Women, Wages, Weather and Food Security in West Africa: The Case of Senegal

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ABSTRACT

Food security in Senegal and across West Africa is increasingly vulnerable to climate change with female-headed households particularly affected due to gendered disparities in agricultural labor and income. This study examines the interconnections between climate change, female household livelihoods and food security in Senegal. Grounded in Resilience Theory and Sustainable Finance Theory, it adopts a mixed-methods approach that integrates quantitative data from the Living Standards Measurement Study (LSMS) with qualitative fieldwork. The analysis employed Logistic Regression, Propensity Score Matching (PSM), and geospatial mapping to assess the impacts of climate change and female farmer's wages on food consumption. Findings revealed a marginally positive association between severe climate exposure and food consumption (Coefficient: 0.219; $p = 0.056$), likely reflecting the role of food aid and adaptive local strategies. However, the absence of female agricultural wage earners significantly decreases household food consumption (Coefficient: -0.485; $p = 0.003$), emphasizing the vital contribution of women's labor to food access. Additionally, market-based food purchasing emerges as a key factor linking income to food security. The study emphasized the importance of a gender-inclusive agricultural policies, climate-resilient livelihoods and income diversification to bolster rural resilience. It provides evidence-based recommendations for improving food security and addressing climate vulnerabilities in West African communities.

Key Words: Climate Change, Livelihood, Wages, Food Security, Female

1. Introduction

Senegal, like many countries in West Africa is facing increasing challenges from global climate change, which has become a defining issue of the 21st century. The country's Sudano-Sahelian climate has experienced rising temperatures, decreased and erratic rainfall and increased frequency of extreme weather events such as droughts and floods (Ministère de l'Environnement et du Développement Durable [MEDD], 2015a; Maguèye & Ingebor, 2023). These climatic shifts exacerbate soil erosion, reduce agricultural productivity and threaten the sustainability of livelihoods especially in rural areas where the majority of the population depends on rain-fed agriculture. Food security in Senegal is thus highly sensitive to these climate-related risks as disruptions in crop yields and infrastructure increasingly affect the availability and accessibility of food (Nébié et al., 2021; World Food Programme, 2023). The consequences of climate variability extend beyond agriculture to social and economic dimensions, driving rural-urban migration as farming communities seek alternative livelihoods in cities. (Rigaud et al., 2021). Between 2011 and 2022, internal migration in Senegal rose sharply, influenced by environmental degradation, economic hardships and the lingering effects of the COVID-19 pandemic (Rigaud et al, 2021).

Women who represent about 70% of the agricultural labour force in Senegal and play a vital role in food production and household livelihoods are particularly vulnerable to climate impacts due to gender disparities and socio-cultural barriers (Africa Development Bank, 2023; Komonsira, 2023). As men migrate or face security challenges, women increasingly bear the burden of agricultural work and household sustenance, heightening their exposure to food insecurity (Edafe et al., 2023, McOmber, 2020). Furthermore, poor land management practices and socio-economic factors compound the vulnerability of agricultural systems while increasing rural-urban migration highlights the growing pressure on rural communities (Rigaud et al., 2021). Existing policies and support mechanisms have been insufficient in building resilience and ensuring food security. This study seeks to fill the knowledge gap by examining the interconnections among climate change and female farmers' livelihoods to better understand their impact on food security in Senegal and to inform targeted interventions for sustainable development.

The research investigates how climate change and female headed household farmers' livelihoods affects food security outcomes in Senegal. The study Objectives include; to analyse the impact of climate change on food security in Senegal and secondly to examine the impact of female farmers wages on food security in Senegal. The motivation of the study is that sustainable female wages could support resilience against climate shocks as well as food security especially among rural farmers. Only few studies have focused on the impact of female farmers headed household wages on food security and limited studies also focused on Senegal using mixed method approach. By exploring these interconnected factors, the study provides empirical evidence to inform policies that enhance climate resilience, gender inclusion and sustainable food security in Senegal.

Reviewed literature revealed that climate change poses severe risks to food security and livelihoods across Sub-Saharan Africa due to complex biophysical, political and socioeconomic factors (Connolly-Bouton & Barry, 2016). The study framework links climate impacts, vulnerability, adaptation, and food security, highlighting the importance of integrated policies that address these interconnected challenges. Similarly, Rusmayandi (2023) studied rural communities in Indonesia revealing that while diverse adaptation

strategies such as changing farming practices and income diversification exist, they remain insufficient to fully mitigate climate risks, underscoring the need for innovative resilience measures. In Nigeria, Ani and Vincent (2021) found that climate variability has undermined food security and exacerbated conflicts over natural resources, threatening human security. Gender plays a crucial role in food security indicating that persistent inequalities limit women's access to resources and decision-making, impeding sustainable development (Odoh et al., 2024). Odoh's analysis of Nigerian households showed that women, particularly in rural and northern regions, face significantly lower empowerment and higher food insecurity. However, the specific vulnerabilities of female smallholder farmers remain underexplored.

Studies comparing male and female-headed households revealed nuanced food security outcomes. Aryal et al. (2019) found no overall difference but highlighted de jure female-headed households as particularly vulnerable. Galabuzi et al. (2021) emphasised on-farm livelihood diversification's positive effect on food security for female-headed households. Reed et al. (2022) examined the relationship between flooding and food security in Africa, with a focus on rural areas. The study used Granger causality analysis and panel modeling to assess how flooding affects food security. The findings showed that about 12% of people experiencing food insecurity between 2009 and 2020 were affected by flooding. While flooding degraded local food security, it occasionally improved regional outcomes. Coping strategies include migration and local adaptations such as flood management (Anwara 2023). These efforts, while critical, point to the broader need for targeted support to build resilience among vulnerable farming populations, especially women.

2.0 Method and Material

2.1 Brief Description of Study Area

This research focuses on Senegal due to a well-established partnership between the World Food Programme (WFP) country office and the International Research Institute for Climate and Society (IRI), aimed at enhancing climate change responses and food security interventions based on vulnerability assessments (Nébié et al., 2021). Secondly, Senegal is located within the Sahel region and the economy and livelihoods of Senegal are predominantly reliant on rain-fed agriculture and livestock, engaging nearly 70% of the population dominated by women (Alfani et al., 2019; USAID, 2017b). This dependence makes the country especially susceptible to shifts in rainfall and temperature caused by climate variability and change.

Senegal benefits from available Living Standards Measurement Study (LSMS) data, facilitating detailed socioeconomic and climate vulnerability analysis. The country spans approximately 197,000 square kilometres with a population of around 18 million. Climatically, Senegal experiences a tropical climate in the south and a Sahelian climate in the north. Its rainfall regime is strongly influenced by the seasonal movement of the Inter-Tropical Convergence Zone (ITCZ), resulting in a single rainy season typically between July and September. Rainfall varies markedly from about 300 mm annually in the arid north to roughly 1,200 mm in the humid southern forests with significant variability across years and decades (FAO, 2021; World Bank, 2021). The average annual temperature hovers around 27.8°C, with peak monthly temperatures reaching 35°C. Senegal faces two major climate hazards: droughts and floods. While floods occur more frequently, droughts tend to have more severe and widespread impacts, (World Bank, 2021; UNDP, 2022). Anticipated increases in climate variability, more frequent droughts and population growth underline the urgency for adopting drought-resistant crops and improved water management strategies to sustain livelihoods especially female farmers amid uncertain future rainfall patterns.

2.2 Empirical Strategy

This study employed a mixed method approach comprising of quantitative and qualitative analysis. The Food Consumption Score (FCS) was used as a proxy for assessing household food security. Developed by

the World Food Programme (WFP) in 1996, the FCS is a composite index reflecting dietary diversity, frequency, and the nutritional value of consumed food groups over the previous seven days. Household-level data on food group consumption frequency were collected and weighted according to nutritional significance to compute the FCS. Based on established thresholds, households were classified into poor, borderline, or acceptable food consumption categories. The FCS provides a validated, standardised measure useful for comparing food security status across different regions and monitoring temporal changes in diet quality(Obasi & Chikezie, 2020).

For quantitative analysis, binary logistic regression was employed to analyse the relationship between various predictor variables and the dichotomous outcome of household food security (food secure vs. insecure). This method estimates the probability of households falling into either category based on independent variables such as climate change exposure, household size, and female-headed household wages.

The study observed the outcome Y=1 if the household was food secured and Y=0 if the household was food insecure.

The model specification is in equations (1) and (2) as follows:

$$\Pr(Yi=1) = Pi \tag{1}$$

$$\Pr(Yi=0) = 1-Pi \tag{2}$$

The probability of a household being food secure is given in equation (3) as:

$$P_i = E\left(Y=\frac{1}{X}\right)=\frac{1}{1+e^{(\beta o+\beta' xi)}} \tag{3}$$

Where X is a vector of independent variables, and β is a vector of their respective coefficients.

For ease of expression and understanding, equation (3) is simplified in equation (4) as:

$$P_i = E\left(Y=\frac{1}{X}\right)=\frac{e^{(\beta o+\beta' xi)}}{1+e^{(\beta o+\beta' xi)}} \tag{4}$$

The probability of a household being food insecure is shown in equation (5) as:

$$(1-P_i) = E\left(Y=\frac{0}{X}\right)=\frac{1}{1+e^{(\beta o+\beta' xi)}} \tag{5}$$

From equations (4) and (5), Pi ranges from 0 to 1 and has a nonlinear relationship with both the regressors and the parameters, which can lead to estimation issues when utilising the Ordinary Least Squares (OLS) estimation technique. It was however possible to formulate these equations in terms of the odds ratio of the probability of a household being food secure to the probability of households being food insecure is shown in equation (6) as follow:

$$\frac{P_i}{1-P_i}=\frac{1+e^{(\beta o+\beta' xi)}}{1+e-^{(\beta o+\beta' xi)}} \tag{6}$$

Pi was simply the odds ratio in favour of a household being food secure and can therefore be

1- Pi simplified as follow:

$$\frac{P_i}{1-P_i} = e^{(\beta o+\beta' xi)} \tag{7}$$

A logit model can be generated by taking the natural logs of equation (7) and making sure that the odds ratio's log, L, is linear in both X and the parameters; L is called the Logit and hence the name Logit model.

$$Ln\left[i\frac{P_i}{1-P_i} \right] = L_i = \left(\beta o + \beta' xi\right) \tag{8}$$

The data is drawn primarily from the Senegal EHCVM 2018/2019 survey, a nationally representative sample of 7,000 households covering urban and rural areas, conducted under the West Africa Economic Monetary Union (WAEMU) harmonised household survey initiative. The survey included household, individual, and community-level questionnaires administered in two waves, with the study focusing on 2018/2019 wave. Additionally, climate variability data from the World Meteorological Organisation (WMO) and geospatial analyses were integrated to assess climate change impacts on food security in Senegal.

Qualitative methods involved fieldwork in Senegal, using purposive sampling to select climate-prone area. Data collection tools included Focus Group Discussions (FGDs) and In-depth Interviews (IDIs) with stakeholders such as male and female farmers, community leaders, and women's groups. FGDs typically comprised 10–15 participants, with sessions conducted until thematic saturation was achieved. Qualitative data were transcribed and interpreted to capture perceptions of climate change impacts on livelihoods and food security. The ethical approval was secured from the Covenant Health Research Ethics Committee (with Reference CU/HRE/OLC/434/24), ensuring informed consent, confidentiality, and cultural sensitivity throughout the research process.

3. Results and Findings

3.1 Descriptive Statistics

This summary provides an overview of key variables comprising of food consumption (FCONSS), climate change (CCS), food purchase (FOOD_PURS), total households (TOTAL-HHS), household wage (HH_WAGESS3), and female agricultural wage earners (FWA) in Senegal context.

Table I: Summary Analysis of Food Consumption and Related Factors in Senegal

Variable	Observation	Mean	Std. Dev.	Min	Max
FCONSS	500,000	0.795	0.404	0	1
CCS	544,906	0.017	0.127	0	1
FOOD_PURS	190,861	1.77	3.58	0	400
TOTAL_HHS	544,906	28.46	28.44	1	627
HH_WAGESS3	544,906	2.99	0.105	1	7
FWA	859	1.28	0.596	1	4

Source: Researchers' estimation using STATA

The descriptive statistics in Table 1 provide key insights into socio-economic factors influencing food security in Senegal, especially under the pressures of climate change. Food consumption, with a mean of 0.795, indicates that approximately 80% of households consume adequate food, though the variability (SD = 0.404) highlights disparities in access. Climate change awareness and adaptation activities are minimal, reflected by a very low mean score (0.016), underscoring the need for increased engagement. Food purchasing behaviour shows a mean of 1.77 with high variability (SD = 3.58), indicating significant differences in household food expenditure, likely linked to income inequality and climate-related disruptions. Household size averages 28.46 members, with a wide range (1–627), suggesting diverse household structures that could strain food resources, especially under climate stress. The household wages are low and relatively stable (mean = 2.99; SD = 0.105), limiting purchasing power. Female agricultural wages are also low (mean = 1.28; SD = 0.596), reflecting gendered income disparities that may impact household food strategies. Collectively, these statistics reveal critical vulnerabilities in food security, shaped by economic constraints, gender inequality and limited climate adaptation factors that should be addressed in policy interventions targeting sustainable livelihoods in Senegal.

3.2 Description of Kernel Density Plots

Figure I presents two density plots comparing food consumption between male- and female-headed households in Senegal. The X-axis represents food consumption (0–1 scale), while the Y-axis shows density.

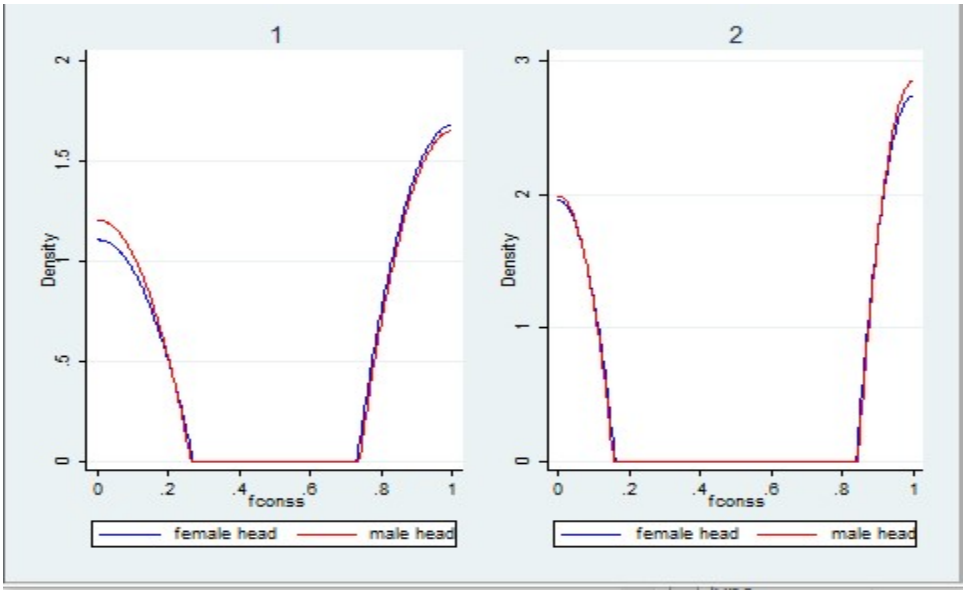

Figure I: Combined food consumption by gender in Senegal

Both plots reveal that male-headed households (red line) exhibit higher density peaks at both low and high consumption levels, indicating a broader distribution. In contrast, female-headed households (blue line) show consistently lower density, suggesting less variability and generally lower food consumption. The first plot, with a higher Y-axis scale, accentuates these differences, clearly illustrating gender disparities in food consumption patterns, with female-headed households facing greater food insecurity risks.

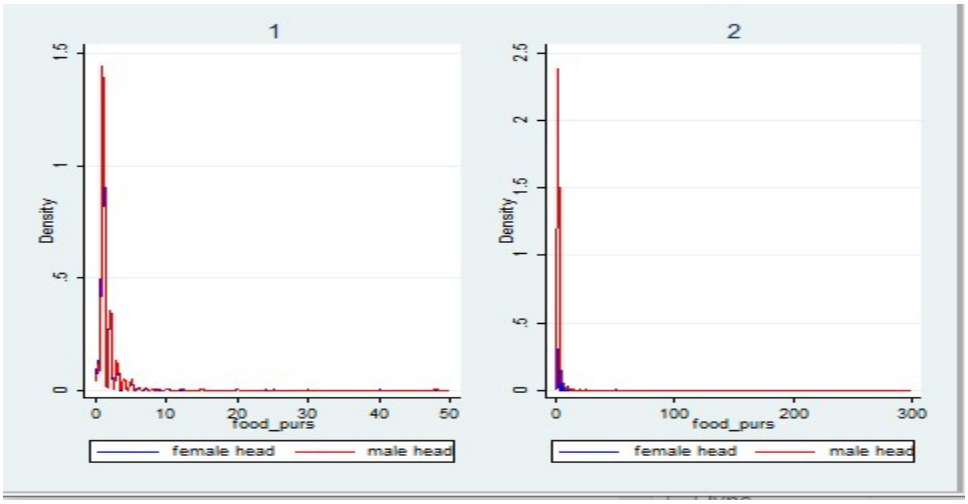

Figure II: Combined food purchase in Senegal

Figure II presents two density plots comparing food purchases by gender in Senegal. The X-axis represents food purchase amounts, while the Y-axis shows observation density. In both plots, male-headed households (red line) exhibit a high concentration of food purchases at lower values, particularly within the 0–10 range. In contrast, female-headed households (blue line) show consistently low density across all purchase levels, indicating limited food purchases. The second plot, with a broader scale, reinforces this trend. Overall, the graphs reveal a clear gender disparity: female-headed households are less likely to make substantial food purchases, suggesting economic vulnerability and potential food insecurity.

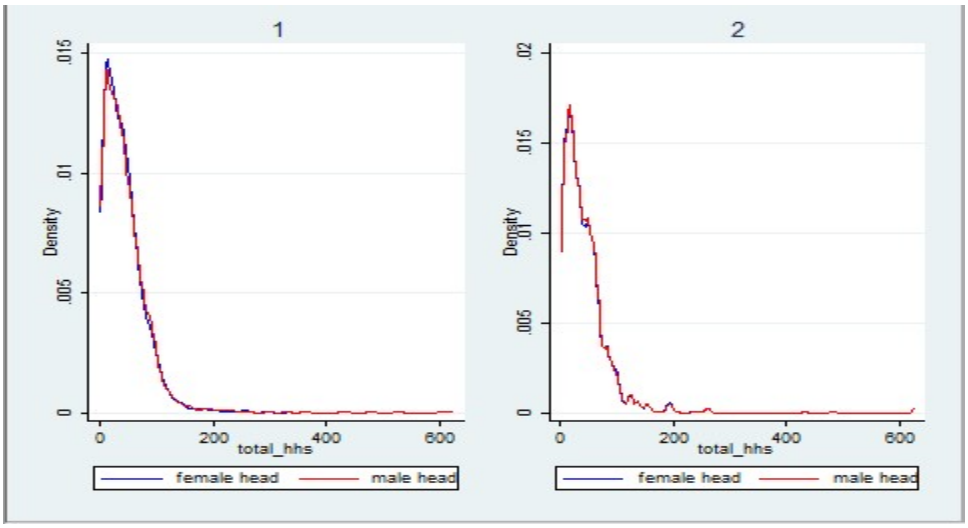

Figure III: Combined Household Size by Gender of Household Heads in Senegal

Figure III shows two density plots illustrating household size distribution by gender of the household head in Senegal. The X-axis represents total household members (0–600), while the Y-axis shows density. Both plots reveal that male-headed households (red line) are more concentrated around smaller sizes (1–3 members), with a sharp decline as size increases. Female-headed households (blue line) follow a similar but consistently lower pattern, indicating fewer small-sized households. Larger households are rare for both genders. The second plot, with an adjusted Y-axis scale, reinforces these trends. Overall, male-headed households tend to be smaller and more common than their female-headed counterparts.

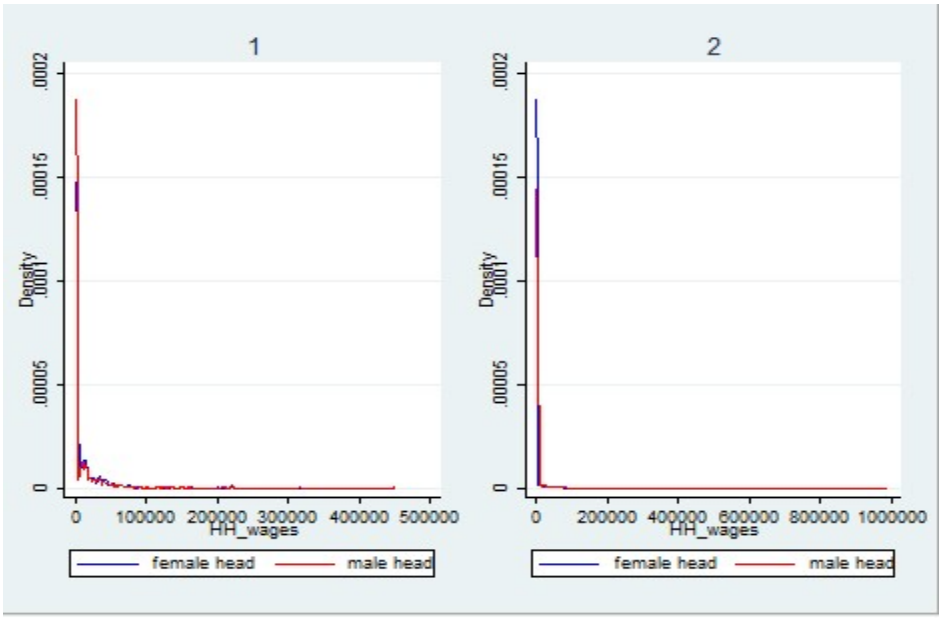

Figure IV: Combined Household Wages by gender of household heads

Figure IV reflects two density plots comparing household wages by gender in Senegal. The X-axis shows household wages (0–1,000,000), and the Y-axis indicates density. Both male- and female-headed households display low wage densities overall, with peaks concentrated at the lower end of the wage scale. Male-headed households (red line) show slightly higher density at low wage levels than female-headed ones (blue line), indicating a marginal income advantage. As wages increase, density sharply declines for both groups, highlighting the rarity of higher income. These trends underscore widespread low household earnings and reflect persistent gender-based economic disparities in Senegal.

3.3 Climate change and food consumption of Households

Table II: Average Treatment Effect for Food Consumption

fcons1_cat	Coef.	Std. Err.	Z-Stat	P>|z|	[95% Conf.	Interval]
CCS	0.219	0.115	1.91	0.056	-0.006	0.445
FOOD_PURS	-0.002	0.005	2.47	0.014	0.003	0.0212
TOTAL_HHS	-0.002	0.001	-2.66	0.008	-0.003	-0.000
HH_WAGESS3	0.036	0.019	1.89	0.060	-0.002	0.075
FWA	-0.116	0.038	-3.02	0.003	-0.191	-0.040
_cons	0.541	0.063	8.61	0.000	0.417	0.664

Source: Researchers' estimation using STATA

The regression analysis in Table II explores the influence of several socio-economic and climate-related variables on food consumption in Senegal. The model explains 3.09% of the variation in food consumption ($R^2 = 0.031$) and is statistically significant ($F(5,776) = 4.95$, $p = 0.0002$), suggesting that the predictors collectively impact food consumption. Climate change severity has a positive, marginally significant effect ($\beta = 0.219$, $p = 0.056$), likely reflecting targeted aid or coping mechanisms in climate-affected areas. Food purchases are positively associated with consumption ($\beta = 0.012$, $p = 0.014$), underscoring the role of purchasing power. Total household size negatively impacts consumption ($\beta = -0.002$, $p = 0.008$), implying resource dilution in larger households. Household wages show a positive, marginal effect ($\beta = 0.037$, $p = 0.060$), while female agricultural wages negatively impact consumption ($\beta = -0.116$, $p = 0.003$), possibly due to structural gender disparities. Policy efforts should enhance income opportunities, support women's empowerment, and strengthen food access.

3.4 Female Farmers Wage Earnings and Food Security

The analysis was performed using propensity score matching (PSM), specifically Direct Nearest Neighbour Matching (DNM) with 4 nearest neighbours, to assess the impact of the predictor variables on food consumption (fconss). The model attempts to match households exposed to climate change (ccs) with those not exposed, controlling for other covariates like food purchases (food_purs), total household size (total_hhs), household wages (HH_wagess3), and female agricultural wage earners (FWA).

Table III: Logistic Regression (PSM) Analysis of Food Security

Logistic regression					LR chi2(5)	25.73
					Prob > chi^2	0.0001
Log likelihood		-528.74427			Pseudo R^2	0.0238
fconss	Coefficient	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
CCS	0.946	0.507	1.87	0.062	-0.048	1.94
FOOD_PURS	0.072	0.034	2.08	0.038	0.004	0.138
TOTAL_HHS	-0.007	0.003	-2.67	0.008	-0.016	-0.002
HH_WAGESS3	0.152	0.080	1.89	0.058	-.005	0.308
FWA	-0.485	0.163	-2.98	0.003	-0.804	-0.166
_Cons	0.146	0.263	0.55	0.581	-0.371	0.662

Source: Researchers' estimation using STATA

The sensitivity analysis for Senegal employed Direct Nearest Neighbour Matching (DNM) with four nearest neighbours using propensity score matching to evaluate how climate change and other factors influence food consumption. Households exposed to climate change were matched with similar non-exposed ones based on covariates including food purchases, household size, wages, and female agricultural wage earners. The model fit was statistically significant (LR $chi^2(5) = 25.73$, $p = 0.0001$), with a pseudo-R^2 of 0.024, indicating modest explanatory power. Climate change exposure had a marginally significant positive effect ($\beta = 0.946$), suggesting that adaptation support may boost consumption. Food purchases positively impacted consumption ($\beta = 0.071$, $p = 0.038$), emphasising the role of market access. Larger households were associated with lower per capita consumption ($\beta = -0.007$, $p = 0.008$), highlighting resource constraints. Household wages showed a marginal positive effect, while the presence of female agricultural wage earners ($\beta = -0.485$, $p = 0.003$) significantly improved food consumption, underscoring the importance of women's economic empowerment.

3.5 Results from Qualitative Data

Keur Matar Community in the Thiès Region, Senegal

The field visit to *Keur Matar* in Senegal's Thiès Region offered rich insights into the climate-induced transformation of rural livelihoods and food systems. The focus group discussion revealed a major occupational shift: men have gradually abandoned farming due to declining profitability, leaving women to take on the core agricultural responsibilities. This role reversal was driven by climate-related stressors notably drought, erratic rainfall, and rising temperatures as well as market challenges, including competition from large-scale commercial farms equipped with advanced technology. Participants highlighted how soil dryness, pest infestations, and unreliable rainfall have made farming unsustainable. As a result, men are seeking alternative livelihoods in urban areas or informal sectors. Meanwhile, women now handle the full farming cycle planting, managing and harvesting—despite lacking equal access to resources, leading to greater gendered burdens.

Farmers expressed deep climate change awareness, citing personal experiences of bushfires, prolonged drought, *and* flash floods. Specific pests, such as "the red insect" and "soya", were linked to rising

temperatures, worsening crop losses. Extreme heat has also depleted groundwater, forcing deeper and often fruitless well digging. Wealthier farms dominate water access through pumps and irrigation systems, further marginalising smallholders. The *s*ocio-economic effects were stark, farming income has dropped drastically, especially for women. Earnings once as high as 200,000 CFA Francs now average between 50,000 and 70,000. With reduced yields, families often consume most of their produce, leaving little for market sales and making it difficult to purchase diverse foods. This shift has negatively affected food security, particularly for women and children, who experience limited access to both quantity and variety in diets.

Despite their efforts—manual watering, pesticide use (*e.g., Métafoss*), and crop diversification—farmers lack the infrastructure and capital to adapt effectively. Water scarcity, lack of cold storage, *and* market exclusion by large-scale agribusiness remain major barriers. Furthermore, government and NGO support is often inconsistent and insufficient, failing to address their urgent needs. The Community suffered a significant bushfire in 2015 which hastened the decision of male farmers to abandon farming for other viable jobs. Though this is not a reoccurring situation but left farmers highly vulnerable. Farmers also noted occasional flash floods but stressed that the predominant issue is the prolonged dry seasons (drought). Historically predictable rainfall patterns have become erratic, leaving crops under watered and exposed to extreme heat.

« L'agriculteur G a réitéré que la hausse des températures a entraîné une augmentation des ravageurs, tels que les criquets et des insectes spécifiques comme l'« insecte rouge » et le « soja », qui ciblent les oignons et d'autres cultures. Les problèmes liés à l'humidité aggravent encore les maladies des cultures, en particulier celles des légumineuses, entraînant une baisse des rendements malgré l'utilisation de pesticides »

'Farmer G reiterated that rising temperatures have led to an increase in pests, such as locusts and specific insects like the "red insect" and "soya," which target onions and other crops. Humidity-related issues further exacerbate crop diseases, particularly in legumes, leading to lower yields despite pesticide use.

Gendered Impacts of Climate Change

The women in Keur community highlighted the disproportionate burden they face due to climate change: Women, who are primary caregivers and farmers have seen their income drop drastically. Earnings that once reached 100,000–200,000 CFA Francs now struggle to reach 50,000–70,000 CFA Francs, as most produce is consumed at home rather than sold. Women now manage both farming and household responsibilities, which are intensified by reduced yields and food shortages. To cope and rebuild, farmers recommended irrigation infrastructure, climate-smart seeds, storage facilities, and subsidies. They also called for training on sustainable practices, gender-responsive policies, and regulations to ensure fair competition. Their experiences underline that climate change is reshaping rural livelihoods and women are at the frontline of adaptation yet continue to face structural constraints. Comprehensive and inclusive interventions are urgently needed to safeguard food security and promote resilience.

3.6 Results from Geospatial Analysis

The results from the geospatial analysis shows a graphical representation of climate change (precipitation, temperature, humidity) and the extent of climate change impact on food production across various states within Senegal

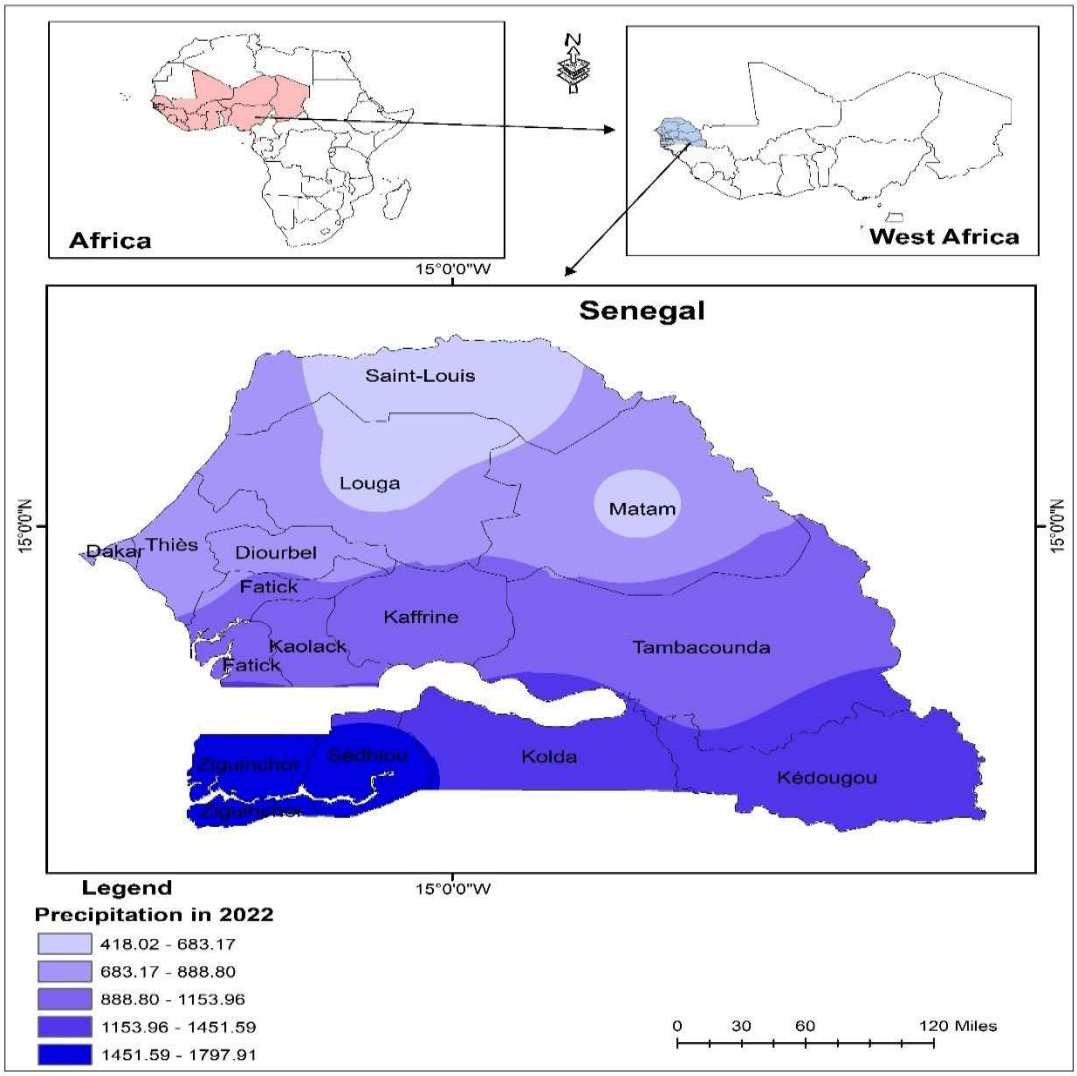

Figure V: Geospatial representation of Precipitation in Senegal (source: Authors Computation)

Figure V presents the spatial distribution of annual rainfall across Senegal in 2022. The highest rainfall totals up to 1797 mm were recorded in the southern regions, particularly in areas such as Sédhiou, Ziguinchor, Kolda, and Kédougou. In contrast, the northern parts of the country, including Saint-Louis, Louga, and Matam, experienced significantly lower rainfall, averaging between 418 mm and 683 mm. This north-south gradient reflects a pronounced climatic disparity, with southern Senegal being more conducive to rain-fed agriculture, while northern regions face a higher risk of drought and water scarcity.

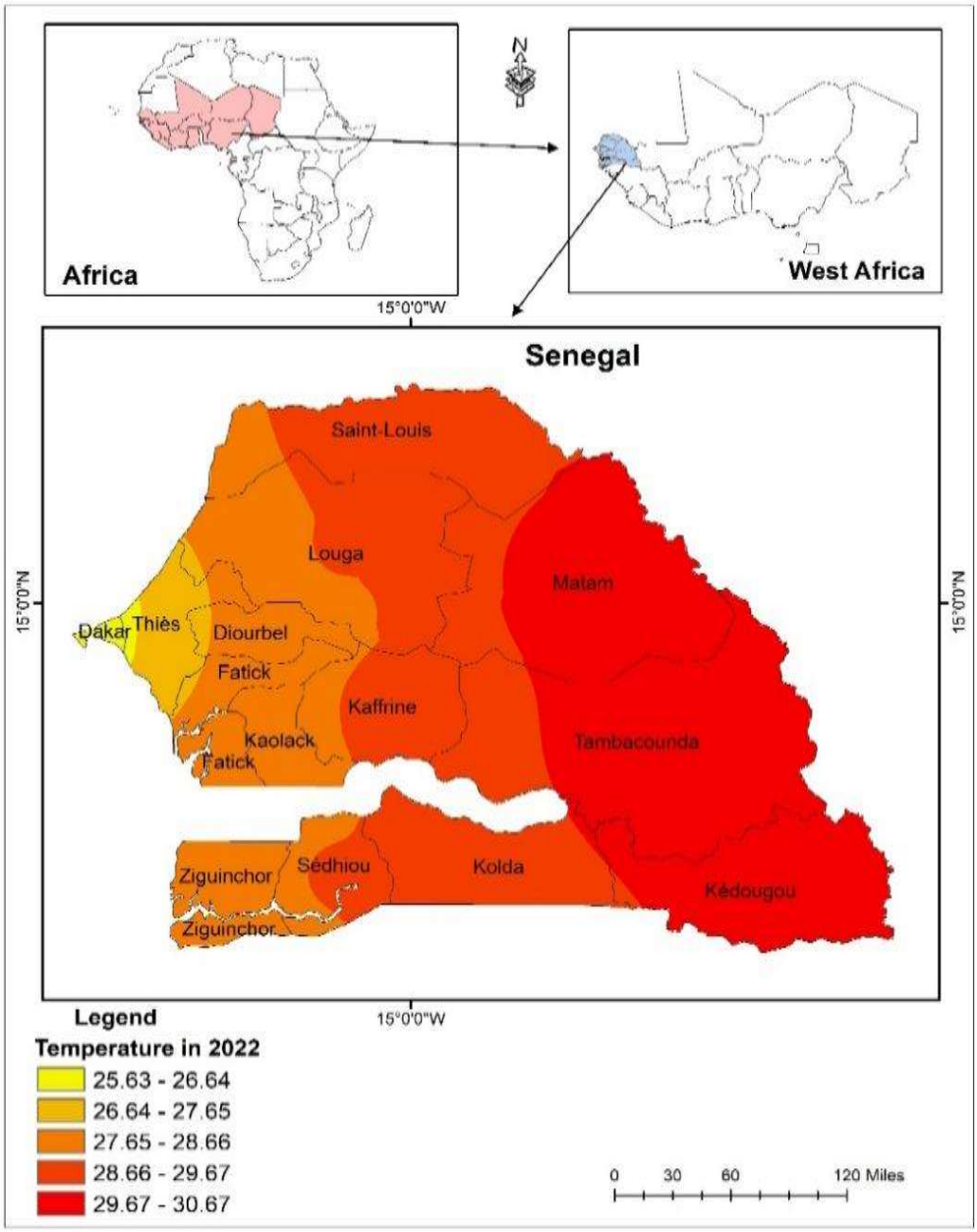

Figure VI: Geospatial representation of Temperature in Senegal

The annual temperature distribution of Senegal in 2022, as illustrated in Figure VI, ranges from approximately 25.0°C to 30.67°C. The highest temperatures were recorded in Matam, Kédougou, and Tambacounda, while lower temperatures were observed in Dakar, Thiès, and Fatick. Senegal's temperature pattern is generally similar in spatial variation; however, Senegal recorded slightly higher average temperatures. This elevated temperature range, particularly in the interior regions, may intensify evapotranspiration rates and place additional stress on agricultural systems, especially under rain-fed conditions, with potential implications for food security.

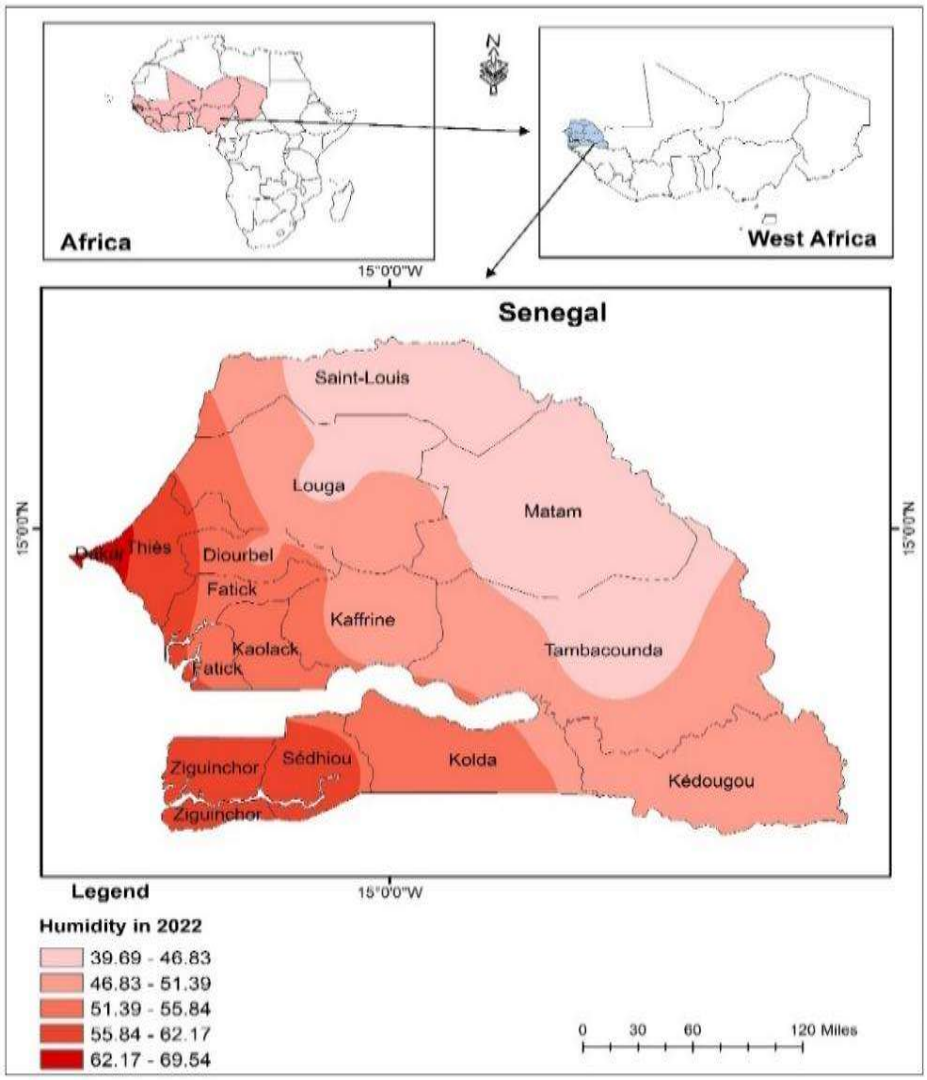

Figure VII Geospatial representation of Humidity in Senegal

The annual humidity levels in Senegal for the year 2022 ranged from approximately 39% in the northern regions such as Saint-Louis, Matam, and Louga to about 62% in the southwestern areas, including Thiès, Dakar, and Diourbel. The spatial pattern reveals a marked north-south humidity gradient, with drier conditions prevailing in the north. Low humidity levels, particularly in the northern regions, can adversely affect agricultural productivity by increasing evapotranspiration and reducing soil moisture availability.

3.6 Discussion of Key Findings

This study investigated the interplay between climate change, household livelihoods and food security in Senegal, with a gender-sensitive lens. The analysis combined quantitative, qualitative, and geospatial data to offer a holistic understanding of the climate-food security nexus. Across all three dimensions, the results consistently reveal how socio-economic inequalities, climate vulnerability and gender disparities shape food consumption patterns and resilience strategies.

Quantitative Discussion

The quantitative results highlight significant socio-economic drivers of food consumption under climate stress. Surprisingly, households exposed to climate shocks reported marginally higher food consumption

levels. While initially counterintuitive, this result suggests that targeted coping mechanisms such as safety nets, agricultural extension services, and emergency support—may effectively offset immediate food security risks. This finding reinforces the importance of climate-responsive safety net programs that enable affected households to maintain or even improve food access amidst adversity. Household wages and food purchases emerged as major positive determinants of food consumption, confirming the central role of income and market access. This underscores the need to expand livelihood opportunities and improve food affordability through income-enhancing strategies. Conversely, larger households experienced lower per capita consumption, likely due to stretched resources. These findings emphasize the importance of targeting larger households for nutritional and income support to ensure intra-household food equity.

The negative impact of reduced female agricultural wage participation on food consumption is a vital point in the study. This points to the critical role of women's economic empowerment in enhancing household food security. Addressing gender based wage gaps and providing support such as childcare services, land access and skill training for female farmers are essential for boosting food resilience. The matching analysis further reinforces the importance of accounting for household heterogeneity in designing and evaluating food and climate interventions. These findings are consistent with previous studies from West Africa (Ani, 2022; Ahmed et al., 2024; Njoroge et al., 2023; Odey et al., 2024), which link climate vulnerability to gendered food insecurity. In contrast to European contexts (SÎLI et al., 2020), where climate impacts are buffered by stronger institutional safety nets, Senegal's case underscores the importance of tailored, gender-sensitive, and resilience-building policies to address systemic vulnerability.

Qualitative Discussion

The qualitative insights from Keur Matar in the Thiès region provide rich context to the numerical findings. Focus group discussions revealed that climate change has transformed rural livelihoods and intensified gendered burdens. As male farmers increasingly abandon agriculture due to declining profitability and climate-induced stressors, women have assumed full farming responsibilities. However, this shift has not been accompanied by corresponding access to resources, training, or infrastructure, exacerbating their vulnerability. Farmers reported increasing drought, erratic rainfall, pest invasions, and soil degradation as major threats. These environmental changes, compounded by economic marginalization from commercial farms and limited government support, have pushed households to consume most of their crops, reducing dietary diversity and income. Female farmers, in particular, experience drastic income declines—down from 100,000–200,000 CFA Francs to 50,000–70,000 intensifying food insecurity for women and children. Despite their resilience through manual watering, pesticide use (e.g., Métafoss), and crop diversification women farmers remain constrained by water scarcity, lack of cold storage, and exclusion from profitable markets. Participants called for irrigation infrastructure, storage solutions, gender-sensitive policies, and capacity-building programs to improve adaptive capacity. These narratives affirm that women are central to food production and adaptation, yet remain structurally disadvantaged. Studies of Ahmed et al, 2021, MacCarthy et al, (2021), Brown, 2008, aligns with the findings of the study.

Geospatial Discussion

The geospatial analysis deepens our understanding of climate vulnerability by visualizing spatial disparities in rainfall, temperature, and humidity. The 2022 rainfall distribution shows a clear north-south gradient with southern regions like Sédhiou and Kédougou receiving up to 1797 mm of rainfall conditions more favorable to rain-fed agriculture, while northern areas like Saint-Louis and Matam faced arid conditions with as little as 418 mm of rain. These regional differences align with reported agricultural productivity and food security disparities in the both the quantitative and qualitative results. Temperature and humidity maps also reflect stress patterns. Interior regions recorded higher temperatures (up to 30.67°C) which heighten evapotranspiration and reduce soil moisture. Low humidity levels in the north (as low as 39%) further stress crops and intensify drought conditions. These spatial patterns underscore the vulnerability of northern Senegal and the need for region-specific interventions such as drought-resistant crops, efficient irrigation systems, and humidity control techniques.

Together, the findings show that climate change significantly impacts food security in Senegal, with gender playing critical roles. Women's disproportionate burden, regional climate disparities, and income-related food access must be central to policy responses. Strengthening gender equity, climate resilience and localized interventions is essential for building sustainable and inclusive food systems.

4.0 Conclusion and Recommendations

This study offers vital insights into the climate change, livelihood and food security nexus in Senegal, with a particular focus on female-headed households. By adopting a mixed-methods approach that integrates regression analysis, propensity score matching, and qualitative data from focus groups and interviews, the study reveals how climate change affects household food security through both direct and indirect pathways. In Senegal, the indirect effects such as inflation, market disruptions, and reduced incomes were more influential in shaping food consumption patterns than the direct impact of climate events. This distinction underscores the need for broader systemic responses that go beyond climate resilience to encompass market and livelihood reforms.

Key contributions include the gender-disaggregated findings which shows that while female agricultural wage earners significantly improve household food outcomes, they continue to face systemic barriers such as poor access to land, credit, and fair wages. This aligns with the Statement of Research Problem (SORP), filling a notable gap in the empirical literature on gender and climate vulnerability. The study also highlights that larger households in Senegal tend to experience greater food insecurity under climate stress. This insight supports targeted social protection programs sensitive to household composition and local context. Importantly, the research finds that households engaged in climate adaptation initiatives such as receiving early warning information, food aid, or extension services fared better in food consumption metrics. This confirms the importance of proactive, well-targeted interventions. The study's emphasis on livelihood diversification, equitable income opportunities, and market-based resilience offers a comprehensive policy pathway aligned with the Sustainable Development Goals, particularly SDGs 2 and 13. Overall, this work contributes to the theoretical and practical understanding of climate vulnerability in Senegal and reinforces the call for gender-inclusive, evidence-based climate adaptation strategies.

Based on the empirical findings from Senegal, this study recommends comprehensive, multi-sectoral strategies to build household resilience and improve food security under climate stress. Priority should be given to promoting climate-smart agriculture, including drought-tolerant crops, sustainable water use practices, and the expansion of early-warning systems. Investments in water infrastructure such as dams, boreholes, and affordable, solar-powered irrigation systems are critical, particularly in rural farming areas facing persistent drought. Community-managed irrigation schemes can ensure equitable access and sustainability. Improving market access and stabilising food prices are equally vital. Policies should support food subsidies, enhance rural transport and storage infrastructure, and provide emergency aid—such as cash transfers and food support—for households in climate-vulnerable zones. Women's empowerment must be central to agricultural and food security policies. This includes expanding access to land, credit, childcare, and vocational training, while addressing wage disparities and structural barriers to participation. Households should be supported in diversifying income sources beyond agriculture through rural employment programs and micro-enterprise development. Special attention should also be given to larger households that face intensified food insecurity due to greater resource demand.

Future research should apply newer waves of data and other evaluation methods such as difference-in-difference and endogenous switching regression to complementing the finding in this present study. Further studies should include other climate-impacted West African countries such as Burkina Faso and Niger for broader regional comparisons. In addition, emerging threats like banditry and insurgency, which impact food systems, require urgent research attention. There is also a need to investigate intra-household food security dynamics, urban farming under climate stress, and the role of community-level mitigation

strategies. Exploring these areas will deepen the understanding of food insecurity and inform more targeted, context-specific policy responses for Senegal and similar West African contexts.

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