35. https://doi:10.1016/j.jenvman.2012.10.03
11. Climate Council (2018) Deforestation and climate change. https://www.climatecouncil.org.au/deforestation/
12. De Sousa K, Casanoves F, Sellare J, Ospina A, Suchini JG, Aguilar A, Mercado L (2018) How climate awareness influences farmers' adaptation decisions in Central America. Journal of Rural Studies 64: 11-19.
13. Dorothee A, Imke H, Jens W (2011) Climate change and media usage: Effects on problem awareness and behavioural intentions. International Communication Gazette 73, 45-63. http://doi/pdf/10.1177/1748048510386741
14. Elum ZA, Modise DM, Marr A (2017) Farmer's perception of climate change and responsive strategies in three selected provinces of South Africa. Climate Risk Management 16, 246-257.
15. Environmental Protection (2017) The hidden dangers of chemical fertilizers. https://eponline.com/Articles/2017/12/07/The-Hidden-Dangers-of-Chemical-Fertilizers.aspx
16. EPA (2018) Global greenhouse gas emissions data. https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

17. Eze JN (2018) Drought occurrences and its implications on the households in Yobe state, Nigeria. Geoenvironmental Disasters, 5(1). https://doi:10.1186/s40677-018-0111-7
18. FAO (2014) FAO Success Stories on Climate-Smart Agriculture. Food and Agriculture Organization of the United Nations, Rome.
19. Fichter K, Clausen J (2021) Diffusion of environmental innovations: Sector differences and explanation range of factors. Environmental Innovation and Societal Transitions 38: 34-51. https://doi.org/10.1016/j.eist.2020.10.005
20. Hasan MK, Kumar L (2021) Discriminated perceptions of climatic impacts on coastal farm management practices. Journal of Environmental Management, 278, 111550. https://doi:10.1016/j.jenvman.2020.111550
21. Hassan AG, Fullen MA, Oloke D (2019) Problems of drought and its management in Yobe State, Nigeria. Weather and Climate Extremes, 100192. https://doi:10.1016/j.wace.2019.100192
22. Huong NTL, Bo YS, Fahad S (2017) Farmers' perception, awareness and adaptation to climate change: evidence from Northwest Vietnam", International Journal of Climate Change Strategies and Management 9 (4), 555-576. https://doi.org/10.1108/IJCCSM-02-2017-0032
23. Hyland JJ, Jones DL, Parkhill KA, Barnes AP, Williams AP (2015) Farmers' perceptions of climate change: identifying types. Agriculture and Human Values, 33(2), 323–339. https://doi:10.1007/s10460-015-9608-9
24. Hwang Y, Jeong S (2009) Revisiting the Knowledge Gap Hypothesis: A Meta-Analysis of Thirty-Five Years of Research. Journalism and Mass Communication Quarterly. https://doi.org/10.1177%2F107769900908600304
25. Ibrahim SB, Ayinde IA, Arowolo AO (2015) Analysis of arable crop farmers' awareness to causes and effects of climate change in south western Nigeria. International Journal of Social Economics, 42 (7) 614 - 628
26. Intergovernmental Panel on Climate Change [IPCC] (2014) Climate change 2014. Synthesis report summary chapter for policymakers IPCC, p. 31. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_SPM.pdf.
27. International Atomic Energy Agency [IAEA] (2020) Greenhouse gas emission. https://www.iaea.org/topics/greenhouse-gas-reduction
28. Junsheng H, Akhtar R, Masud MM, Rana MS, Banna H (2019) The role of mass media in communicating climate science: An empirical evidence. Journal of Cleaner Production, 117934. https://doi:10.1016/j.jclepro.2019.117934.
29. Keneilwe RK, Phatsimo CL, Olaotswe EK (2018) Agropastoralists' determinants of adaptation to climate change. International Journal of Climate Change Strategies and Management 10 (3), 488-500, https://doi.org/10.1108/IJCCSM-02-2017-0039.
30. Kompas T, Pham VH, Che TN (2018) The effects of climate change on GDP by country and the global economic gains from complying with the Paris Climate Accord. Earth's Future 6, 1153-1173. https://doi.org/10.1029/2018EF000922.
31. Kramer S (2020) Polygamy is rare around the world and mostly confined to a few regions. https://www.pewresearch.org/fact-tank/2020/12/07/polygamy-is-rare-around-the-world-and-mostly-confined-to-a-few-regions/
32. Kutir C (2015) Farmers awareness and response to climate change : A case study of the North bank region , The Gambia, 6(24), 32–41.
33. Li S, Juhász-Horváth L, Harrison P A, Pintér L, Rounsevell MDA (2017) Relating farmer's perceptions of climate change risk to adaptation behaviour in Hungary. Journal of Environmental Management, 185, 21-30. https://doi:10.1016/j.jenvman.2016.10.050
34. Madhuri, Sharma U (2020). How do farmers perceive climate change? A systematic review. Climatic Change. https://doi:10.1007/s10584-020-02814-2
35. Mahamadou DY, Abiodun AL, Olarewajo AO (2019) Adaptation strategies to climate change among cereal crop farmers in Kita, Kayes region of Mali. Journal of Agricultural Extension, 23(3) 107-116. http://eoi.citefactor.org/10.11226/v23i3.
36. Mahmood N, Arshad M, Mehmood Y, Shahzad MF, Kächele H (2021) Farmers' perceptions and role of institutional arrangements in climate change adaptation: Insights from rainfed Pakistan. Climate Risk Management 32: 100288. https://doi.org/10.1016/j.crm.2021.100288
37. Mango N, Makate C, Tamene L, Mponela P, Ndengu G (2017) Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa. International Soil and Water Conservation Research, 5(2), 122–129. https://doi:10.1016/j.iswcr.2017.04.003.
38. Masud MM, Azam MN, Mohiuddin M, Banna H, Akhtar R., Alam ASAF, Begum H (2017) Adaptation barriers and strategies towards climate change: Challenges in the agricultural sector. Journal of Cleaner Production, 156, 698-706. http://dx.doi.org/10.1016/j.jclepro.2017.04.060
39. Mbow C, Rosenzweig C, Barioni LG, Benton TG, Herrero M, Krishnapillai M, Tubiello FN (2019) Food security. In Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security and greenhouse gas fluxes in terrestrial ecosystems. IPCC.
40. McCright AM, Dunlap RE, Xiao C (2013) Perceived scientific agreement and support for governmentaction on climate change in the USA. Climate Change 19:511–518.
41. Menike LMCS, Arachchi KAGP (2016) Adaptation to climate change by smallholder farmers in rural communities: Evidence from Sri Lanka. Procedia Food Science 6, 288 – 29.
42. Montcho M, Padonou EA, Montcho M, Mutua MN, Sinsin B (2022) Perception and adaptation strategies of dairy farmers towards climate variability and change in West Africa. Climatic Change (2022) 170: 38. https://doi.org/10.1007/s10584-022-03311-4

43. Mudombi S, Nhamo G, Muchie M (2014) Socio-economic determinants of climate change awareness among communal farmers in two districts of Zimbabwe. Africa Insight 44 (2) 1-15.
44. Muench S, Bavorova M, Pradhan P (2021) Climate Change Adaptation by Smallholder Tea Farmers: A case study of Nepal. Environmental Science and Policy 116: 136-146. https://doi.org/10.1016/j.envsci.2020.10.012
45. NiMet (2020) State of climate in Nigeria. 2020 annual report. Published by Nigerian Agency, Abuja Nigeria.
46. NIWA (2018) Climate change and agriculture. https://niwa.co.nz/education-and-training/schools/students/climate-change/agriculture
47. Oduniyi OS, Tekana SS (2019) Adoption of agroforestry practices and climate change mitigation strategies in Northwest province of South Africa. International Journal of Climate Change Strategies and Management, 11 (5), 716-729. https://DOI10.1108/IJCCSM-02-2019-0009
48. Oluwaseun SO, Micheal AA, Sibongile ST (2019) Prioritization on cultivation and climate change adaptation techniques: a potential option in strengthening climate resilience in South Africa. Agronomía Colombiana, 37(1), 62–72. https://doi:10.15446/agron.colomb.v37n1 .
49. Sciencing (2017) The effects of bush burning on soil conditions. https://sciencing.com/ecological-succession-definition-types-stages-examples-13719237.html.
50. Shi-yan Z, Gen-xin S, Yao-chen Q, Xin-yue Y, Leipnik M (2018) Climate change and Chinese farmers: Perceptions and determinants of adaptive strategies. Journal of Integrative Agriculture 17(4): 949-963.
51. Sonam WW, Woo-Kyun L, Yowhan S (2017) An assessment of climate change impacts and adaptation in South Asian agriculture. International Journal of Climate Change Strategies and Management. https://doi.org/10.1108/IJCCSM-05-2016-0069.
52. Tichenor PA, Donohue GA, Olien CN (1970) "Mass media flow and differential growth in knowledge". Public Opinion Quarterly. 34 (2), 159–170. doi:10.1086/267786
53. Trinh TQ, Rañola RFJr, Camacho LD, Simelton E (2018) Determinants of farmers' adaptation to Climate change in agricultural production in the central region of Vietnam, Land Use Policy 70: 224-231.
54. UN (2018) Global warming severe consequences for West Africa. https://www.un.org/africarenewal/magazine/december-2018-march-2019/global-warming-severe-consequences-Africa.
55. UNFCCC (2015) Nigeria's intended nationally determined contribution. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Nigeria%20First/Approved%20Nigeria's%20INDC_271115.pdf
56. UNICEF (2021) UNICEF in Nigeria supports children so they can attend school and learn. https://www.unicef.org/nigeria/education.
57. USAID (2019) Greenhouse Gas Emissions Factsheet: Nigeria. https://www.climatelinks.org/resources/greenhouse-gas-emissions-factsheet-nigeria#:~:text=In%20Nigeria%2C%2038.2%20percent%20of,percent%20respectively%20to%20GHG%20emissions.
58. Usigbe L (2021) Dogged by massive floods, Nigeria ramps up actions to tackle climate crisis. https://www.un.org/africarenewal/magazine/november-2021/dogged-massive-floods-nigeria-ramps-actions-tackle-climate-crisis#:~:text=The%20wall%2C%20spanning%201%2C500%20kilometers,%2C%20Jigawa%2C%20Yobe%20and%20Borno.
59. World Bank (2016) Poverty Reduction in Nigeria in the Last Decade. https://documents1.worldbank.org/curated/en/103491483646246005/pdf/ACS19141- REVISED-PUBLIC-Pov-assessment-final.pdf.
60. World Bank (2020) Climate change knowledge portal for development practitioners and policy makers. https://climateknowledgeportal.worldbank.org/country/nigeria/climate-data-historical
61. World Climate Guide (2019) Nigerian climate: Average weather, temperature, precipitation and best time. https://www.climatestotravel.com/climate/nigeria.

Figures

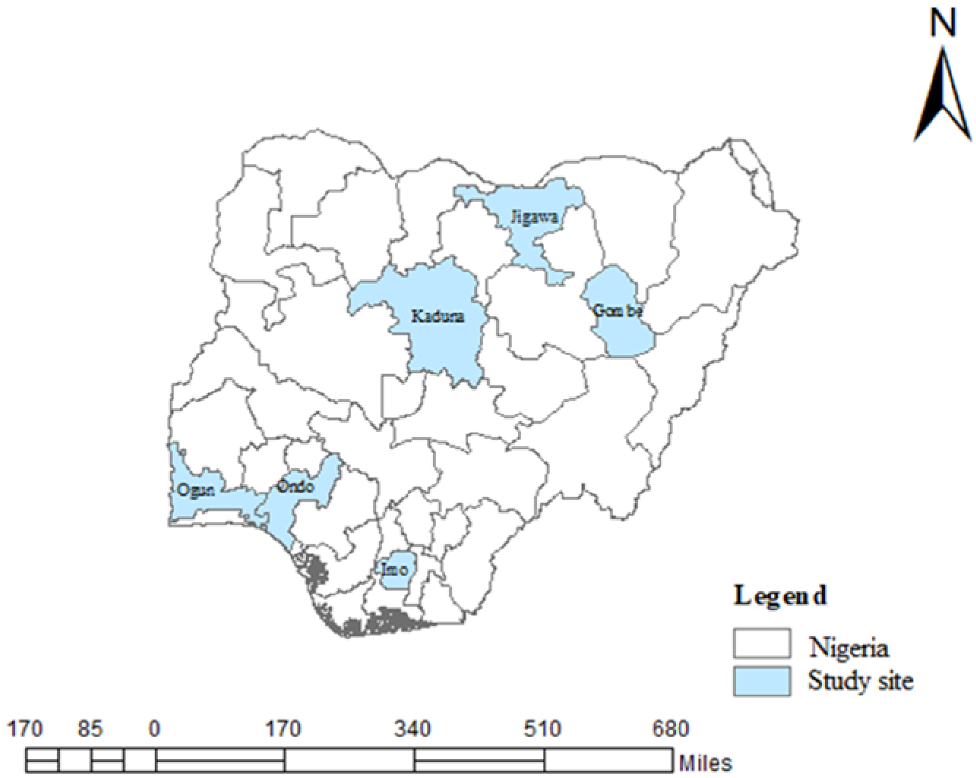

Figure 1

Map of Nigeria showing the study sites