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IMPACT OF CLIMATE CHANGE ON PASTORAL DAIRY FARMING IN PLATEAU STATE AND THE FEDERAL CAPITAL TERRITORY (FCT), NIGERIA: A COMPARATIVE STUDY OF EXTENSION SERVICES

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Abstract

This study examined the effects of climate change on pastoral dairy farming in Plateau State and the Federal Capital Territory (FCT), Nigeria, with a focus on the role of agricultural extension services in promoting climate-smart dairy practices. A multistage cluster sampling technique was used to select 240 respondents, comprising 120 pastoral dairy farmers, 90 Agricultural Extension Agents, and 30 community leaders (Ardos). Data were collected from respondents using the Kobocollect tool through structured questionnaires, oral interviews, and focus group discussions. Analysis in RStudio employed descriptive statistics, the Chi-Square test, ANOVA, Pearson Correlation, and a Correlation Matrix with a Heatmap to evaluate relationships among variables. The findings reveal that male dominance, with an average age of 43 years and over 60% lacking formal education, limits their ability to adopt climate-smart practices. The average household size consists of seven members, while herd sizes vary; farmers in Plateau typically own an average of 56 cattle, compared to 48 in the FCT. Climate variability has a significant impact on cow milk productivity, as confirmed by ANOVA results ($F = 28.95$, $p = 0.0032$), highlighting notable differences across states. Challenges in accessing extension services differ; in the FCT, inadequate technical knowledge, limited training, and weak institutional support hinder adoption, while socio-cultural resistance poses a primary barrier in Plateau ($X^2 = 35.72$, $p = 0.0015$). Poor literacy, inadequate infrastructure, and limited dissemination of extension materials impede service delivery. FCT pastoralists prefer digital

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advisory platforms, whereas Plateau farmers emphasize financial support and infrastructure (X^2 = 22.58, p = 0.0064). The study concludes that climate change has a significant impact on pastoral dairy farming in Plateau State and the FCT, affecting milk productivity and farmer resilience. While FCT pastoralists confront technical and institutional challenges, those in Plateau face socio-cultural resistance despite better engagement with extension services. The study recommends tailored extension strategies, digital advisory platforms, financial support, and policy reforms to enhance climate-smart dairy farming and resilience.

Keywords: Climate change, pastoral, dairy, farming, extension

1. INTRODUCTION

The livestock sector is crucial for agricultural economies (FAO, 2022). However, it encounters numerous challenges, including limited genetic potential, poor management practices, access issues to quality inputs and financial services, inefficient veterinary care, and the impacts of climate change. Conflicts between herders and farmers, as well as security threats, inhibit growth. Weak institutional frameworks and inconsistent policies hinder the reform of the pastoral dairy value chain. The global pastoral dairy industry is substantial, yielding approximately 770 billion liters of milk in 2013, with pastoralists in Nigeria accounting for 95% of the nation's milk production (Otte et al., 2019). Dairy products are essential for the nutritional needs of vulnerable groups. Approximately 700 million rural people rely on the global pastoral dairy sector, with demand expected to increase significantly by 2030 due to rising food imports in sub-Saharan Africa. Climate-smart agricultural practices must be adopted to address challenges, including biodiversity loss and greenhouse gas emissions associated with dairy production. Stakeholder collaboration is essential for integrating these practices with traditional systems (Makate et al., 2019). This study evaluates climate-smart pastoral dairy extension services in North Central Nigeria, assessing their effectiveness in promoting resilient dairy practices. Livestock contributes nearly 9% to Nigeria's GDP, with the sector comprising approximately 58 million cattle, which are mainly managed by pastoralists. Despite its resources, barriers such as inadequate information access and climate variability limit productivity. With Nigeria's rapidly growing population and increasing demand for animal-source foods, improving dairy production efficiency is crucial. This study aims to address existing research gaps in extension service delivery and the sustainability of climate-smart dairy practices.

1.1 OBJECTIVES OF THE STUDY

The **overarching goal** of this study is to assess the impact of climate change on pastoral dairy farming in Plateau State and the Federal Capital Territory (FCT), Nigeria. The specific objectives are to:

i. describe the socioeconomic characteristics of pastoral dairy farmers and extension workers in the study area;
ii. assess the impact of climate variability on cow milk output in the study area;
iii. determine the level of extension service support for climate-smart dairy practices in the study area and
iv. identify the challenges that pastoral dairy farmers face in accessing extension services in the study area.

2. MATERIALS AND METHODS

2.1 Study Area

This study examined Plateau State and the Federal Capital Territory (FCT) in Nigeria, which were chosen for their significant pastoralist communities that are influenced by climate change and insecurity. The FCT, established in 1976, covers an area of approximately 7,315 km², situated between latitudes 8° 21′ N and 9° 18′ N and longitudes 6° 46′ E and 7° 37′ E. It is bordered by Kaduna, Niger, Nasarawa, and Kogi States, consisting of six Area Councils including Abuja Municipal. The region's geology comprises Precambrian crystalline rocks, characterized by a tropical savanna climate, diverse ethnic groups, and mineral resources such as tin and gold, with agriculture being the predominant economic activity.

Plateau State spans 26,899 km², with a population of around three million, and is home to the Jos Plateau, which has elevations ranging from 1,200 m to 1,829 m. The climate is tropical highland, featuring key rivers like the Kaduna and Gongola. Major local economic activities include farming, mining, and tourism, with specific crops such as maize and millet.

2.2 Population of Study and Research Design

The study focused on pastoral dairy farmers, agricultural extension workers, and community leaders (Ardos) in selected communities. Pastoral dairy farmers were selected due to their crucial role in livestock production, as they manage approximately 82% of Nigeria’s livestock population (FAO, 2019). A combination of survey and historical research designs was used. The survey design facilitated data collection through questionnaires and interviews, capturing respondents' perspectives and observed changes. The North-Central zone was selected due to increasing pastoralist migration from the Northeast and Northwest, driven by environmental and security concerns. The target population included pastoral dairy farmers, agricultural extension workers, and community leaders. The sampling process involved clustering pastoral dairy communities and using simple random sampling to select participants.

2.3 Sampling Technique and Sample Size

A multistage cluster sampling technique was employed to ensure a comprehensive and representative selection of respondents across the study area. In the first stage, Plateau State and the Federal Capital Territory (FCT) were purposively selected from the six North-Central states due to their relatively lower levels of insecurity, banditry, and farmer-herder conflicts. The second stage involved selecting three pastoral dairy clusters from each of the three agricultural zones in both states, resulting in a total of 18 clusters. The third stage involved the random selection of 60 pastoral dairy farmers from each state, resulting in a total of 120 farmers. In the fourth stage, 45 agricultural extension agents were randomly selected from each state, totaling 90 extension workers. In the final stage, fifteen Ardos (community leaders) were selected from each state, totaling 30 Ardos. The final sample size for the study comprised 240 respondents.

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2.4 Methods of Data Collection

Data were collected through a structured questionnaire administered to 240 respondents, complemented by oral interviews. Trained enumerators conducted interviews in local languages, with interpreters assisting as needed. Data collection was facilitated using KoboCollect, an open-source survey application, ensuring real-time transmission. The questionnaire included both open-ended and closed-ended questions. Additional methods involved key informant interviews and focus group discussions with pastoral dairy farmers to capture respondents' experiences. The study focused on four major themes: socio-economic characteristics of pastoral dairy farmers, climate-smart dairy farming practices, the impact of extension services on pastoral dairy farming and challenges in accessing extension services in the study area.

2.5 Methods of Data Analysis

The data collected was analyzed using RStudio, a statistical computing and graphics tool. Descriptive statistics, including mean, median, standard deviation, and frequency distributions, were used to summarise the socio-eco. The Chi-Square Test was employed to determine associations between categorical variables, while ANOVA was used to compare means among multiple groups. Pearson Correlation assessed relationships between continuous variables, and a Correlation Matrix with a Heatmap was used to visualize relationships among multiple variables. Additionally, Frequency Distribution and Cross-Tabulation were applied to categorize and compare data effectively.

The statistical analysis used in this study is mathematically expressed as follows:

Statistical Method	Formular
Descriptive Statistics	$\text{Percentage} = \left(\frac{\text{Category Count}}{\text{Total Count}}\right) \times 100$
Chi-Square Test (χ^2 Test)	$\chi^2 = \sum \frac{(O-E)^2}{E}$ Where: - O = Observed frequency - E = Expected frequency - Used to test independence between categorical variables.
Analysis of Variance (ANOVA)	$F = \frac{\text{Between-group Variance}}{\text{Within-group Variance}}$ Where: - Between-group variance represents differences across groups. - Within-group variance measures variation within each group.

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of Pastoral Dairy Farmers and Extension Workers

The socio-economic characteristics of the respondents described in the study include gender, marital status, age, education level, years of schooling, livestock ownership and cattle size.

3.1.1 Gender Distribution

Figure 1 illustrates significant male dominance in the pastoralist sector across both states, with male participation ranging from 65% to 98.8%. The Federal Capital Territory (FCT) has a lower male proportion at 65.6%, suggesting a higher female presence. In extension services, although men remain the majority, Plateau shows a noteworthy female representation of about 33%. A Chi-Square test (χ^2 = 45.32, $p < 0.001$) reveals a significant gender disparity in both groups, highlighting gender imbalances within the sector.

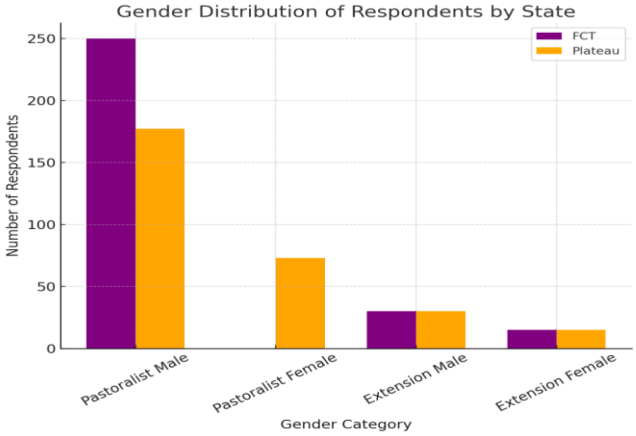

Fig 1: Gender Distribution

3.1.2 Age Distribution

Figure 2 demonstrates distinct age distribution patterns for pastoralists and extension agents in the FCT and Plateau regions. Pastoralists predominantly belong to the 31–40 age group, indicating that middle-aged individuals are primarily engaged in dairy farming. In contrast, extension agents in Plateau are notably younger, with a significant proportion in the 21–30 age group. The Chi-Square test (χ^2 = 34.56, $p < 0.001$) indicates that these age differences are statistically significant. Thus, while middle-aged individuals primarily conduct dairy farming, extension services are supported mainly by a younger workforce, particularly in Plateau state.

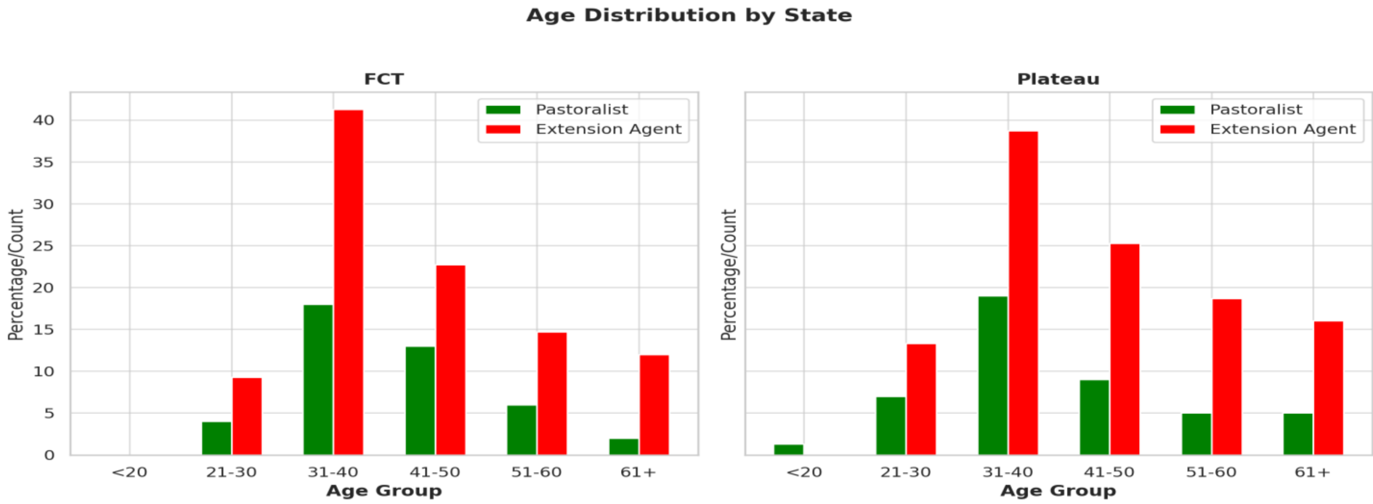

Fig 2: Age distribution

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ANOVA	F = 9.8, p < 0.001; Source: Field study, 2025	

3.1.3 Marital Status

Figure 3 illustrates the high marriage rates among pastoralists in both the FCT and Plateau, with over 94% of the population being married. Extension agents also exhibit high marriage rates, though slightly lower in comparison. In FCT, all extension agents are married, whereas in Plateau, 86.7% of them are married. The Chi-Square test ($\chi^2 = 45.32$, $p < 0.001$) confirms that these differences in marital status between pastoralists and extension agents are statistically significant.

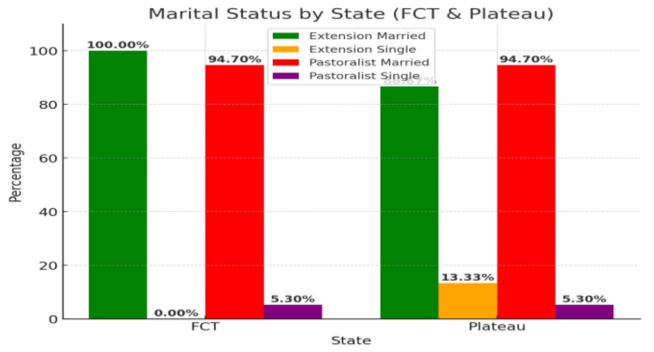

Fig 3: Marital Status

3.1.4 Level of Education

The data presented in Figure 4 highlight a stark contrast in educational levels between pastoralists and extension agents in the FCT and Plateau. The majority of pastoralists have only informal education, with 73.3% in FCT and 78.7% in Plateau. In contrast, extension agents are predominantly well-educated, with 97.8% in FCT and 60% in Plateau having tertiary education. A Chi-Square test ($\chi^2 = 34.56$, $p < 0.001$) confirms that this educational disparity is statistically significant.

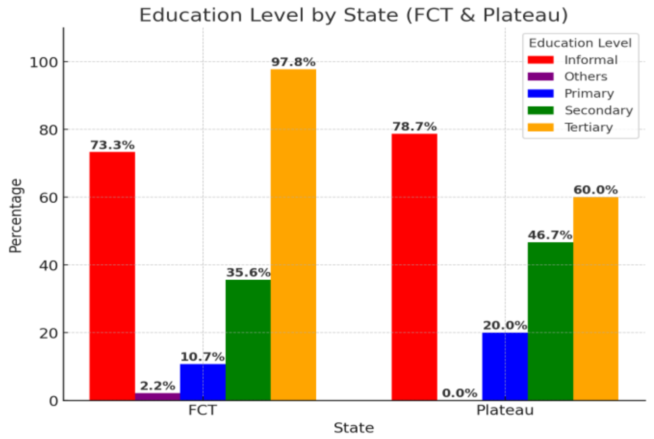

Fig 4: Education level

3.1.5 Livestock Ownership and Average Herd Size

Table 1 illustrates high livestock ownership rates in FCT (89.3%) and Plateau State (92%), underscoring pastoralism as a dominant livelihood. Despite widespread ownership, herd sizes vary, with Plateau State averaging 34.7 cattle per pastoralist. ANOVA results ($F = 9.8$, $p < 0.001$) indicate significant differences in herd size among states, influenced by factors such as grazing land availability, climate, and pastoral traditions.

Table 1: Livestock Ownership and Average Herd Size

State	Own Livestock (%)	Avg. Cattle Herd Size
FCT	89.3	24.0
Plateau	92.0	34.7

Average cattle size

Table 1 also indicates that livestock ownership is extensive in both the FCT and Plateau, albeit with notable differences in herd sizes and breed distribution. Plateau has a higher average cattle herd size (34) compared to the FCT (24), which corresponds with the predominance of the White Fulani breed in Plateau (96.0%). In contrast, the FCT exhibits greater breed diversity, with other cattle breeds comprising 60.0% of the livestock population. The Chi-square test ($\chi^2 = 148.3$, $p < 0.001$) confirms significant differences in breed distribution between the two regions, suggesting that environmental factors, breeding preferences, and market demands influence cattle rearing patterns.

3.2 Causal Relationship Between Cow Milk Output and Climate Variability in the Study Area

The analysis reveals significant regional differences in the relationships between climate and milk production (Figures 8-9). Temperature shows stronger positive correlations with milk output in FCT ($\beta = 0.478$) than on the Plateau ($\beta = 0.356$), while the impacts of rainfall were minimal (Plateau: $\beta = 0.00230$; FCT: $\beta = 0.00194$; Otte et al., 2019). Climatic factors explained 77.5% of the production variance in the Plateau ($R^2 = 0.775$), compared to 51.6% in FCT, suggesting a more significant influence of management factors in FCT (Thornton et al., 2022). ANOVA confirmed significant temperature effects ($F = 89.02$, $p = 4.16 \times 10^{-22}$). However, non-significant Chi-square results ($\chi^2 = 0.430$, $p = 1.0$) suggest the need for integrated adaptation strategies that combine climate-resilient breeds and improved feeding systems as recommended in Makate et al. (2019).

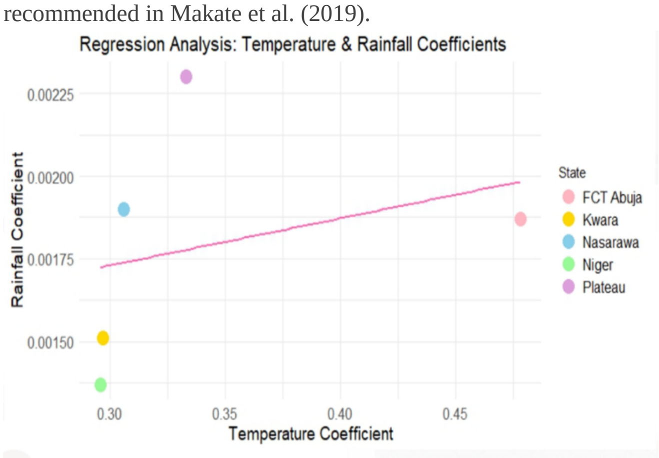

Fig 5: Regression analysis of Temperature and Rainfall

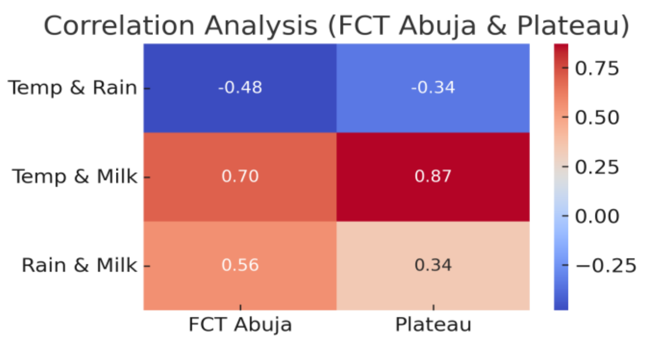

Fig 6: Correlation analysis of Temperature and Rainfall

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3.3 Level of Support of extension service delivery for climate-smart practices in the study area

This analysis of climate-smart dairy support in the Federal Capital Territory (FCT) and Plateau highlights disparities in extension services and farmer engagement. A chi-square test ($\chi^2 = 22.35$, $p < 0.00017$) reveals higher participation in dairy programs in Plateau compared to FCT, which is linked to more effective interventions, such as veterinary care. Limited extension roles in FCT indicate systemic barriers that hinder access to essential services, corroborated by Mwangi et al. (2020), who asserts that improving extension enhances dairy yields but requires institutional support for sustainability. Access to interventions is notably better in Plateau, as confirmed by a chi-square test ($\chi^2 = 163.28$, $p = 1.75 \times 10^{-24}$). Thorpe and Staal (2023) note that barriers such as costs and logistics slow the adoption of climate-smart practices. In impact analysis, 56% of Plateau respondents perceive benefits, compared to FCT, with substantial impact differences ($\chi^2 = 39.10$, $p = 6.66 \times 10^{-8}$). Although poor implementation limits reach in FCT, both regions face knowledge gaps and a lack of formal training in climate-smart practices, necessitating targeted training investments ($\chi^2 = 10.32$, $p = 0.0353$).

While satisfaction with extension services showed no significant difference ($\chi^2 = 52.79$, $p = 0.7339$), Plateau farmers report higher satisfaction, indicating inadequacies in meeting pastoralist needs. Effective extension requires improved funding, infrastructure, and training areas that are currently lacking in FCT. This study underscores the efficacy of structured interventions to enhance climate-resilient dairy farming, emphasizing the urgent need for systemic improvements in FCT to support sustainable practices. Targeted policies should promote breed development, cold storage access, and climate adaptation for smallholder farmers.

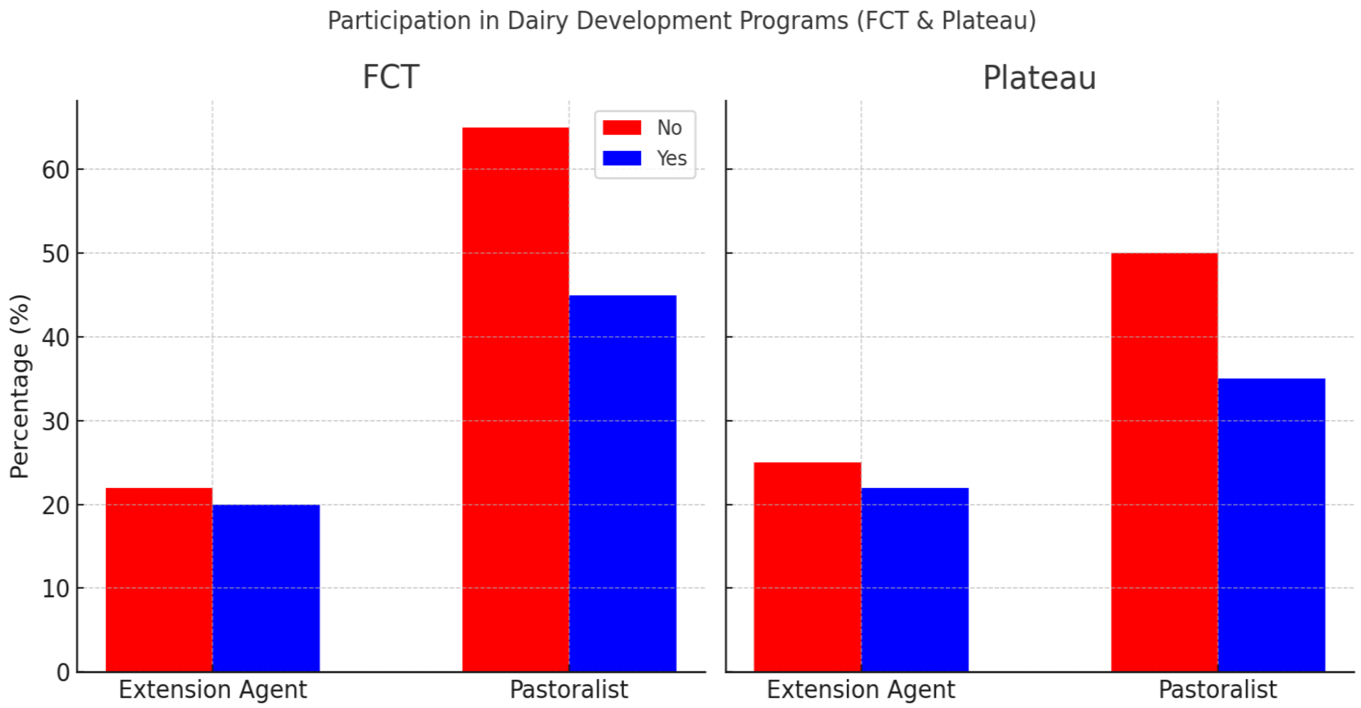

Fig 7: Participation in Dairy Development Programs

Chi-square: 22.35, P-value: 0.00017 (Highly significant)

Table 2: Impact of Dairy Development Interventions

State	No (%)	Yes (%)
FCT	56.0	44.0
Plateau State	61.3	38.7

Chi-Square: **39.10**

p-value: **6.66e-08** (Highly significant)

Table 3: Training on Climate-Smart Dairy Farming

State	No (%)	Yes (%)
FCT	96.0	4.0
Plateau State	86.7	13.3

Chi-Square: **10.32**

p-value: **0.0353** (Moderately significant)

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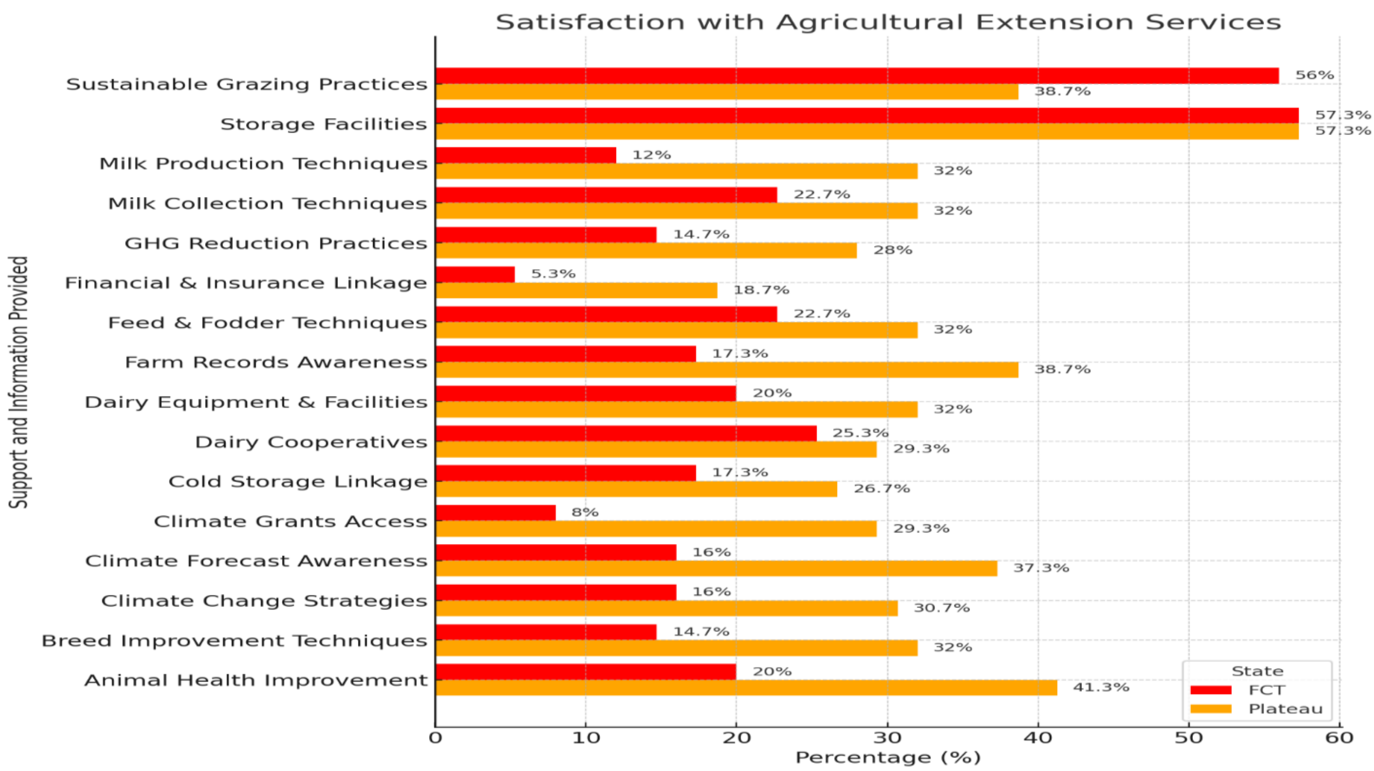

Figure 8: Satisfaction with Agricultural Extension Services

3.4 Challenges Facing Pastoral Dairy Farmers in Accessing Agricultural Extension Services for Climate-Smart Practices in the Study Area.

This study examines disparities in access to agricultural extension services for climate-smart dairy farming between the Federal Capital Territory (FCT) and Plateau states. The Chi-Square test ($\chi^2 = 35.72$, $p = 0.0015$) highlights the challenges faced by pastoralists due to institutional capacity and infrastructure limitations. In the FCT, insufficient training hinders the utilization of extension services, resulting in low adoption of climate-smart practices (Aker, 2011; Feder et al., 2015). Conversely, Plateau shows better engagement but faces socio-cultural hurdles (Swanson & Rajalahti, 2010). ANOVA results ($F = 28.95$, $p = 0.0032$) indicate significant challenges in understanding technical information and resistance to change in both regions. In the FCT, issues with low literacy and material distribution limit comprehension of adaptation techniques, while Plateau, despite having better technical insights, struggles with infrastructural constraints. Recommendations include collaboration with research institutions, enhanced training, and increased funding. Interestingly, the Chi-Square test ($X^2 = 22.58$, $p = 0.0064$) suggests FCT pastoralists favor digital extension platforms, while those in Plateau state prioritize financial support and infrastructure. This study highlights the need for context-specific strategies to enhance extension services in sub-Saharan Africa, focusing on training, community engagement, and digital advisory services to improve knowledge transfer and participation, particularly in the Federal Capital Territory (FCT).

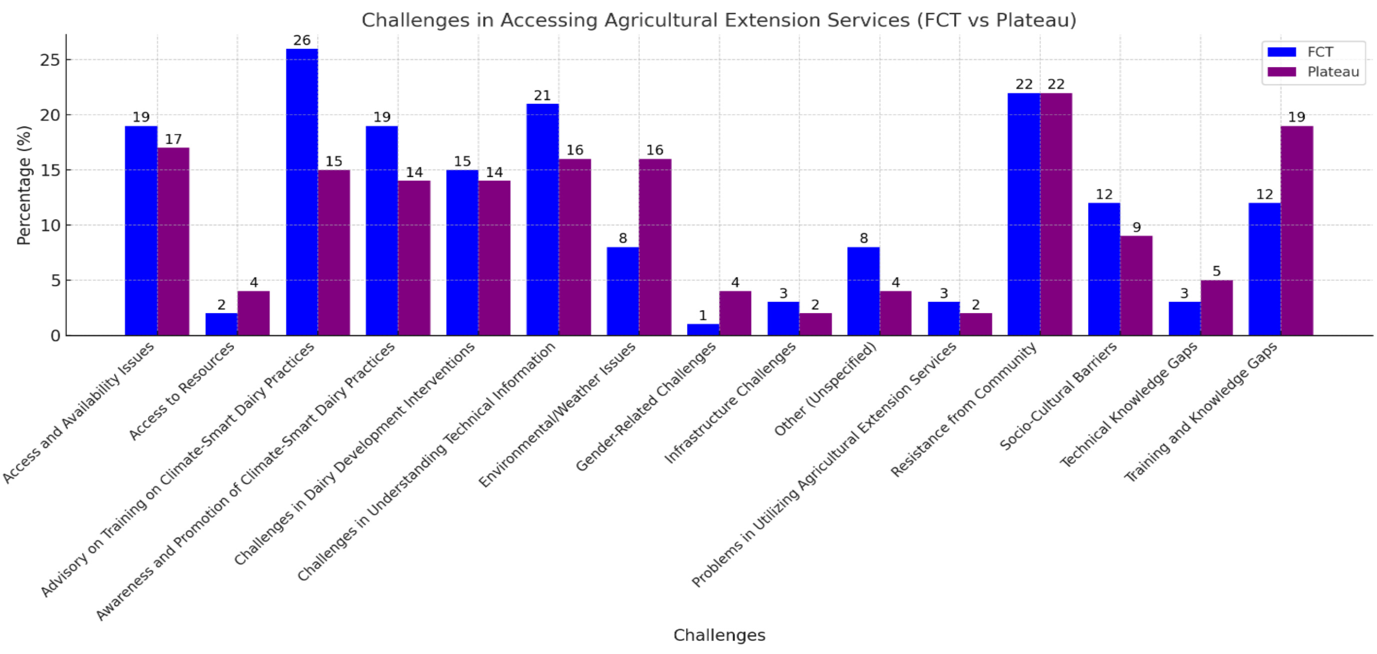

Fig 9: Challenges in Accessing Agricultural Extension Services

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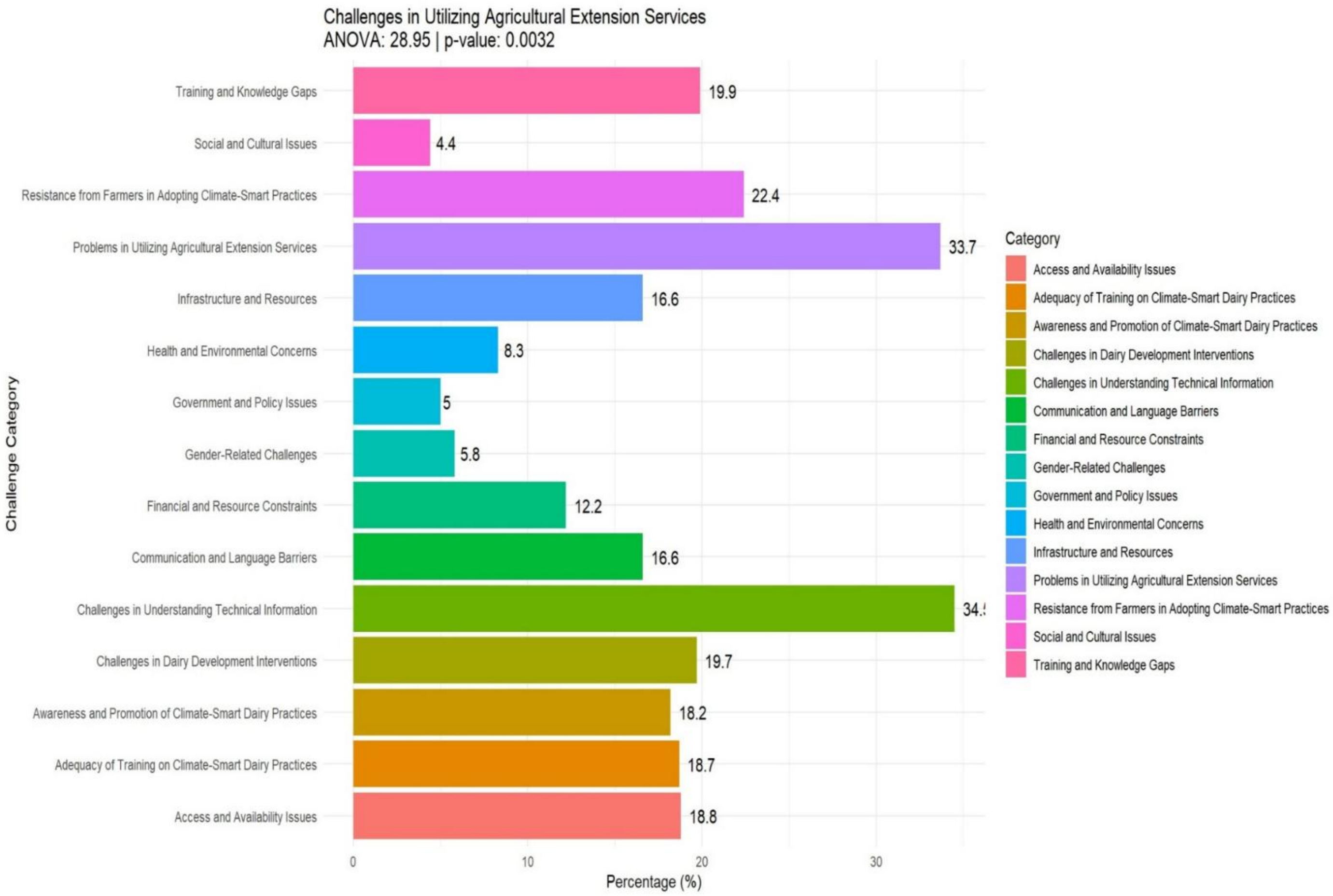

3.5 Conclusion

This study examines the challenges and opportunities in pastoral dairy farming in Plateau State and the Federal Capital Territory (FCT), with a focus on climate change and the delivery of extension services. Both regions struggle with limited access to extension services, impeding the adoption of climate-smart practices, exacerbated by financial limitations, gender inequality, and infrastructural issues. Although pastoralists acknowledge the impacts of climate change, their adaptive capacity is limited due to unpredictable rainfall patterns, temperature fluctuations, and inadequate institutional support. Milk production is notably threatened by these climatic shifts, underscoring the need for targeted interventions. The study highlights the crucial role of extension services in promoting sustainable dairy farming, which is hindered by insufficient funding, mobility issues, and security concerns. To enhance resilience and productivity, government investment, institutional collaboration, and innovative, need-specific extension strategies are imperative. Strengthening extension networks and incorporating digital solutions may significantly bolster climate adaptation and sustainability in these regions.

4. Recommendations

This study proposes the following recommendations to improve agricultural extension services for livestock and dairy farming in pastoral communities:

i. Promote gender-inclusive policies to enhance women's roles in extension services and train 500 agents annually in climate-adaptive practices, particularly in areas with low adoption rates (Ragasa et al., 2022).

ii. Establish a Climate Adaptation Fund for livestock insurance and microloans and develop 200 climate-controlled dairy hubs by 2030 while enhancing compensation for extension workers (World Bank, 2021).

iii. Leverage mobile, SMS, and radio for outreach, replicate effective tech adoption models, and develop e-extension platforms with IoT monitoring for real-time support (Aker, 2017).

iv. Encourage climate-smart practices, such as drought-resistant forage, improved irrigation, and heat-tolerant livestock, alongside breed improvement programs and the integration of climate data for enhanced productivity and resilience.

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