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Climate Crunch: Coping with Climate Change in Irrigated Agriculture in Dutse, Jigawa, Nigeria

Aminu Abubakar[1]; Sule Magaji[2]; Yahaya Ismail[3]

[1]Sustainable Development Center
University of Abuja

[2]Department of Economics
University of Abuja
ORCID ID: 0000-0001-9583-3993

[3]Department of Economics
University of Abuja
ORCID ID: 0009-0006-7876-9524

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Abstract: This study examines the coping mechanisms employed by irrigation farmers in the Dutse Local Government Area (LGA) of Jigawa State, Nigeria, to mitigate the adverse effects of climate change. Employing a mixed-methods strategy, data were gathered from 150 smallholder farmers using structured questionnaires, focus group discussions (FGDs), and key informant interviews (KIIs). The results indicate substantial shifts in rainfall and temperature trends, leading to increased water stress, reduced crop productivity, and altered planting timelines. Farmers have adapted to climate change by employing strategies such as using tube wells, cultivating drought-resistant crops, and utilising traditional weather prediction methods. Nonetheless, significant obstacles remain, including restricted access to extension services, insufficient financial resources, gender inequalities, and poor institutional coordination. The findings highlight the connection between environmental vulnerability and socioeconomic challenges, underscoring the need for integrated and participatory frameworks for adaptation. The study concludes that while there are observable local innovations, enhancing institutional support, improving access to resources, and promoting community-based adaptation initiatives are essential for building resilience against climate variability. The research is grounded in theories of Natural Resource Management (NRM), Sustainability Theory, and the Social-Ecological Systems (SES) framework.

Keywords: *Climate Change, Irrigation Farming, Adaptation Strategies, Dutse LGA, Jigawa State, Sustainable Land Management, Resilience, Socio-Ecological Systems, Rural Livelihoods, Water Stress.*

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I. INTRODUCTION

Climate change is one of the most pressing environmental and developmental issues of this century (Magaji et al., 2024), particularly affecting communities that rely on agriculture, notably in low- and middle-income countries (Ibrahim, Olusola, & Magaji, 2025). In Nigeria, especially in the northern regions, the impacts of climate change are increasingly pronounced. These effects include rising temperatures, prolonged dry periods, unpredictable rainfall, land degradation, and encroachment into deserts. Such conditions directly jeopardise food security, water availability, and the livelihoods of rural populations, all of which are closely tied to the agricultural sector (IPCC, 2022; NIMET, 2023).

Northern Nigeria is especially susceptible due to its positioning within semi-arid and arid ecological zones. States like Jigawa, Katsina, Yobe, and Borno are located in the Sudan-Sahelian belt, characterised by low and inconsistent rainfall, high evapotranspiration rates, and fragile ecosystems. According to the Nigerian Meteorological Agency (NIMET), the average annual rainfall in some regions of Jigawa has decreased by about 15% over the past 20 years, while average temperatures have risen by nearly 1.3°C (NIMET, 2023). These changes have led to the

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shrinking of water bodies, declining crop yields, and an increase in pest outbreaks and soil degradation.

In this context, irrigation agriculture has become a vital adaptation method for farmers dealing with shortened and unreliable rainy seasons. Irrigation supports dry-season cultivation, prolongs the growing season, and lessens crop susceptibility to rainfall unpredictability (Umar, Ahmad & Ismail, 2025). In the Dutse Local Government Area (LGA) of Jigawa State, irrigation farming has become an essential source of livelihood. This region is equipped with a network of fadama (low-lying floodplain) areas, seasonal streams, and shallow wells that support small-scale irrigation practices. However, these resources face increasing pressure from climatic challenges, population growth, and unsustainable land-use behaviours (Usman & Musa, 2021).

Despite the increasing reliance on irrigation, climate change has introduced new dimensions of vulnerability (Jafaru, Aliyu, & Sule, 2025). For example, increasing temperatures heighten the rate of evapotranspiration, undermining water usage efficiency. Similarly, alterations in rainfall patterns impact the replenishment of groundwater and surface water resources, leading to water shortages during critical crop growth phases. Furthermore, many irrigation systems in Dutse are informal, manually operated, and technologically outdated, which constrains their ability to cope with climatic shocks (Yahaya, 2022).

The consequences of these issues go beyond agricultural yield and family livelihoods. They align with several significant global development objectives, particularly those outlined in the United Nations' Sustainable Development Goals (SDGs). This research directly relates to SDG 2 (Zero Hunger), which aims to eliminate hunger, secure food availability, and foster sustainable agriculture. Climate-related disruptions in irrigation farming jeopardise food accessibility and availability in rural areas, thus hindering this goal (Tanko, Magaji, & Musa, 2025). Moreover, the study also pertains to SDG 13 (Climate Action), which emphasises the urgent need to address climate change and its impacts. Gaining insight into local adaptation methods is vital for formulating climate-resilient policies and strategies.

Additionally, there are significant connections to SDG 6 (Clean Water and Sanitation), as effective water management is essential for proper irrigation. The overuse of water resources and inefficient irrigation practices can worsen water scarcity, affecting both agricultural irrigation and household water usage. The research also addresses SDG 1 (No Poverty), as disruptions in agriculture caused by climate change directly impact rural earnings and exacerbate poverty rates (Aluko & Magaji, 2020). Ultimately, by examining knowledge-sharing networks, cooperative resilience, and institutional support systems, the research indirectly contributes to SDG 17 (Partnerships for the Goals), underscoring the importance of collaboration among stakeholders for effective climate adaptation.

This study is particularly relevant for local and national stakeholders seeking to enhance rural livelihoods, strengthen climate resilience, and improve the sustainability of food production systems. It seeks to examine the various coping mechanisms that irrigation farmers in Dutse LGA adopt, evaluate the effectiveness and constraints of these mechanisms, and pinpoint existing deficiencies in institutional and infrastructural support. Utilising both quantitative and qualitative data, the study provides valuable insights into the real-life challenges of farming under climate stress, offering evidence-based recommendations for policymakers, development organisations, and farmer cooperatives.

The paper is guided by the following research questions: What impacts do farmers perceive climate change has on irrigated agriculture in Dutse LGA? What strategies are farmers implementing to address climate-related risks? How can policy and institutional frameworks be enhanced to back climate-resilient irrigation practices?

Ultimately, this research contributes to the growing body of literature that highlights the need for localised and context-specific strategies to address climate change in agriculture. By focusing on the specific realities of Dutse LGA, the study provides empirical support for ongoing national initiatives aimed at establishing a climate-resilient agricultural sector, as emphasised in Nigeria's National Adaptation Plan (Federal Ministry of Environment, 2021).

II. LITERATURE REVIEW

A. Conceptual Definition

Climate Change refers to long-term changes in temperature, precipitation, wind patterns, and other components of the Earth's climate system (Sabiu & Magaji, 2024). The Intergovernmental Panel on Climate Change (IPCC, 2022) characterises climate change as a statistically significant deviation in either the average state of the climate or in its variability over an extended period, typically decades or more. In agricultural contexts, climate change presents as more frequent droughts, irregular rainfall patterns, extreme heat, and decreased water availability for crops.

Adaptation to climate change is described by the United Nations Framework Convention on Climate Change (UNFCCC) as adjustments made to ecological, social, or economic systems in response to actual or anticipated climatic stimuli and their consequences or impacts (UNFCCC, 2022). In terms of agriculture, adaptation involves changes to farming methods, technological advancements, crop selection, and water management techniques aimed at reducing the risks associated with climate variability (Magaji & Musa, 2024).

Irrigated agriculture involves applying controlled amounts of water to plants at necessary intervals. It serves to complement rainfall and boost crop yield, particularly in arid and semi-arid regions. In northern Nigeria, irrigation methods include traditional shallow wells, tube wells, and river diversion systems, which are essential for dry-season farming and enhancing food security (Yahaya, 2022).

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Coping strategies differ from long-term adaptation. Coping typically represents a short-term response to immediate threats or shocks (Ellis, 2000). Although coping may involve reallocating resources, migration, or temporary changes in livelihoods, adaptation refers to systemic and persistent responses (Ismail, Bash & Magaji, 2019), such as investments in climate-smart agriculture (CSA), technological advancement, and strengthening institutions.

B. Theoretical Framework

This research utilises the Sustainable Livelihoods Framework (SLF) and Climate Resilience Theory as theoretical foundations, providing valuable perspectives for examining the coping and adaptation responses of irrigation farmers. The Sustainable Livelihoods Framework (SLF), developed by the UK's Department for International Development (DFID, 1999), provides a comprehensive view of how individuals access and utilise various forms of capital—natural, physical, social, financial, and human—to support their livelihoods. In the context of climate stress, the ability to access these capitals is crucial for farmers' capacity to modify their agricultural practices. For instance, access to financial capital permits investments in irrigation pumps or drought-resistant seeds, while social capital (such as farmer cooperatives) enhances knowledge sharing.

Conversely, Climate Resilience Theory emphasises the capabilities of individuals, communities, and systems to withstand shocks and sustain function amidst climatic stress. Resilience involves not only recovery but also transformation—creating structures, processes, and institutions that mitigate future vulnerabilities (Folke et al., 2010). This theory is especially pertinent for smallholder farmers, who are frequently exposed to unpredictable weather events, necessitating constant adjustments to their farming systems to remain viable.

Together, these theories enhance the analysis of how various forms of capital and systemic capabilities impact coping and adaptation strategies in Dutse LGA.

C. Empirical Review

Recent research across sub-Saharan Africa has examined the effects of climate change on irrigated agriculture and the tactics farmers adopt to cope. In Nigeria, the northern regions have garnered significant academic focus due to their susceptibility to climate-induced stress. Research conducted by Usman and Musa (2021) in Jigawa State revealed that most smallholder irrigation farmers recognise changing climate patterns but lack formal knowledge of climate-smart practices. They often resort to traditional methods, such as adjusting planting dates, using drought-resistant varieties, and practising crop rotation, though these strategies do not always suffice.

In a study by Olayemi and Oni (2022) in Kano State, access to climate information and extension services was found to significantly affect the types and effectiveness of adaptation strategies utilised by irrigation farmers. Their findings indicated that farmers with access to formal climate information were more inclined to adopt advanced irrigation methods, such as drip irrigation and mulching, to conserve water. However, access to such resources was often limited by factors such as education level, farm size, and income.

Yahaya (2022) investigated water stress management in semi-arid northern Nigeria, noting that traditional irrigation systems are becoming increasingly inadequate due to declining groundwater levels and rising evaporation rates. Farmers commonly turn to night irrigation to reduce water loss, although this method can be labour-intensive and economically unproductive. Yahaya also highlighted the necessity for government intervention in providing subsidised irrigation technology and climate insurance.

Internationally, research such as that conducted by Adger et al. (2014) has emphasised the significance of institutional frameworks in promoting agricultural adaptation. Their research findings in East Africa indicated that with supportive policies, training initiatives, and infrastructure improvements, smallholder farmers were in a stronger position to incorporate adaptive strategies into their farming practices.

Recent studies have highlighted the connection between climate change and the Sustainable Development Goals (SDGs). For example, a 2023 report by the United Nations Development Programme (UNDP) highlighted that climate adaptation in agriculture directly contributes to SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 6 (Clean Water and Sanitation). However, progress remains inconsistent in countries like Nigeria due to insufficient funding for agricultural policy, inadequate institutional coordination, and subpar rural infrastructure.

A study by Ahmed and Ibrahim (2024) examined the adaptive behaviours of irrigated tomato farmers in Kano and Jigawa States. Analysing panel data from 2021 to 2023, they discovered that while nearly all respondents were aware of climate change, only 47% had embraced advanced coping strategies beyond traditional techniques. Techniques such as plastic mulching, alternate wetting and drying (AWD), and the use of short-maturity varieties were positively linked to access to extension services and membership in farmer cooperatives. The authors highlighted the importance of institutional connections in scaling up climate-smart agricultural practices.

Chukwu and Abdulmalik (2023) studied the implementation of digital weather advisory systems in Northern Nigeria. Their randomised controlled trial, involving 600 farmers in Bauchi, Jigawa, and Gombe States, revealed that access to mobile-based weather forecasts significantly enhanced the likelihood of adjusting planting schedules, water management, and crop selections. Nevertheless, adoption remained hindered by inadequate network connectivity and low digital literacy levels, especially among older and less educated farmers. These results indicate the potential for integrating climate information services within broader rural development strategies.

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In a 2025 study, Ogundele et al. (2025) investigated the impact of climate variability on irrigation water availability and food security in the Hadejia-Jama'are floodplain, which spans parts of Jigawa State. They reported a 21% decrease in dry-season water volumes over five years, resulting in lower yields and shorter growing seasons. Farmers indicated a greater dependence on water rationing and night-time irrigation as adaptation strategies. However, these methods were found to be labour-intensive and unsustainable without external technical assistance. The study concluded that investing in infrastructure—specifically in water storage and lined canals—is crucial for long-term adaptation and resilience.

Tanko and Suleiman (2024) performed a gender-focused analysis of adaptation among female irrigation farmers in northern Nigeria. Their findings indicated that although women were often more vulnerable due to restricted access to land and credit, they displayed higher adoption rates of specific innovations, such as intercropping and crop residue mulching, mainly when supported by NGOs. The research underscored that adaptation is influenced by social factors, necessitating that successful interventions be customised to local gender dynamics.

On a global scale, recent comparative studies reflect similar patterns. Mwangi and Dube (2023) examined irrigation resilience in East Africa and found that farmer-led innovations were more successful when bolstered by supportive policies and public-private collaborations. Their findings resonate with the situation in Dutse, where fragmented institutional support constrains the scalability of effective practices.

At the national policy level, the Federal Ministry of Agriculture and Food Security (FMAFS, 2024) acknowledged in its National Agricultural Resilience Report that irrigated agriculture is not only essential for food security but also a sector highly vulnerable to climate risks. The report emphasised the necessity for decentralised climate action strategies, increased funding for small-scale irrigation initiatives, and farmer-led water management solutions.

Additionally, a meta-analysis conducted by UNDP Nigeria (2023) highlighted that Nigeria's advancements regarding SDG 13 (Climate Action) and SDG 2 (Zero Hunger) greatly rely on targeted actions in agricultural communities vulnerable to climate change. The analysis indicated that when climate adaptation funding is accessible, it has a positive influence on yield stability and farmers' incomes, especially when paired with capacity-building initiatives. Together, these current studies support previous findings and offer modern perspectives on climate change adaptation in irrigated agriculture. They underscore the increasing significance of information and communication technology (ICT) in promoting adaptation, the critical need for institutional backing, particularly from extension services and cooperatives, the influence of gender dynamics and socioeconomic disparities on adaptive capacity, and the ongoing deficiencies in infrastructure and finance that hinder the effectiveness of adaptation efforts. These insights provide a robust empirical basis for the current study in Dutse LGA, allowing for a well-founded analysis of both individual and institutional responses to agricultural stress caused by climate change.

III. METHODOLOGY

A. Research Design

This research employed a mixed-methods approach, combining both quantitative and qualitative data to gain a thorough understanding of how irrigation farmers in Dutse LGA manage climate change. The quantitative aspect involved structured questionnaires aimed at identifying statistically relevant patterns and relationships, while the qualitative part incorporated focus group discussions (FGDs) and key informant interviews (KIIs) to obtain a deeper understanding of farmers' experiences, perceptions, and local responses. The integration of both methodologies facilitated triangulation, thereby enhancing the reliability and validity of the results.

B. Study Area

Dutse LGA, the capital of Jigawa State, is situated in Nigeria's semi-arid Sudan-Sahel ecological zone. This region is characterised by low annual rainfall (averaging between 600 and 900 mm), high temperatures (ranging from 30°C to 42°C), and a substantial reliance on fadama lands and tube wells for irrigation. Agriculture is the primary economic activity, with rice, tomatoes, onions, and peppers being the predominant crops cultivated during the dry season under irrigation.

C. Population and Sampling Technique

The target population consisted of all smallholder irrigation farmers across the selected wards within Dutse LGA. A multi-stage sampling technique was employed; initially, five central irrigation-active wards—Yalwan Damai, Limawa, Sakwaya, Takur Addu'a, and Gida Dubu—were purposively chosen based on the level of irrigated agricultural activities. Subsequently, 150 farmers were randomly selected from these five wards using simple random sampling, ensuring that each ward contributed 30 respondents for representativeness.

D. Data Collection Methods

- *Quantitative Data Collection*

A structured questionnaire was distributed to the 150 selected participants. The questionnaire comprised three principal sections: socio-economic characteristics, perceptions of climate change impacts, and coping strategies employed. The instrument underwent pre-testing and modifications for clarity and contextual relevance.

- *Qualitative Data Collection*

Four Focus Group Discussions (FGDs) took place in the chosen wards, each involving groups of 8–10 farmers. These discussions centred on historical shifts in rainfall patterns, community coping mechanisms, traditional forecasting techniques, and institutional assistance. Moreover, six Key Informant Interviews (KIIs) were conducted with agricultural

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extension officers, irrigation coordinators, and traditional leaders to gather expert viewpoints and institutional insights.

E. Data Analysis

Quantitative Analysis: Data collected from the structured questionnaires were coded and assessed using the Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics (frequencies, means, percentages) summarised the socio-economic data and climate adaptation strategies, while inferential statistics, including logistic regression analysis, were employed to determine the factors influencing the adoption of adaptation strategies among respondents.

Logistic Regression Model Specification: The binary logistic regression model used to analyse the determinants of adaptation to climate change is specified as follows:

$$\text{Ln}(P1-P) = \beta0 + \beta1\text{EDU} + \beta2\text{HHSIZE} + \beta3\text{CREDIT} + \beta4\text{CLIMINFO} + \beta5\text{FARMEXP} + \beta6\text{EXTSERV} + \varepsilon$$

Where:
Ln (P1−P) = is the log odds of a farmer adopting a climate change adaptation strategy.
P = probability of adaptation (i.e., the farmer adopts at least one adaptation strategy).
β0 = constant term (intercept).
β1,β2,…,β6 = coefficients of the independent variables.
ε = error term.

Explanatory Variables:
EDU = Education Level (categorical: 0 = no formal education, 1 = primary, 2 = secondary or higher)
HHSIZE = Household Size (number of persons in the household)
CREDIT = Access to Credit (dummy: 1 = access, 0 = no access)
CLIMINFO = Access to Climate Information (dummy: 1 = access, 0 = no access)
FARMEXP = Farming Experience (years)
EXTSERV = Access to Extension Services (dummy: 1 = access, 0 = no access)

This model allows for the estimation of how each of these socioeconomic and institutional variables affects the likelihood (odds) of a farmer adopting at least one adaptation strategy to climate change.

Qualitative Analysis: Data from focus group discussions (FGDs) and key informant interviews (KIIs) were transcribed and analysed thematically using content analysis. The transcripts were coded according to the emerging themes, which included access to water, indigenous knowledge, barriers to adaptation, and institutional support. These themes were subsequently triangulated with the quantitative findings to enrich the interpretation.

Ethical Considerations: Ethical approval was secured from the relevant local research ethics committee. Informed consent was obtained both verbally and in writing from all participants. Respondents were guaranteed the confidentiality of their answers, and their participation was entirely voluntary. All transcripts and datasets were anonymised by removing names and other identifiable details.

Limitations of the Study: Although the study offers valuable insights, certain limitations have been recognised. Firstly, perceptions of climate were based on self-reported experiences, which could be vulnerable to recall bias. Secondly, the research was confined to Dutse Local Government Area (LGA) and may not adequately reflect the regional diversity within Jigawa State. Nevertheless, employing mixed methods helped address these limitations by providing both breadth and depth to the data.

IV. RESULTS AND DISCUSSION

This section outlines and discusses the findings from the field survey, focus group discussions (FGDs), and key informant interviews (KIIs), all of which aim to understand how irrigation farmers in Dutse LGA are responding to the challenges of climate change.

A. Socioeconomic and Demographic Characteristics of Respondents

Table 1: Socioeconomic and Demographic Characteristics of Respondents (N = 150)

Variable	Frequency	Percentage (%)
Gender		
Male	134	89.3
Female	16	10.7
Age Group		
Under 30	22	14.7
30–50	94	62.7
Above 50	34	22.6
Educational Level		
No formal education	18	12.0
Primary	48	32.0
Secondary	66	44.0

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Variable	Frequency	Percentage (%)
Post-secondary	18	12.0
Primary Occupation		
Full-time farming	117	78.0
Trading	15	10.0
Manual labour	18	12.0
Household Size		
1–4 members	19	12.7
5–8 members	85	56.7
Above eight members	46	30.6

Source: Field Survey, 2025

Most participants were male (89%), with the majority being in the 30–50-year age bracket. Educational levels varied: 44% had completed secondary education, 32% had primary education, and only 12% held post-secondary qualifications. Approximately 78% were full-time farmers, while others participated in trading and manual labour. The average household size was seven, a common occurrence in agrarian communities within Northern Nigeria. These characteristics indicate a predominantly male, moderately educated, and labour-intensive farming demographic that might influence the types of adaptation strategies they employ.

B. Perceived Impacts of Climate Change

Table 2: Perceived Impacts of Climate Change (N = 150)

Climate Impact Indicator	Frequency	Percentage (%)
Decline in Rainfall Quantity		
Yes	108	72.0
No	42	28.0
Increase in Temperature		
Yes	102	68.0
No	48	32.0
Shorter Rainy Season		
Yes	89	59.3
No	61	40.7
Increased Pest and Disease Incidence		
Yes	93	62.0
No	57	38.0
Reduced Crop Yields		
Yes	98	65.3
No	52	34.7
Adoption of Irrigation as a Coping Means		
Yes	112	74.7
No	38	25.3

Source: Field Survey, 2025

A significant number of respondents (72%) indicated an apparent reduction in rainfall over the past 10–15 years. Roughly 68% noted a rise in temperatures, while 59% recognised that the rainy season has become shorter than it used to be. In focus group discussions held in Takur Addu'a and Limawa, farmers linked erratic rainfall patterns to "God's punishment" or "a sign of the end times," showcasing deep-rooted cultural and religious beliefs. However, younger farmers (those under 40) were more inclined to connect these changes to global environmental issues.

A key informant, who is an extension officer in Yalwan Damai, validated that "rain-fed agriculture is no longer dependable," compelling many to resort to irrigation as a coping strategy. Farmers also reported increased pest invasions and lower crop yields due to climate irregularities. This observation aligns with the findings of Ayanlade and

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Radeny (2023), who stated that smallholder farmers in Nigeria primarily perceive climate change through noticeable alterations in temperature and rainfall patterns.

C. Logistic Regression Analysis

To identify the key factors influencing the adoption of climate change adaptation strategies among irrigation farmers, a binary logistic regression was performed. The dependent variable was adoption of any climate change adaptation strategy (coded as 1 = adopter, 0 = non-adopter). Independent variables included: level of education, household size, access to credit, access to climate information, farming experience, and access to extension services.

The model was found to be statistically significant, $\chi^2(6) = 36.82$, $p < 0.001$, indicating that the predictors reliably distinguished between adopters and non-adopters of adaptation strategies. The Nagelkerke R^2 of 0.41 suggests a moderate explanatory power.

Table 3: Logistic Regression Results

Predictor Variable	B Coefficient	Sig. (p-value)	Odds Ratio (Exp(B))	Interpretation
Education Level	0.785	0.004 **	2.193	Educated farmers were more likely to adopt adaptation strategies.
Household Size	0.163	0.149	1.177	Not statistically significant.
Access to Credit	0.901	0.000 **	2.462	Strong predictor: Access increases the likelihood of adaptation.
Access to Climate Information	1.002	0.000 **	2.724	Farmers who were informed about climate change were nearly three times more likely to adapt.
Farming Experience (Years)	0.354	0.021 *	1.425	Experienced farmers are more likely to adapt to new conditions.
Access to Extension Services	0.628	0.010 *	1.874	Farmers with support from extension agents are more likely to adopt new practices.

*Significance Level: $p < 0.01$, $p < 0.05$

Interpretation: Education Level had a positive and significant effect on adaptation ($p = 0.004$). Farmers with at least a secondary education were over twice as likely to adopt adaptation strategies compared to those with no formal education.

Access to Credit ($p = 0.000$) and Access to Climate Information ($p = 0.000$) emerged as the strongest predictors of adaptation. Financial and informational resources significantly empower farmers to take proactive adaptation measures.

Farming Experience and Extension Services were also positively associated with adaptation. Seasoned farmers likely have greater exposure to past climate variability, while extension support provides technical guidance.

Household Size, though positively related to adaptation, was not statistically significant, indicating that household labour availability may not directly influence adaptation decisions.

D. Coping Strategies Employed by Farmers

Table 2 Highlights the Key Coping Mechanisms Adopted by Farmers:

Coping Strategy	Frequency	Percentage (%)
Use of tube wells and boreholes	96	64
Crop diversification	82	55
Use of drought-resistant seeds	61	41
Adjusting the planting calendar	58	39
Accessing weather forecasts	32	21
Indigenous soil conservation	27	18

The predominant adaptation strategy involved relying on tube wells and boreholes for crop irrigation during dry spells. Focus group discussions revealed that the costs associated with borehole maintenance pose a significant challenge, particularly for smallholder farmers. There was also a trend towards diversifying into crops that require less water, such as millet and sorghum. Nonetheless, access to modern climate-smart resources (like certified drought-resistant seeds and irrigation tools) was relatively low, with only 21% reporting regular receipt of weather updates. One participant from Gida Dubu expressed frustration: “Our radios seldom provide local weather forecasts; we depend more on the elders who observe the sky and wind patterns.”

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In terms of institutional support and obstacles, merely 37% of respondents indicated having received assistance from government agencies over the past five years. The quality of extension service delivery was deemed poor by 52% of farmers, while 26% remained neutral. Focus group discussions in Sakwaya revealed that many farmers have become sceptical of the promises made by state authorities regarding inputs and credit. Key informant interviews with traditional leaders revealed that community members often find themselves excluded from donor-funded climate initiatives due to insufficient documentation or lack of awareness.

These insights resonate with findings from Mohammed and Okorie (2024), who argue that the fragmentation of institutions and the absence of targeted support pose considerable hindrances to climate adaptation in Northern Nigeria.

When examining gender dimensions in adaptation, it became evident that, although most participants were men, women farmers involved in focus group discussions faced various coping challenges. Women encountered more significant obstacles in securing land and had limited financial means to invest in boreholes or hybrid seeds, as one woman from Limawa remarked, “Our husbands decide what crops to plant and when. We mainly take care of home gardens and sell tomatoes.” This highlights the gender inequalities identified by Nuhu and Danjuma (2025), who emphasise that patriarchal land tenure systems and unequal access to extension services hinder adaptive capacity.

The thematic summary derived from focus groups and key informant interviews reveals several recurring themes:

- Adaptation fatigue indicates that farmers are primarily resorting to short-term reactive strategies rather than engaging in long-term planning.
- A trust deficit reflects a prevalent scepticism regarding government-led initiatives.
- The knowledge-practice gap suggests that although awareness of climate change is growing, technical proficiency in sustainable land management and irrigation innovations remains limited.
- Community resilience showcases how, despite challenges, local networks—particularly cooperatives and religious groups—provide support against environmental shocks by organising joint borehole maintenance and seed exchange programs.

In the discussion, the mixed-method evidence highlights that irrigation farmers in Dutse do not merely suffer from climate change; instead, they actively observe, interpret, and adapt to evolving conditions by utilising the knowledge and resources available to them. However, this adaptability is inconsistent and hindered by institutional shortcomings, financial barriers, and sociocultural norms. The findings reinforce the Social-Ecological Systems (SES) framework, in which human actions (such as adaptation strategies) interact continuously with environmental changes (including rainfall, temperature, and pest issues). The ability to adapt varies greatly depending on access to infrastructure, social networks, and institutional backing.

Consistent with the Natural Resource Management (NRM) theory, the findings indicate that sustained adaptation will necessitate integrated approaches that involve stakeholders across multiple tiers. This includes harmonising local knowledge with scientific forecasts, enhancing extension services, and ensuring the inclusive implementation of policies that effectively reach marginalised groups, including women and youth.

V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

This investigation examined how irrigation farmers in Dutse LGA, Jigawa State, are mitigating the impacts of climate change, employing both quantitative and qualitative methods. The results highlight a complex yet adaptive rural community that responds to climate-related challenges through irrigation, crop diversification, traditional knowledge, and localised social resilience strategies. Although farmers are actively employing coping strategies, such as utilising tube wells, drought-resistant seeds, and modifying planting schedules, their initiatives are hindered by insufficient institutional backing, weak extension services, gender disparities, and restricted access to climate-smart technologies and financing.

The findings indicate that climate change has already altered rainfall and temperature patterns, reduced agricultural productivity, and intensified water stress burdens in Dutse LGA. These environmental shifts, alongside socio-economic vulnerabilities, emphasise the critical necessity for comprehensive and inclusive climate adaptation strategies. While innovation and community resilience are visible, they often fall short of ensuring long-term agricultural sustainability without intentional institutional assistance and inclusive policymaking.

The research highlights the significance of Natural Resource Management (NRM) theory, Sustainability Theory, and the Social-Ecological Systems (SES) framework, all of which emphasise the importance of integrated, participatory, and adaptive systems that recognise the interconnection between humans and nature.

B. Recommendations

Drawing from the findings, the following policy and programmatic suggestions are recommended:

➢ *Improve Extension Service Delivery:*

Enhance and broaden agricultural extension services by training more agents and decentralising outreach efforts to increase their reach and impact. Extension officers should be equipped to provide customised climate adaptation information, particularly regarding Sustainable Land

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Management (SLM) techniques, water conservation, and early warning systems.

- *Enhance Access to Climate-Smart Inputs:*

Governments and NGOs should subsidise and distribute drought-resistant seeds, affordable irrigation kits, and organic soil enhancers to support sustainable agriculture practices. Access to these resources should consider gender considerations and prioritise support for the most vulnerable farmers.

- *Strengthen Climate Information Systems:*

Broaden localised climate forecasting platforms through radio broadcasts, mobile alerts, and community-based weather stations. Farmers require timely and precise information to make informed decisions about crop selection and planting cycles.

- *Foster Community-Based Adaptation (CBA):*

Utilise existing community structures, such as farmer cooperatives, religious organisations, and women's groups, to implement adaptation initiatives. These local entities possess social capital and credibility that can help bridge the gap between policy and practice.

- *Address Gender Inequality in Adaptation Efforts:*

Ensure that climate adaptation initiatives are inclusive of women and youth. Land rights, financial access, and training opportunities must be structured to empower marginalised groups to engage in and benefit from climate-resilient agriculture.

- *Promote Institutional Coordination:*

Enhance collaboration between federal and state ministries, the National Agency for the Great Green Wall (NAGGW), NGOs, and traditional authorities to develop a cohesive climate adaptation framework for Jigawa State.

- *Support Research and Innovation:*

Invest in research focused on context-specific climate adaptation. Encourage partnerships between universities, research institutions, and farmer groups to create scalable, cost-effective adaptation technologies that are culturally relevant and environmentally sustainable.

By implementing these recommendations, stakeholders can enhance the adaptive capacity of irrigation farmers in Dutse LGA and contribute to the broader goals of environmental sustainability, food security, and rural resilience in northern Nigeria.

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