

Research Article

Gender-Differentiated Vulnerability to Climate Change and Adaptation Challenges in Wamakko Local Government Area, Sokoto, Northwestern Nigeria

Ibrahim Mustapha Dankani ^a, Musa Yakubu Fakai ^a

^aDepartment of Geography, Usmanu Danfodiyo University, Sokoto, Nigeria.

ABSTRACT

Climate change is increasingly reshaping livelihoods, resource access, and household well-being in semi-arid northern Nigeria, yet the social and gendered dimensions of these impacts remain insufficiently documented at the local scale. This study assessed gender-differentiated perceptions of climate change impacts, vulnerability, and adaptation challenges in Wamakko Local Government Area of Sokoto State, northwestern Nigeria. A cross-sectional survey design was adopted, and primary data were collected from 381 adult respondents using a structured questionnaire administered through purposive and systematic sampling. Descriptive statistics, comprising frequencies and percentages, were used to summarize respondents' characteristics and perceptions. The findings indicate that increased temperature and heatwaves (28%), drought, water scarcity and water stress (26%), and flooding (22%) were among the most frequently reported climate-related impacts. Overall, 77% of respondents perceived climate change as either moderately serious or very serious. A substantial 73% perceived women and children as facing greater risks during extreme weather events. Respondents associated women's vulnerability with unequal access to land and productive resources, restricted participation in decision-making, unpaid domestic responsibilities, limited climate information, and constrained access to finance, training, and extension services. Lack of knowledge and training was the most frequently identified constraint to climate-smart agriculture (40%), while 68% perceived men as more likely than women to adopt climate-smart agricultural practices. The study argues that these patterns reflect socially differentiated adaptive capacity rather than exposure to climate hazards alone. Effective adaptation in Wamakko therefore requires gender-responsive climate governance, equitable access to productive resources, inclusive climate information systems, stronger agricultural extension, and recognition of women's local knowledge and agency.

ARTICLE HISTORY

Submitted 10 August 2026
Accepted 12 October 2026
Published 19 October 2026

GUEST EDITOR

A. M. Ahmed

KEYWORDS

Climate change; gender; vulnerability; adaptive capacity; climate-smart agriculture; Wamakko; Sokoto State; Nigeria.

1 Introduction

Climate change has become a major environmental and development challenge because its consequences extend beyond changes in temperature and rainfall to affect livelihoods, food systems, water availability, health, economic security, and social relations (Intergovernmental Panel on Climate Change [IPCC], 2022; Ngcamu, 2023). The IPCC emphasizes that climate-related risks emerge through interactions among climatic hazards, exposure, and vulnerability, with vulnerability shaped by social, economic, institutional, and historical conditions (IPCC, 2022). This perspective is particularly important in regions where livelihoods depend heavily on climate-sensitive activities and where households have limited capacity to absorb environmental shocks. Recent research on climate vulnerability in Africa further demonstrates that interacting inequalities, including gender, income, and social position, can compound climate risks and influence people's capacity to respond effectively (Ayanlade et al., 2023). Consequently, understanding climate change requires attention not only to environmental conditions but also to the social structures and institutional arrangements that determine how climate impacts are experienced and managed.

Africa is among the regions experiencing

substantial climate-related risks despite its relatively low historical contribution to global greenhouse-gas emissions (IPCC, 2022; WMO, 2024). Across the continent, rising temperatures, rainfall variability, drought, flooding, land degradation and water stress interact with poverty and dependence on natural resources to shape livelihood outcomes (IPCC, 2022; WMO, 2024). The IPCC reports that agricultural systems across Sub-Saharan Africa remain highly exposed because approximately 95% of the region's cropland is rainfed, while rural populations and households with limited resources face considerable livelihood risks from climate hazards. A review of climate-smart agricultural practices in Sub-Saharan Africa similarly identifies climate change as a major challenge to agricultural production and highlights economic, institutional, environmental, and gender-related barriers to the adoption of adaptation practices (Ogisi & Begho, 2023). These conditions make climate adaptation inseparable from questions of poverty, resource access, and social equity. Furthermore, evidence from the region indicates that the effectiveness of adaptation interventions depends partly on whether farmers can access productive resources, relevant information and institutional support (Hailemariam et al., 2024).

Nigeria is similarly exposed to multiple climate hazards across its ecological zones. The country's National Climate Change Policy identifies changing rainfall patterns, rising temperatures, drought, flooding and land degradation among the climate-related challenges requiring coordinated mitigation and adaptation responses (Federal Ministry of Environment, 2021). The World Bank's Climate Risk Country Profile: Nigeria also documents the country's exposure to increasing temperatures, rainfall variability and associated risks to agriculture, water resources, health and economic development (World Bank Group, 2021). In northern Nigeria, these concerns are particularly important because agricultural and livestock livelihoods remain strongly dependent on rainfall, pasture, water availability and seasonal environmental conditions (IPCC, 2022; World Bank Group, 2021). Empirical evidence from Kwara and Nasarawa States confirms that farmers experience and respond to climate variability differently and that gender influences access to agricultural resources, decision-making power, and adaptation practices (Ayanlade et al., 2023). These findings establish the importance of investigating climate vulnerability not merely as an environmental problem but also as a development challenge shaped by gender relations and inequalities in access to adaptation resources.

Sokoto State lies within the Sudano-Sahelian transition environment and is characterized by a relatively short rainy season, high temperatures, and recurring dry-season water stress, conditions consistent with the wider climatic characteristics of the Sahel and northern Nigeria (IPCC, 2022; World Bank Group, 2021). The dependence of many households on farming, livestock production, trading and other natural-resource-based activities makes climatic variability an important determinant of livelihood security. Across Sub-Saharan Africa, the strong dependence of rural livelihoods on rainfed agriculture and natural resources increases the sensitivity of households to drought, rainfall variability and other climate-related stresses (IPCC, 2022; Ogisi & Begho, 2023). Climate impacts are therefore experienced not simply as physical environmental changes but as changes in the availability of productive resources, household labour requirements, income opportunities and food security. The IPCC's assessment of Africa similarly emphasizes that climate risks interact with existing socioeconomic inequalities, making vulnerability dependent on both environmental pressures and the resources available to affected populations (IPCC, 2022). These relationships make a locally grounded assessment of climate vulnerability particularly relevant to understanding livelihood security in Sokoto State.

Importantly, climate change does not affect all

members of a household or community in the same way. Gender relations shape people's responsibilities, access to resources, exposure to hazards, ability to obtain information, and participation in decisions about adaptation (Awiti, 2022; Deva & Manalo, 2023). Evidence from Africa indicates that women frequently face constraints in access to land, finance, extension services, technologies and climate information, while carrying substantial responsibilities for household provisioning and care (Awiti, 2022; Food and Agriculture Organization of the United Nations [FAO], 2023). The FAO's *The Status of Women in Agrifood Systems* documents persistent gender inequalities in land tenure, credit, training and agricultural technology, demonstrating how structural disadvantages can constrain women's economic opportunities and productive capacity (FAO, 2023). Recent empirical research across agricultural communities in Kenya, Uganda and Senegal also identifies gender differences in the adoption of climate adaptation practices, with access to information, farm characteristics and household circumstances influencing these differences (Hailemariam et al., 2024; Jost et al., 2023). These constraints can reduce adaptive capacity even where women and men are exposed to similar climatic hazards. Therefore, examining gender-differentiated climate vulnerability requires consideration of the social and institutional factors that influence access to resources, climate information and opportunities for effective adaptation (Deva & Manalo, 2023; Hailemariam et al., 2024).

The gender dimension is not, however, a simple assertion that women are always more vulnerable. Men may also experience important forms of climate vulnerability, particularly where social expectations place responsibility for commercial agriculture, livestock, income generation and household financial obligations on men. Gendered vulnerability is therefore better understood as the result of socially constructed roles and unequal access to assets, institutions, information and decision-making power (Doss & Meinzen-Dick, 2015; Haque et al., 2023). Research on climate risk perceptions among spouses in Kenya, Uganda and Senegal demonstrates that both women's and men's perceptions of climatic risks can influence household adaptation decisions, illustrating the importance of examining gender relations within households rather than treating households as socially homogeneous units (Jost et al., 2023). Similarly, research in Nigeria found that men and women differed in their perceptions of climate change, access to agricultural resources and adaptation responses, although the nature of these differences varied across the study locations (Ayanlade et al., 2023). These findings suggest that gendered vulnerability should be examined relationally, taking account of how responsibilities,

resource ownership, social expectations and decision-making power shape the experiences of different household members. Such an approach avoids assuming that either women or men constitute a uniformly vulnerable group and instead recognizes the importance of socioeconomic and institutional context in determining adaptive capacity (IPCC, 2022; Ayanlade et al., 2023).

Recent research reinforces this perspective. Pérez et al. (2015) demonstrated across farming communities in several African countries that access to land, common-property resources, income, and institutions influence gender-differentiated resilience. Although this study is older, its comparative evidence remains relevant to understanding the structural determinants of vulnerability. More recent research by Hailemariam et al. (2024), using individual-level data from Kenya, Uganda, and Senegal, found significant gender gaps in the adoption of several climate-smart agricultural practices. Their findings indicate that access to weather and production information, farm characteristics, personal values, and social norms help explain differences between men and women in agricultural adaptation. Similarly, Perelli et al. (2024), examining Ethiopia, Malawi, South Africa, and Tanzania, found that women's involvement in intra-household agricultural decision-making influences the adoption of climate-smart agricultural practices, while the effects of land ownership and social norms vary across countries. A review of climate-smart agriculture in Sub-Saharan Africa also identifies gender-related constraints, alongside economic, institutional, and environmental barriers, as important determinants of adoption (Ogisi & Begho, 2023). In Nigeria, Ayanlade et al. (2023) found that gender influenced farmers' climate change perceptions, resource access and adaptation responses in Kwara and Nasarawa States. Collectively, these studies demonstrate that climate resilience depends not simply on the availability of adaptation technologies or programmes but also on the social and institutional conditions that determine who can access, adopt and benefit from them. Nevertheless, findings from other African settings cannot automatically be generalized to Sokoto State, reinforcing the need for context-specific empirical investigation.

The policy relevance of gender-responsive adaptation is reflected in international and national frameworks. Sustainable Development Goals 5 and 13 call for gender equality and climate action, respectively, while the United Nations Framework Convention on Climate Change and the Paris Agreement recognize the importance of gender-responsive approaches to climate action (United Nations, 2015; United Nations Framework Convention on Climate Change [UNFCCC], 2015). At the national level, Nigeria's National Climate Change Policy provides a framework for addressing climate risks and

integrating adaptation into development planning (Federal Ministry of Environment, 2021), while the Climate Change Act establishes an institutional and legal basis for national climate governance (Federal Republic of Nigeria, 2021). The FAO (2023) further emphasizes that reducing gender inequalities in agrifood systems is important for improving livelihoods, strengthening resilience, and promoting more inclusive development. Nevertheless, locally grounded evidence remains necessary because gender roles, resource institutions, livelihood systems, and adaptation opportunities vary substantially among communities (Deva & Manalo, 2023; Ayanlade et al., 2023). Although recent studies have advanced understanding of gendered climate vulnerability and adaptation in Nigeria and other parts of Sub-Saharan Africa (Ayanlade et al., 2023; Hailemariam et al., 2024; Perelli et al., 2024), their findings also demonstrate the importance of examining vulnerability within specific ecological, socioeconomic, and institutional settings. In Sokoto State, where livelihoods are shaped by the climatic conditions of the Sudano-Sahelian environment and dependence on agriculture and other natural resources, a context-specific assessment is necessary to understand how gender relations influence climate vulnerability and adaptive capacity. Such evidence can support more inclusive adaptation policies and interventions that respond to the distinct circumstances of women and men while strengthening household and community resilience.

Against this background, the present study examines gender-differentiated climate change impacts, vulnerability, and adaptation challenges in Wamakko Local Government Area of Sokoto State. Specifically, the study examines perceived climate-related impacts, the factors shaping gendered vulnerability and adaptive capacity, barriers to climate information and climate-smart agriculture, and strategies for strengthening gender-responsive resilience.

2 Conceptual and Theoretical Framework

2.1 Climate Vulnerability and Adaptive Capacity

Vulnerability is commonly understood as the propensity of a system, community, or individual to be adversely affected by hazards. Adger (2006) emphasizes that vulnerability is shaped by exposure, sensitivity, and adaptive capacity, while Turner et al. (2003) show that vulnerability emerges from interactions between environmental stresses and social conditions operating at multiple scales. This framing is useful for the present study because households in Wamakko may experience similar climate hazards while possessing very different capacities to prepare for, cope with, and recover from them.

In this study, exposure refers to the extent to which

people and livelihoods encounter hazards such as heatwaves, drought, water scarcity and flooding. Sensitivity refers to the degree to which livelihood systems and household well-being are affected by those hazards. In contrast, adaptive capacity refers to the resources, knowledge, institutions, technologies and social relationships available to anticipate and respond to climate stress. Gender is treated as a cross-cutting social determinant that influences all three dimensions rather than as a stand-alone characteristic.

2.2 Feminist Political Ecology

The principal theoretical lens is Feminist Political Ecology (FPE), associated with the work of Rocheleau et al. (1996) and later developments in feminist environmental scholarship. FPE examines how gender, power and social relations shape access to natural resources, environmental knowledge, labour and decision-making. Elmhirst (2011) notes that feminist political ecology provides a way of examining environmental change through questions of power, resource access, governance and differentiated experience.

Applied to Wamakko, FPE suggests that gender-differentiated climate vulnerability cannot be explained solely by physical exposure. Instead, it must be understood through the social organization of land, labour, information, finance, agricultural technologies, household responsibilities and community leadership. Women's vulnerability may therefore increase where environmental stress intersects with limited control over productive assets and high unpaid care responsibilities, while men may face particular economic pressures where social expectations make them responsible for income generation and agricultural production.

2.3 Gender, Climate Information and Early Warning

Access to timely and understandable climate information is an important component of adaptive capacity. Climate forecasts and early warning systems can support decisions about planting, livestock movement, water management, harvesting and disaster preparedness. However, information only becomes an adaptation resource when people can receive, understand and act upon it. Literacy, language, access to mobile phones and radio, participation in community meetings and household responsibilities can therefore create gendered differences in access. The IPCC identifies context-specific climate information and inclusive communication as important components of effective adaptation in Africa (Trisos et al., 2022).

2.4 Gender and Climate-Smart Agriculture

Climate-smart agriculture (CSA) seeks to improve productivity and resilience while, where possible, reducing greenhouse-gas emissions. Adoption, however,

is shaped by more than awareness of technologies. Ogisi and Begho (2023) identify financial, institutional, knowledge, farm-level, and structural barriers to CSA adoption in sub-Saharan Africa, with gender inequalities affecting access to resources and opportunities. Hailemariam et al. (2024) similarly show that gender differences in CSA adoption reflect heterogeneity in land access, information, household bargaining power, and other enabling conditions.

2.5 Conceptual Integration

The conceptual logic of the study can be summarized as follows: climate hazards such as heat, drought, water scarcity, and flooding create exposure; livelihood dependence and household conditions determine sensitivity; and social and institutional conditions determine adaptive capacity. Gender relations influence access to land, finance, information, technologies, extension, social protection, and decision-making at each stage. Adaptation outcomes are consequently produced through the interaction of environmental stress and social institutions. This conceptualization provides the basis for interpreting the survey findings without treating women or men as inherently vulnerable groups.

3 Materials and Methods

3.1 Study Area

The study was conducted in Wamakko Local Government Area (LGA) of Sokoto State, northwestern Nigeria. Wamakko has an area of approximately 697 km² and was created in 1991. The headquarters is located in Wamakko town, close to Sokoto city. The LGA includes the districts of Dundaye, Wamakko, Gumbi, and Gumburuwa (Figure 1). The local economy is characterized by farming, livestock production, trading, pottery, leatherwork, and other livelihood activities (Ahmed, 2026). Major crops cultivated in the area include millet, sorghum, cowpea, rice, groundnut, sugarcane, and vegetables, while livestock production includes cattle, sheep, goats, camels, donkeys, and poultry (Abubakar et al., 2026).

The climate is characterized by a pronounced dry season extending broadly from October/November to April/May and a shorter rainy season from approximately May to September/October. The annual rainfall ranges from about 500 - 1,300 mm, and the mean annual temperature is around 35°C. Harmattan conditions are commonly experienced during the dry season (Hayatu et al., 2018). The environmental setting and dependence on climate-sensitive livelihoods make Wamakko appropriate for examining perceived climate change impacts and gendered adaptive capacity.

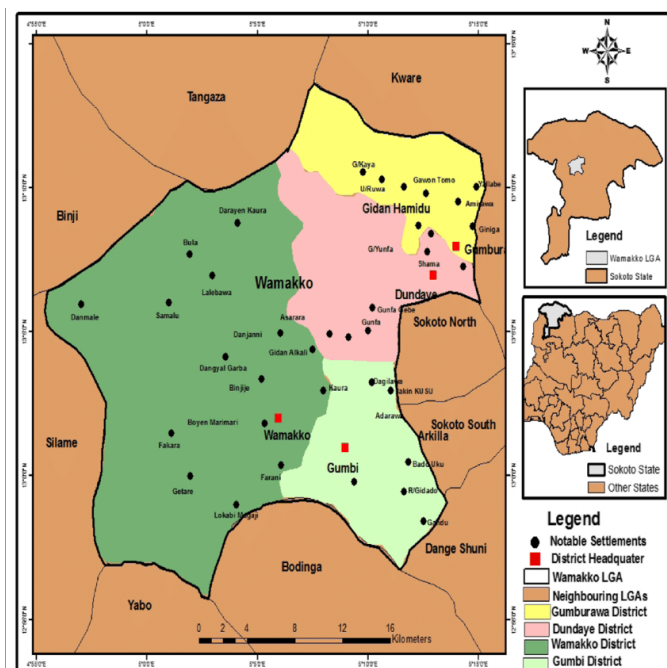


Figure 1: Study area

3.2 Research Design and Population

A cross-sectional survey design was adopted. The target population comprised adult male and female residents of Wamakko LGA, with particular attention to residents engaged in climate-sensitive livelihoods such as farming, livestock rearing, trading, agro-processing, and other natural-resource-dependent activities. The survey design was considered appropriate because it allowed the collection of standardized information on respondents' perceptions, experiences, resource access, adaptation constraints, and views about gender differences.

3.3 Sample Size and Sampling Procedure

A sample of 381 respondents was determined using the sample-size determination approach of Krejcie and Morgan (1970). A multistage sampling procedure involving purposive selection of wards and systematic selection of households was adopted. At the first stage, Wamakko, Huchi, and Lokobin Magaji wards were purposively selected based on their relevance to the study objectives, particularly the presence of climate-sensitive livelihood activities and the suitability of the wards for investigating perceived climate change impacts and gender-differentiated adaptive capacity. To improve transparency and reduce the potential for selection bias, the selection of these wards was guided by these predefined criteria rather than by convenience alone.

At the second stage, the sample of 381 respondents was distributed among the three selected wards as follows: 229 respondents (approximately 60%) from Wamakko, 95 (approximately 25%) from Huchi and 57 (approximately 15%) from Lokobin Magaji. These allocations were based on the relative population sizes of the selected wards. Within each ward, a household

sampling frame was identified for eligible households and established the order for systematic selection. The sampling frame was constructed from an available household register, an updated enumeration of residential households. The sampling interval was then calculated separately for each ward by dividing the number of eligible households in its sampling frame by the number of respondents allocated to that ward. A random starting point was selected, after which households were selected at the calculated interval until the ward's sample quota was achieved.

Within selected households, the eligible respondent was identified according to the study's respondent-selection criteria. Where more than one eligible adult was present, a consistent selection procedure was applied to avoid interviewer discretion influencing who participated. This approach improved the transparency and reproducibility of the sampling procedure while helping to minimize household-selection bias.

3.4 Instrument for Data Collection

A structured questionnaire was developed from the study objectives and relevant literature on gender, climate vulnerability, and adaptation. It comprised closed-ended and limited open-ended questions covering respondents' socioeconomic characteristics, perceived climate change impacts and severity, gender-differentiated risks, access to climate information, adaptation needs, local knowledge, economic implications, and climate-smart agriculture. Content validity was assessed by reviewing the instrument against the study objectives and relevant literature, while pilot testing, where conducted, was used to identify ambiguous questions and improve clarity and contextual appropriateness. The questionnaire was administered in English or Hausa according to respondents' language preferences, with standardized explanations provided to ensure consistent understanding. Where applicable, reliability was assessed using an appropriate statistic for multi-item scales. Closed-ended responses were coded for quantitative analysis, while open-ended responses were organized into thematic categories to identify recurring patterns relating to perceived climate impacts, livelihood challenges, gender differences, and adaptation strategies. The qualitative findings were used to complement and contextualize the quantitative results.

3.5 Data Collection and Ethical Considerations

Questionnaires were administered by the researcher and trained research assistants. Where necessary, questions were explained or translated into Hausa to improve comprehension. Participation was voluntary, and respondents were informed about the purpose of the study. Confidentiality and anonymity were maintained during data collection and analysis. No personally

identifying information is reported in this manuscript.

3.6 Data Analysis

Completed questionnaires were coded, entered, and cleaned using the Statistical Package for the Social Sciences (SPSS), Version 21. Frequencies and percentages were used to summarize respondents' characteristics and perceptions. The analysis is therefore descriptive and should be interpreted as evidence of respondents' reported or perceived experiences rather than as a statistical attribution of observed climatic trends to anthropogenic climate change.

4 Results

4.1 Socio-Economic Characteristics of Respondents

The socio-economic characteristics show that the survey captured a predominantly economically active population with strong dependence on climate-sensitive livelihoods. The occupational structure is particularly important because farming was the dominant occupation, meaning that climatic variability can directly affect income, food availability, and household welfare.

Table 1: Socio-economic characteristics of respondents

Variable	Response	Frequency	Percent
Sex	Male	292	77
	Female	86	23
	Total	381	100
Age	reported		
	<20	19	5
	21–30	87	23
	31–40	152	40
	41–50	81	21
	>50	42	11
Marital status	Total	381	100
	Single	49	13
	Married	263	69
	Divorced	26	7
	Widowed	43	11
Education	Total	381	100
	Islamic	125	33
	Primary	102	27
	Secondary	130	34
	Tertiary	24	6
Occupation	Total	381	100
	Full-time	56	15
	housewife		
	Petty	42	11
	trading		
	Farming	189	50
	Civil servant	36	9
	Business	28	7
	Artisan	30	8
	Total	381	100

Farming accounted for 50% of respondents, followed by full-time housework (15%), petty trading (11%), civil service (9%), artisan activities (8%), and business (7%)

(Table 1). This structure is consistent with the wider observation that climate variability can affect households through both direct livelihood losses and indirect changes in household labour requirements. The relatively low share of respondents with tertiary education also has implications for the design of climate information and extension programmes. Climate information that depends heavily on technical language or written communication may not reach all groups equally, reinforcing the importance of locally appropriate communication channels.

The predominance of married respondents (69%) is also relevant because climate shocks are rarely experienced as isolated individual events. Changes in agricultural production, water availability, or household income can affect food provisioning, education, health, and care responsibilities. The interaction between household responsibilities and environmental stress is central to understanding gendered vulnerability, consistent with the broader literature on household resource allocation and collective action (Doss & Meinzen-Dick, 2015).

4.2 Perceived Climate Change Impacts and Livelihood Consequences

Increased temperature and heatwaves were the most frequently identified impacts (28%), followed by drought, water scarcity and water stress (26%), flooding (22%), and crop failure or food insecurity (17%) (Figure 2). The pattern is consistent with the vulnerability of semi-arid livelihood systems to heat stress, water shortages and rainfall variability. For farming households, higher temperatures and irregular rainfall can affect crop growth, soil moisture and livestock productivity, while water scarcity increases competition between domestic and productive uses. Morton (2007) similarly emphasizes the sensitivity of smallholder and subsistence agriculture to climatic variability, while Trisos et al. (2022) highlight the importance of climate risks for African agricultural livelihoods.

The identification of flooding alongside drought and water scarcity is also important. It suggests that households are responding to variability in the timing and intensity of rainfall rather than simply to a single directional change. Such variability can make planning more difficult because households must prepare for water scarcity during one period and intense rainfall or flooding during another. The finding therefore supports adaptation strategies that combine drought preparedness, water management and flood risk reduction rather than treating hazards independently.

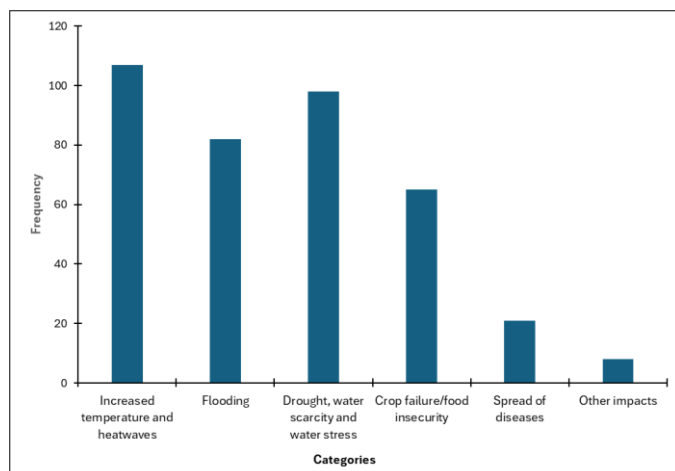


Figure 2: Perceived impacts of climate change

4.3 Perceived Severity of Climate Change

Half of the respondents described climate change as moderately serious, while 27% described it as very serious (Figure 3). Together, these groups represent 77% of the sample, indicating that climate change is widely perceived as a meaningful environmental and livelihood concern. Only 4% regarded it as not serious. These perceptions are consistent with the broader evidence that climate risks in Africa interact with existing development challenges and can compound livelihood insecurity (Trisos et al., 2022).

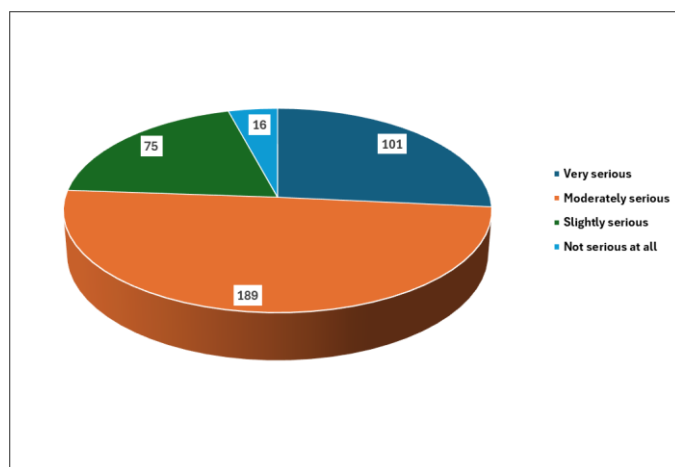


Figure 3: Perceived severity of climate change

Perception of severity should not be interpreted as a direct measurement of climatic trends. Rather, it represents respondents' experiences and interpretation of environmental changes. Such perceptions are nevertheless important for adaptation because people are more likely to support or use adaptation measures when they recognize a climate-related threat and perceive that action is necessary.

4.4 Gender-Differentiated Experiences of Extreme Weather

A striking 73% of respondents perceived women and children as facing greater risks during extreme weather events. This finding should be interpreted as a perception

of differentiated vulnerability rather than evidence that all women are uniformly more vulnerable than all men. It indicates that respondents associate caregiving, household resource collection and limited access to resources with greater difficulty during climatic stress.

Table 2: Perceptions of how women, children and men are differently affected by extreme weather

Response	Frequency	Percent
All groups are affected equally	26	7
Women and children face greater risks	279	73
Men are more affected because of rescue responsibilities	49	13
Children are the only group affected	27	7

The finding is consistent with the gender-and-climate literature, which emphasizes that women's responsibilities for water, food, fuel and household care can increase their exposure to environmental stress while reducing the time available for paid work, education and participation in public decision-making (Awiti, 2022; FAO, 2023). At the same time, 13% of respondents perceived men as more affected because of their involvement in rescue operations and physically demanding activities. This response is important because it demonstrates that climate vulnerability is multidimensional and socially differentiated.

4.5 Traditional Gender Roles and Adaptive Capacity

The responses indicate that gender roles influence vulnerability through resource access, labour responsibilities, and representation in decision-making. Limited access to land and productive resources can reduce the ability to invest in climate-resilient livelihoods, while responsibility for water and fuelwood collection can increase the time and physical costs of environmental degradation and drought. These mechanisms align closely with the Feminist Political Ecology perspective, which emphasizes how environmental change is mediated through power, resource access, and socially differentiated responsibilities (Elmhirst, 2011; Rocheleau et al., 1996).

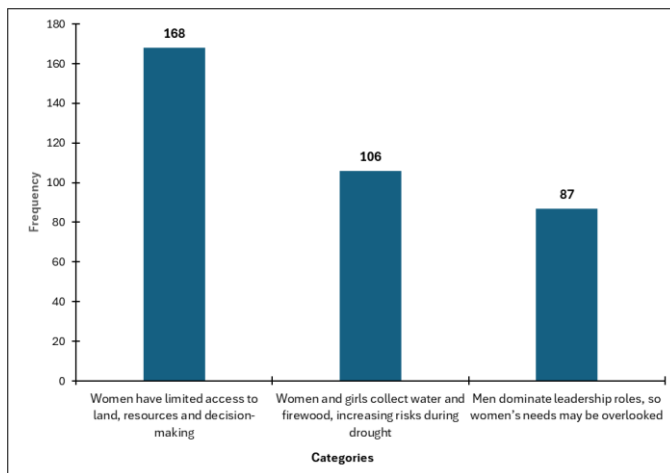


Figure 4: Perceived influence of traditional gender roles on climate vulnerability

The result also supports evidence that gendered resource constraints can influence resilience at household and community levels. Pérez et al. (2015) found that women in African farming communities often had less access to land, common-property resources and cash, while Haque et al. (2023) show that adaptation perceptions and practices vary with education, household power, social status and institutional context.

4.6 Barriers to Women's Access to Climate Information and Early Warning

Low literacy or limited formal education was the most frequently identified barrier (31%), followed by cultural restrictions on participation in meetings and decision-making (25%) and caregiving responsibilities (20%) (Table 3). These findings show that access to climate information is not simply a technological problem. Information can remain inaccessible when communication systems fail to account for literacy, language, time availability, and social participation.

Table 3: Barriers to women's access to climate information and early warning

Response	Frequency	Percent
Low literacy or limited formal education	118	31
Limited access to mobile phones, radio or internet	41	11
Cultural norms restricting participation	97	25
Messages not communicated in local languages/formats	51	13
Caregiving and household time constraints	74	20

This finding is important for adaptation policy because early warning systems are only useful when information reaches the people responsible for household decisions and is presented in forms that they can understand and

act upon. The IPCC emphasizes inclusive, context-specific climate information as an important adaptation resource in Africa (Trisos et al., 2022). Awiti (2022) similarly identifies gender-responsive climate information as an important component of climate resilience.

4.7 Strategies for Gender-Responsive Climate Adaptation

The strongest support was for women's participation in climate planning and decision-making (27%), followed by improved access to land, credit and training (25%), women's leadership and women-led initiatives (21%), and support for childcare and household responsibilities (20%) (Table 4). These responses point toward empowerment-oriented adaptation rather than approaches that treat women merely as passive recipients of assistance.

Table 4: Strategies for tailoring climate adaptation to women's needs

Response	Frequency	Percent
Involve women in planning and decision-making	102	27
Improve access to land, credit and training	95	25
Design gender- and literacy-sensitive early warning	26	7
Provide childcare/household support	76	20
Promote women's leadership and women-led initiatives	82	21
Total	381	100

Such an approach is consistent with gender-responsive adaptation frameworks, which emphasize women's participation, access to finance and technologies, gender-disaggregated data and institutional reform (Awiti, 2022). It also reflects the evidence that adaptation effectiveness depends on the ability of individuals and communities to exercise agency and access resources, rather than on exposure reduction alone.

4.8 Local Knowledge and Gender-Responsive Resilience

Nearly half of respondents (45%) emphasized the value of identifying gender-specific roles and responsibilities, while 29% highlighted women's traditional knowledge of water, agriculture, and food preservation (Figure 5). This indicates that local knowledge is perceived as an adaptation resource rather than simply an informal practice to be replaced by external interventions.

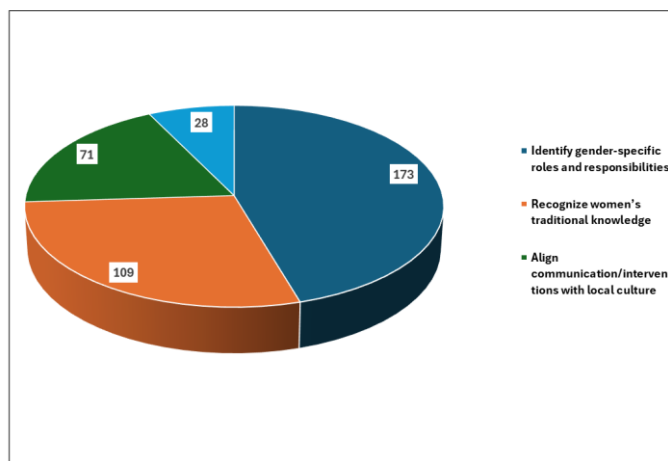


Figure 5: Role of local knowledge in gender-responsive climate resilience

The result is compatible with the IPCC's recognition of Indigenous and local knowledge as an important resource for climate adaptation in Africa (Trisos et al., 2022). From an FPE perspective, however, documenting local knowledge should also address whose knowledge is recognized, who participates in decision-making, and who controls the benefits generated from adaptation interventions (Elmhirst, 2011). Women's knowledge should therefore be incorporated through meaningful participation rather than symbolic consultation.

4.9 Economic Implications of Climate Change Across Gender Groups

The most frequently selected economic implication was increased unpaid domestic labour among women (33%) (Table 5). A further 28% identified income losses among women engaged in informal or subsistence activities, while 25% pointed to unequal access to climate-resilient employment and technologies (Table 5). These results indicate that climate impacts can be transmitted through time, labour, and income, not only through direct physical damage.

Table 5: Perceived economic implications of climate change across gender groups

Response	Frequency	Percent
Women in informal/subsistence sectors face greater income loss	105	28
Women's unpaid domestic labour increases	126	33
Gender pay gaps may widen through unequal access to resilient jobs/technology	94	25
Both genders face job insecurity, but women have fewer safety nets	56	14
Total	381	100

The finding reinforces the broader argument that climate change can intensify pre-existing inequalities when vulnerable groups have fewer assets and weaker social protection. FAO (2023) documents disproportionate livelihood effects of climate change among rural poor populations, women and youth. In Wamakko, the additional burden of water and household resource collection may reduce women's time for income-generating activities and participation in adaptation programmes.

4.10 Constraints to Climate-Smart Agriculture Adoption

Lack of knowledge and training was the leading constraint to CSA adoption (40%). High technology costs and limited access to credit or subsidies each accounted for 18%, while land tenure insecurity accounted for 10% (Figure 6). These findings indicate that adoption is constrained by a combination of knowledge, finance, institutional support and structural conditions rather than by unwillingness to innovate alone.

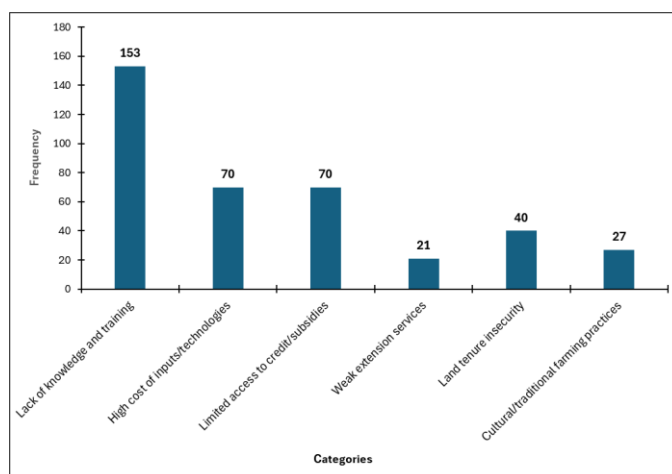


Figure 6: Constraints to the adoption of climate-smart agriculture

The result corresponds with the review by Ogisi and Begho (2023), which identifies economic, institutional, social and structural constraints to CSA adoption across sub-Saharan Africa. It also supports the argument that extension and training should be combined with access to credit, inputs, and secure productive assets. Information without the resources needed to act on that information may have limited practical effect.

4.11 Perceived Gender Differences in Climate-Smart Agriculture Adoption

Most respondents (68%) perceived men as more likely to adopt climate-smart agricultural practices, compared with 19% for women and 13% who considered both genders equally likely (Figure 7). Because the study measures perceptions rather than observed adoption records, this finding should not be interpreted as evidence that men are inherently more innovative or that women are unwilling

to adopt climate-smart practices. Rather, it points to perceived differences in the resources and institutional opportunities available to men and women.

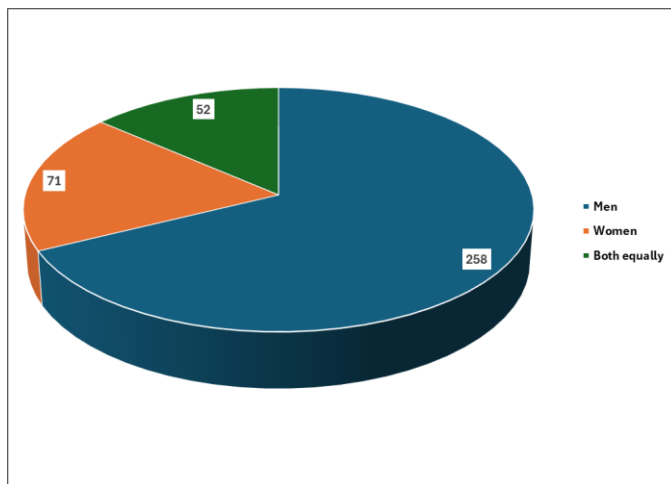


Figure 7: Perceived likelihood of adopting climate-smart agriculture by gender

The finding is consistent with evidence that land ownership, access to information, credit, extension, and household decision-making shape gender differences in CSA adoption (Hailemariam et al., 2024; Ogisi & Begho, 2023). Teklewold (2023) further shows that gender differences in CSA portfolios are influenced by resource ownership and bargaining power. Thus, improving women's access to productive assets may be as important as providing information about technologies.

4.12 Integrated Interpretation Through Feminist Political Ecology

Taken together, the results support the FPE proposition that climate vulnerability is produced through the interaction between environmental hazards and social relations. Respondents reported a range of hazards affecting livelihoods, but the consequences were perceived as differentiated because women and men occupy different positions within household labour systems, resource institutions and community decision-making structures. Women's unpaid labour, limited access to productive resources and barriers to information were repeatedly identified as mechanisms that can reduce adaptive capacity.

At the same time, the results do not justify treating women as a homogeneous or universally vulnerable category. Age, livelihood, household position, education and access to institutions can produce different experiences among women, just as occupational responsibilities can expose men to particular forms of economic risk. Haque et al. (2023) emphasize this contextual nature of gendered climate perceptions and adaptation. A gender-responsive policy therefore needs to address structural inequalities while remaining

sensitive to differences within gender groups.

The results also demonstrate the importance of agency. Respondents not only identified problems; they emphasized women's participation, leadership, local knowledge, access to training, and resource control as components of adaptation. This is consistent with contemporary approaches to gender-transformative climate action, which seek to alter the institutional and social conditions that restrict adaptive choices rather than simply adding women to existing programmes.

Table 6: Crosstabulation on perceived climate vulnerability

Response category	Male n (%)	Female n (%)	Sex not recorded	Reported total
All groups affected equally	22 (7.5%)	4 (4.7%)	0	26
Women and children face greater risks	208 (71.2%)	68 (79.1%)	3	279
Men are more affected due to rescue responsibilities	39 (13.4%)	10 (11.6%)	0	49
Children are the only group affected	23 (7.9%)	4 (4.7%)	0	27

Pearson chi-square: $\chi^2 (3, N=378) = 2.48, p = 0.478$; Cramér's $V = 0.081$.

The cross-tabulation shows that perceptions of climate vulnerability differ between male and female respondents, particularly regarding the greater risks faced by women and children during extreme weather events (Table 6). Such a pattern is consistent with the argument that climate vulnerability is shaped not only by exposure to environmental hazards but also by gendered responsibilities, resource access, and adaptive capacity. Ayanlade et al. (2023), in their study of gendered vulnerabilities and adaptation responses in Kwara and Nasarawa States, Nigeria, revealed that climate perceptions and adaptation responses vary by gender and social context.

Table 7: Crosstabulation on Barriers to women's access to climate information

Response category	Male n (%)	Female n (%)	Sex not recorded n	Reported total
Low literacy/formal education	85 (29.1%)	30 (34.9%)	3	118
Limited communication technology	33 (11.3%)	8 (9.3%)	0	41
Cultural restrictions	75 (25.7%)	22 (25.6%)	0	97
Language or message format	43 (14.7%)	8 (9.3%)	0	51
Caregiving/time constraints	56 (19.2%)	18 (20.9%)	0	74

Pearson χ^2 (4, N=378) = 2.53, $p = 0.640$; Cramér's $V = 0.082$

Table 7 illustrates that women experience greater constraints in accessing climate information, particularly through limited formal education, cultural restrictions, and household caregiving responsibilities. These barriers matter because climate information contributes to decisions about planting, water management, livestock care, and preparedness for extreme weather. Chete's study of farming communities in Oke-Ogun, Oyo State, found that women had less access than men to climate information, agricultural extension, training, credit, and other productive resources, while also participating less in adaptation decision-making (Chete, 2018). This Nigerian evidence supports the relevance of investigating gendered information barriers in Wamakko.

5 Policy Implications and Recommendations

The findings have implications for climate governance, agricultural development, disaster risk reduction, gender equality and livelihood planning in Sokoto State. The evidence suggests that gender responsiveness should be mainstreamed across adaptation programmes rather than implemented as a separate or peripheral activity.

First, local agricultural and climate-adaptation programmes should strengthen the dissemination of climate information through accessible community channels. The reported barriers—including low literacy, limited communication technology, cultural restrictions, language difficulties and caregiving responsibilities—indicate the need for simple, locally understandable messages delivered through community meetings, farmer groups and agricultural extension agents. Information should be provided in Hausa where appropriate and at times that enable participation by people with household and farming responsibilities.

Second, agricultural extension services should prioritize practical training and demonstrations on climate-smart agricultural practices. The reported constraints, particularly inadequate knowledge and

training, limited access to credit or subsidies, and high technology costs, suggest that information alone may be insufficient to support adoption. Extension agencies should therefore combine demonstrations with guidance on accessing affordable inputs, credit and relevant agricultural support schemes.

Third, adaptation initiatives should respond to the reported demand for greater participation of women, improved access to land, credit and training, childcare support, and women's leadership. Local agricultural groups and adaptation committees should provide opportunities for women to contribute to decisions about programme priorities and resource allocation. Where feasible, training and support activities should be scheduled to accommodate household and caregiving responsibilities.

Finally, government agencies and development partners should promote access to affordable support for CSA adoption, particularly credit, subsidies and extension assistance. Programme monitoring should record participation and uptake by sex to assess whether women and men benefit equitably. These measures would directly address the barriers identified in Wamakko while allowing future assessments to establish which interventions produce measurable improvements in adaptation capacity.

6 Conclusion

The study concludes that climate change in Wamakko Local Government Area is not solely an environmental problem but also a livelihood and social-equity challenge. Respondents identified increasing temperature and heatwaves, drought and water stress, flooding, and crop failure among the major climate-related impacts. Most respondents considered climate change moderately or very serious, indicating substantial local recognition of climate-related risks.

The findings further show that climate vulnerability is differentiated by gender through social roles, access to productive resources, information, decision-making, and livelihood opportunities. A large majority of respondents perceived women and children as facing greater risks during extreme weather, while women's unpaid household responsibilities, limited access to land and finance, and barriers to climate information were repeatedly identified as constraints to adaptive capacity. Men also face important vulnerabilities, particularly through climate-related agricultural and livelihood losses and responsibilities for income generation.

The evidence on climate-smart agriculture reinforces the same pattern. Lack of knowledge and training was the leading reported barrier, while most respondents perceived men as more likely to adopt climate-smart practices. The study interprets this pattern primarily

through unequal access to resources and institutional opportunities rather than inherent differences in willingness or ability.

The study has limitations that should be considered. First, the survey relied substantially on respondents' perceptions and self-reported experiences, which may not correspond directly to measured climatic trends or objectively observed adaptation outcomes. Second, the

cross-sectional design captures views at a particular period and cannot establish causal relationships between gender, climate vulnerability, access to resources, and adaptation decisions.

References

- Abubakar, B. B., Abdullahi, A. N., Yelwa, F. J., & Eboji, C. O. (2026). Adoption And Preference Analysis of Improved Pearl Millet Varieties Under Participatory Technology Dissemination in Wamakko Local Government Area, Sokoto State, Nigeria. *Journal of Arid Agriculture*, 27(1), 29-35.
- Adger, W. N. (2006). Vulnerability. *Global Environmental Change*, 16(3), 268–281. <https://doi.org/10.1016/j.gloenvcha.2006.02.006>
- Ahmed, A. (2026). Monitoring Ecosystem Change and Its Impact on Livelihoods in Wamakko Local Government Area of Sokoto State: An Integrated Approach. *Kaduna Journal of Geography*, 8(1), 283-290.
- Awiti, A. O. (2022). Climate change and gender in Africa: A review of impact and gender-responsive solutions. *Frontiers in Climate*, 4, 895950. <https://doi.org/10.3389/fclim.2022.895950>
- Ayanlade, A., Oluwatimilehin, I. A., Ayanlade, O. S., Adeyeye, O., & Abatemi-Usman, S. (2023). Gendered vulnerabilities to climate change and farmers' adaptation responses in Kwara and Nasarawa States, Nigeria. *Humanities and Social Sciences Communications*, 10, Article 911. <https://doi.org/10.1057/s41599-023-02380-9>
- Chete, O. B. (2018). Gender and climate change adaptation strategies among farming communities in Oke-Ogun, Oyo State, Nigeria. *Moor Journal of Agricultural Research*, 19(1), 151 - 161
- Deva, D. S., & Manalo, J. A., IV. (2023). Gender and adaptive capacity in climate change scholarship of developing countries: A systematic review of literature. *Climate and Development*, 15(10), 829–840. <https://doi.org/10.1080/17565529.2023.2166781>
- Doss, C. R., & Meinzen-Dick, R. (2015). Collective action within the household: Insights from natural resource management. *World Development*, 74, 171–183. <https://doi.org/10.1016/j.worlddev.2015.05.001>
- Elmhirst, R. (2011). Introducing new feminist political ecologies. *Geoforum*, 42(2), 129–132. <https://doi.org/10.1016/j.geoforum.2011.01.006>
- Federal Ministry of Environment. (2021). National climate change policy for Nigeria 2021–2030. Federal Republic of Nigeria. https://www.climatechange.gov.ng/wp-content/uploads/2021/08/NCCP_NIGERIA_REVISED_2-JUNE-2021.pdf
- Federal Republic of Nigeria. (2021). Climate Change Act, 2021. Government of Nigeria.
- Food and Agriculture Organization of the United Nations. (2023). The unjust climate: Measuring the impacts of climate change on rural poor, women and youth. FAO. <https://doi.org/10.4060/cc5343en>
- Hailemariam, A., Kalsi, J., & Mavisakalyan, A. (2024). Gender gaps in the adoption of climate-smart agricultural practices: Evidence from sub-Saharan Africa. *Journal of Agricultural Economics*, 75(2), 764–793. <https://doi.org/10.1111/1477-9552.12583>
- Haque, A. T. M. S., Kumar, L., & Bhullar, N. (2023). Gendered perceptions of climate change and agricultural adaptation practices: A systematic review. *Climate and Development*, 15(10), 885–902. <https://doi.org/10.1080/17565529.2023.2176185>
- Hayatu, N. G., Abdullahi, I. L., Sale, A., Samuel, C. D., Sharu, M. B., Haruna, F. D., ... & Yusif, S. A. (2018). Properties and classification of soils developed under different land utilization types in Gidan Sule, Dundaye District, Wamakko LGA, Sokoto State. *Journal of Agriculture and Environment*, 14(2), 257-266.
- Intergovernmental Panel on Climate Change. (2022). Africa. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability* (pp. 1285–1455). Cambridge University Press. <https://doi.org/10.1017/9781009325844.011>
- Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Biström, M.-L., Nelson, S., & Kristjanson, P. (2016). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development*, 8(2), 133–144. <https://doi.org/10.1080/17565529.2015.1050978>
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30(3), 607–610. <https://doi.org/10.1177/001316447003000308>
- Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, 104(50), 19680–19685. <https://doi.org/10.1073/pnas.0701855104>
- Ngcamu, B. S. (2023). Climate change effects on vulnerable populations in the Global South: A systematic review. *Natural Hazards*, 118, 977–991. <https://doi.org/10.1007/s11069-023-06070-2>
- Ogisi, O. D., & Begho, T. (2023). Adoption of climate-smart agricultural practices in sub-Saharan Africa: A review of the progress, barriers, gender differences, and recommendations. *Farming System*, 1(2), 100019. <https://doi.org/10.1016/j.farsys.2023.100019>

- Perelli, C., Cacchiarelli, L., Peveri, V., & Branca, G. (2024). Gender equality and sustainable development: A cross-country study on women's contribution to the adoption of climate-smart agriculture in sub-Saharan Africa. *Ecological Economics*, 219, Article 108145. <https://doi.org/10.1016/j.ecolecon.2024.108145>
- Pérez, C., Jones, E. M., Kristjanson, P., Cramer, L., Thornton, P. K., Förch, W., & Barahona, C. (2015). How resilient are farming households and communities to a changing climate in Africa? A gender-based perspective. *Global Environmental Change*, 34, 95–107. <https://doi.org/10.1016/j.gloenvcha.2015.06.003>
- Rocheleau, D. E., Thomas-Slayter, B. P., & Wangari, E. (Eds.). (1996). *Feminist political ecology: Global issues and local experiences*. Routledge.
- Teklewold, H. (2023). Understanding gender differences on the choices of a portfolio of climate-smart agricultural practices in sub-Saharan Africa. *World Development Perspectives*, 29,
- Trisos, C. H., Adelekan, I. O., Totin, E., Ayanlade, A., Efitre, J., Gameda, A., Kalaba, K., Lennard, C., Masao, C., Mgaya, Y., Ngaruiya, G., Olago, D., Simpson, N. P., & Zakieldean, S. (2022). Africa. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegria, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability* (pp. 1285–1455). Cambridge University Press. <https://doi.org/10.1017/9781009325844.011>
- Turner, B. L., II, Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences of the United States of America*, 100(14), 8074–8079. <https://doi.org/10.1073/pnas.1231335100>
- United Nations Framework Convention on Climate Change. (2015). Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
- United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. <https://sdgs.un.org/2030agenda>
- World Bank Group. (2021). *Climate risk country profile: Nigeria*. World Bank Group. <https://climateknowledgeportal.worldbank.org/country/nigeria>
- World Meteorological Organization. (2024). *State of the climate in Africa 2023*. <https://wmo.int/publication-series/state-of-climate-africa-2023>