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SPECIAL ISSUE: CELEBRATING 20 YEARS OF GEOGRAPHY IN KADUNA STATE UNIVERSITY - ADVANCES AND FRONTIERS IN GEOGRAPHY

Evaluating Farmers' Perspectives and Adaptive Responses to Climate Variability in Bauchi Local Government Area, Bauchi State, Nigeria

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ABSTRACT

Climate variability poses significant challenges to agricultural productivity and rural livelihoods, especially in regions dependent on rain-fed farming. Understanding farmers' perceptions and responses in Bauchi is vital for designing effective adaptation strategies. This study evaluated farmers' perceptions of and strategies for adapting to climate variability in the Bauchi Local Government Area (LGA), Bauchi State, Nigeria. Rainfall data (mm) spanning 41 years (1981-2022) were obtained from the Nigerian Meteorological Agency, while demographic and perception data were collected through questionnaires and focus group discussions. Rainfall trends were analysed via regression analysis, while demographic and perception data were examined with tables, pie charts, and percentages. The results revealed an increasing trend in rainfall. Most respondents (85.6%) believed that human activities contributed to climate variability; 11.1% disagreed, and 3.3% were neutral. Furthermore, 74.4% reported a decrease in crop yield due to climate variability, whereas 17.8% disagreed and 7.8% were neutral. Increased rainfall was identified as a sign of climate variability. The respondents experienced adverse impacts on crop production and livelihoods, leading to reduced outputs and higher food costs. Coping strategies included early planting, improved crop varieties, and irrigation facilities. Access to credit, information, and training can enhance farmers' resilience and sustain productivity under changing climatic conditions.

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1 Introduction

Recent scientific research has demonstrated a continuous rise in atmospheric greenhouse gas (GHG) concentrations (Intergovernmental Panel on Climate Change, 2022). This increasing trend in GHG levels has contributed to an increase in global average temperatures and altered the quantity and geographic distribution of precipitation (IPCC, 2023). Under the most severe projections, global temperatures could rise by 2.5 °C to 3.2 °C by 2100, accompanied by a 9% to 27% reduction in rainfall (IPCC, 2014). The accelerating pace of climate change represents a pressing global issue and a serious threat in the current century (Ali & Hassan, 2023). Its impacts extend across critical sectors, jeopardizing water resources, public health, agricultural productivity, and food security (Ankrah et al., 2023; File et al., 2023).

These challenges are particularly acute in Sub-Saharan Africa and the broader African continent, where smallholder farmers often lack the capacity to respond effectively to the growing risks associated with climate change (Ali & Hassan, 2023). As one moves from the equator, the climate shifts to subtropical and Mediterranean climates, which are distinguished by more noticeable seasonal fluctuations and mild temperatures (Nicholson, 2013).

The largest hot desert in the world, the Sahara Desert, is found in northern Africa and significantly impacts the area's climate. The Sahara continues to dominate North Africa's climate, with extreme aridity and summer temperatures often surpassing 40 °C (Tian et al., 2023; NASA, 2024). The comparatively low and irregular rainfall in this desert-to-savanna transitional zone causes droughts, floods, and problems with desertification. Since changing rainfall patterns and rising temperatures affect agricultural output and exacerbate food poverty, the Sahel area has been susceptible to the effects of climate change (Nicholson, 2013).

Farmers are not only associated with poverty, but also due to the great uncertainty about the impact and magnitude of climate variability. Krishnamurthy et al. (2014) show a high correlation between hunger and climate risk, especially for areas most affected by food insecurity. The analysis describes the impact of climate on crop yields, provides a multidimensional analysis of vulnerability, and shows the vital role of adaptive capacities of farming households in reducing vulnerability. Exposure to climate variability and the increasing intensity of extreme weather events, such as droughts and frequent floods, will exacerbate many of the challenges farmers face. Exposure to climate variability

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and extremes, especially drought and floods, pose a risk to people living in areas of marginal land quality. Some interventions on land use, livelihoods, and environmental management systems have been developed to enable households to build resilience to stress from drought, flooding, and other climate variations (Mbae, 2014).

Climate variability and its associated effects can cause stress (small-scale disturbances to livelihoods) or crises (large-scale, rare, and unpredictable disturbances with direct impacts on livelihoods) (Scoones, 1988). Human resources play a crucial role in adapting to climate variability, as they influence the strategy and adaptability that farming households will employ. Adaptation efforts in the agricultural sector are critical to national development, given the large number of people working in the industry, both as farmers and farm laborers. The focus on agricultural growth is expected to contribute to food availability.

Therefore, this study evaluated how farmers in Bauchi LGA, Bauchi State, Nigeria, perceive and respond to climatic variability. The goals are to assess farmers' perceptions of climatic variability, examine how agricultural output in the study region is affected by it, and examine the coping mechanisms used by farmers in the study region.

2 Materials and Methods

2.1 Study Area

The Bauchi Local Government Area (LGA) is in Bauchi State, northeastern Nigeria. The city of Bauchi, founded in the early 19th century, is an administrative and commercial hub noted for its history and trade (Bachama et al., 2020). Located between latitudes 10°17′N – 10°22′N and longitudes 9°49′E–9.817°E, it borders Toro, Alkaleri, and Dass LGAs. At approximately 620 m above sea level, Bauchi is a major urban centre with schools, markets, hospitals, and government offices (Adamu et al., 2015; Mohammed & Ahmed, 2018).

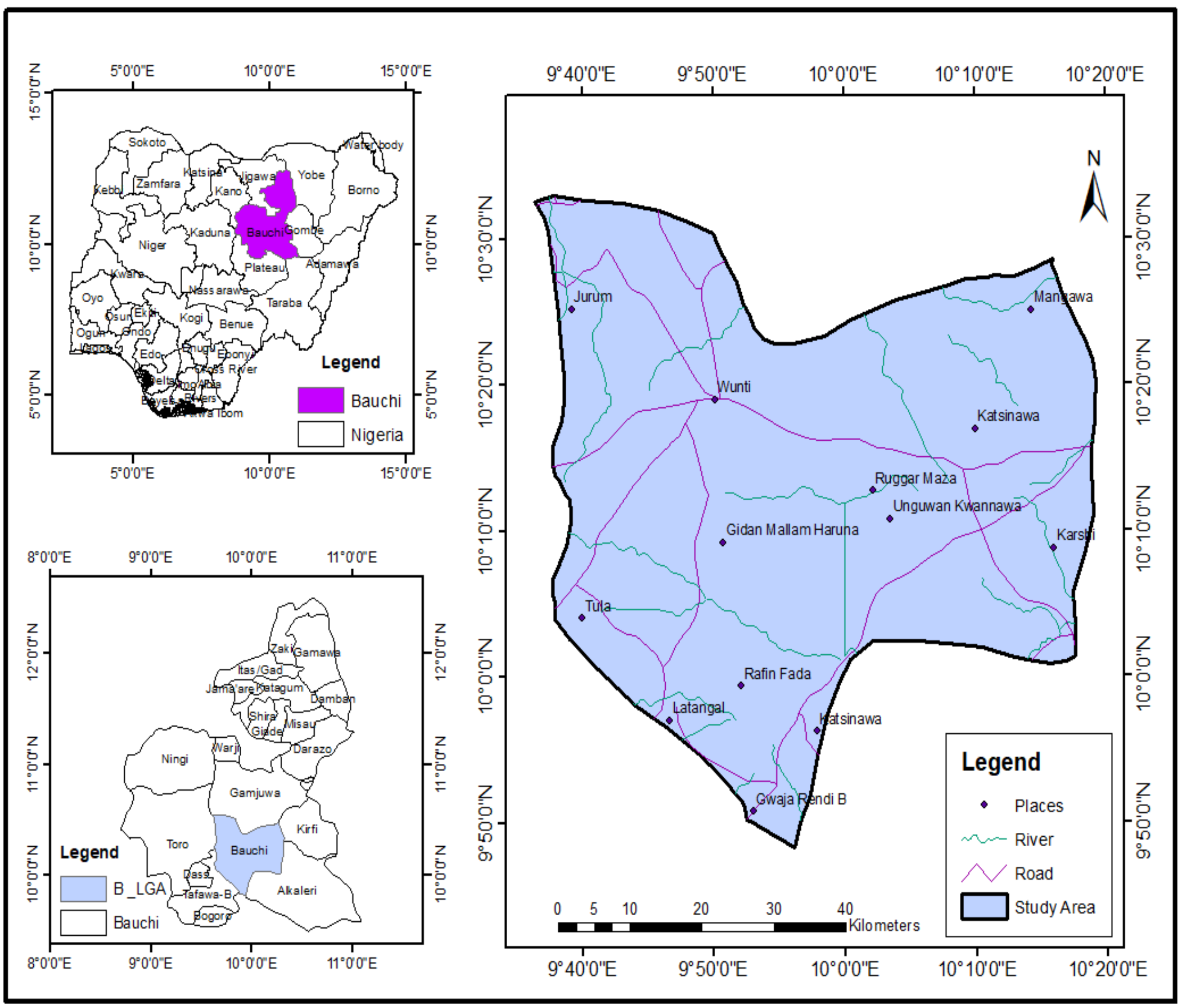

Figure 1: Study area
Source: Gombe Geographic Information Service

The relief of Bauchi LGA is undulating, with elevations ranging from 500-700 m above sea level (Adewuyi et al., 2017). Plains and gentle hills shape their drainage, with seasonal rivers such as the Gongola, which feeds the Benue. These water bodies support agriculture, especially during the rainy season, by providing irrigation (Usman et al., 2020). Geologically, Bauchi LGA lies on basement complex rocks such as granites and gneisses of the Nigerian Precambrian Shield. The soils are mainly sandy loam, which is fertile in lowlands due to alluvial deposits but shallow and less productive in uplands, requiring careful management (Adamu & Mohammed, 2016). The population is diverse, dominated by Hausa and Fulani, with Sayawa and Kanuri minorities. Agriculture is central to the economy, with crops such as millet, bambaranuts, maize, groundnut, and sorghum widely cultivated. The vegetation belongs to the Sudan savanna zone and features grasses, shrubs, and scattered trees such as Acacia, neem (*Azadirachta indica*), and baobab (*Adansonia digitata*). Farming has altered natural vegetation, leaving cultivated fields interspersed with patches of native cover (Moses, 2020).

2.2 Data sources

The primary data for the study were sourced from a set of questionnaires administered to farmers, in addition to focus group discussions (FGDs) scheduled with elderly farmers. The questionnaire was set with alternative answers devised for a survey or statistical study. The questionnaire was specifically administered in areas that were selected during the research. Climate data, such as the rainfall amount from the Nigerian Meteorological Agency for forty-one years (1981–2022), were used.

2.3 Sampling Procedure

Three areas of Bauchi LGA, Wunti, Jahun, and Dungal, were purposively selected because they represent communities highly dependent on rain-fed agriculture and are particularly vulnerable to climate variability. Purposive sampling is widely recognized as appropriate when specific populations are most relevant to the research objectives (Scribbr, 2022; Hassan, 2024). Similar climate perception studies have employed purposive sampling to capture information-rich cases and ensure diversity in responses (Mudassir & Maiwada, 2021; Arora et al., 2022). A total of 90 questionnaires were administered, with 30 in each area, to provide balanced representation and enable comparative analysis of farmers' perceptions and adaptation strategies.

2.4 Data analysis

Climate data analysis: Climate data (rainfall amount in mm, 1981–2022) were analysed via trend analysis through linear regression to determine the direction and magnitude of rainfall changes over time. The regression model applied is shown in Equation (1).

$$Y_t = \beta_0 + \beta_1 t + Ɇ \quad (1)$$

where: Y_t = rainfall in year (t)
β_0 = intercept
β_1 = slope (trend coefficient)
Ɇ = error term

Statistical analysis was conducted via Microsoft Excel, which generated regression outputs and trend line plots. The questionnaire responses were analysed via descriptive statistics (frequency counts, percentages, and proportions). The data were coded and entered into Excel for analysis. The formula for percentage calculation is given in Equation (2).

$$Percentage = \frac{No.of\ respondents\ in\ category}{Total\ no.of\ respondents} * 100 \quad (2)$$

The results are presented in tables, pie charts, and bar charts to illustrate farmers' perceptions and adaptation strategies. Microsoft Excel was used for data entry, coding, regression analysis, and graphical representation (pie charts, bar charts, trend lines).

3 Results and Discussion

Figure 2 shows a linear regression of the rainfall trend in the study area. In contrast, 2009-2022 experienced high variability. As annual rainfall has increased, crop yields are also expected to increase if other crop production factors are favourable.

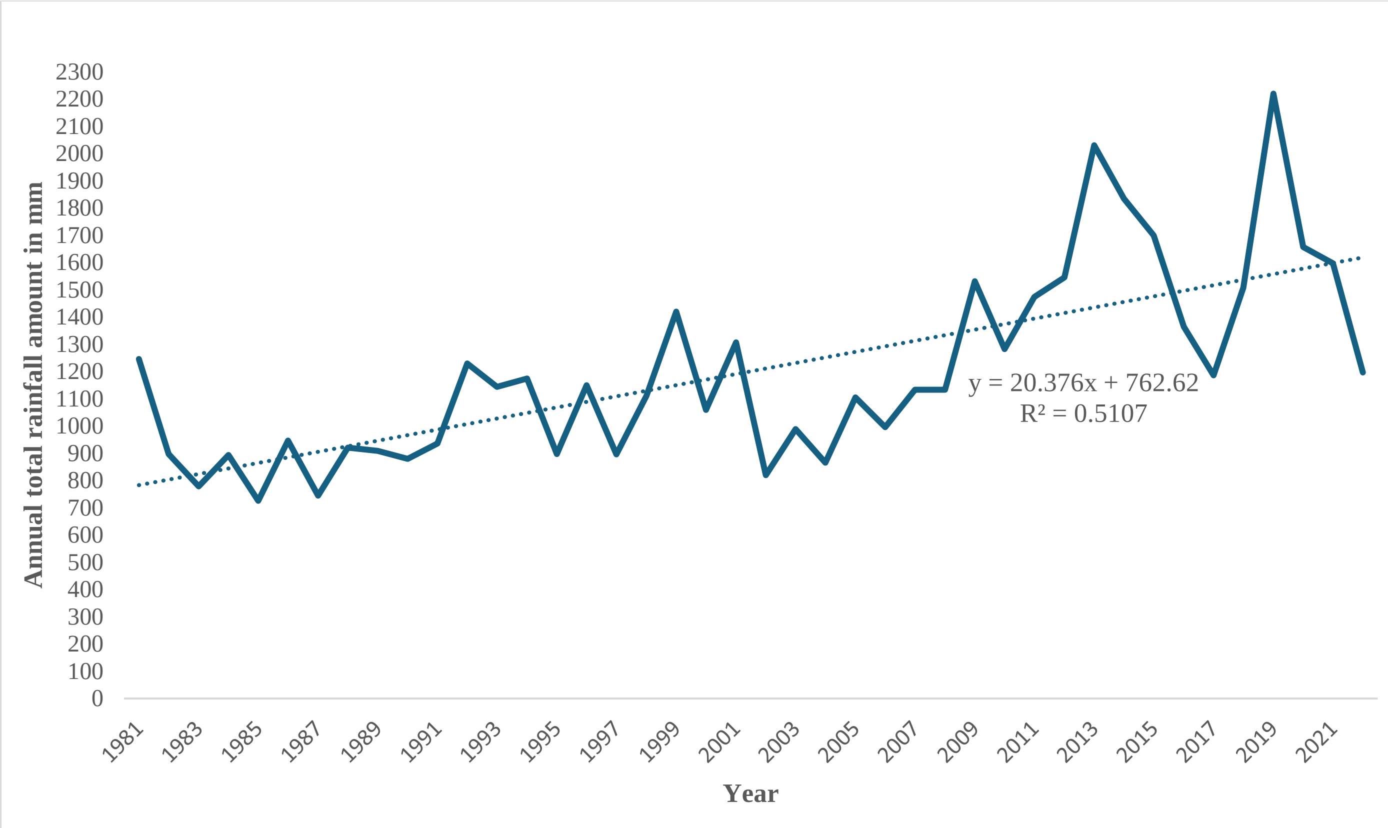

Figure 2: Annual total rainfall from 1981 to 2022

Time series analysis revealed an increase in the rainfall trend, with the year-to-year data contributing 5.1% to its increase, whereas other factors (shift in the climatic belt, deforestation, and overgrazing) were responsible for 94.9% of the increase. Moreover, this increase is inconsistent, as variability is observed in the results. In 1981, the amount of rainfall was 1245.8 mm, which increased to its peak in 2019 (2219.5 mm) and then decreased to 1196.5 mm in 2022. Rainfall variability seemed to be moderate between 1981 and 2008. The rainfall trend in the study area tends to increase. This increase might be due to climate change. Ibrahim and Mohammed (2015) reported significant increases in temperature across northern Nigeria, confirming evidence of global warming in the region. Similarly, Ahmed and Murtala (2019) reported shifts in rainfall patterns in Sokoto State, highlighting climate variability as another indicator of climate change in extreme northern Nigeria. Together, these findings reinforce the broader trend of rising temperatures and changing rainfall regimes across northern Nigeria and agree with the findings of this research. By implication, Bauchi is vulnerable to flooding and ecosystem change, which has a detrimental effect on agricultural produce, thereby leading to decreased crop yield and food scarcity.

Table 1 provides a summary of the socioeconomic characteristics of the respondents in Bauchi State. The indicators include gender, age distribution, marital status, educational level, farming type, and experience.

Table 1: Demographic characteristics of the respondents in Bauchi LGA

Gender	Frequency (f)	Percentage (%)
Male	62	75.6
Female	28	24.4
Age (Years)		
Less than 20	15	16.7
21-30	23	25.6
31-40	16	17.8
41-50	14	15.6
50 and above	22	24.4
Marital status		
Single	30	33.3
Married	53	58.9
Divorce	4	4.4
Widow	1	1.1
Widower	2	2.2
Educational Level		
Primary	3	3.3
Secondary	53	58.9
Tertiary	20	22.2
None	14	15.6
Type of Farming		
Commercial	47	52.2
Subsistence	43	47.8
Years of Experience		
1-10	49	54.4
11-20	33	36.7
20 and above	8	8.9

Important demographic patterns among respondents from Bauchi LGA are shown in Table 1. A total of 75.6% of the sample consisted of male respondents, indicating a possible gender bias in agricultural representation in this area. Given that males frequently predominate in conversations about resource management and farming practices, this discrepancy may impact the decision-making processes associated with climate adaptation methods (FAO, 2011). Owing to their lower percentage (24.4%) in agricultural areas, women's viewpoints on climate change may be underrepresented or ignored. According to the respondents' age distribution, 25.6% of the farmers polled were younger (aged 21-30). Their relatively low number raises questions regarding knowledge transmission from older generations. This group is critical since young participation can result in creative methods for adaptation measures (World Bank, 2020). A significant proportion of people over 50 years of age (24.4%) indicates a wealth of expertise that might be used to create successful adaptation strategies. On the other hand, the middle-aged groups (those aged 31–40 and 41–50) make up a lower percentage of the sample (33.4%), which suggests a possible lack of expertise throughout crucial stages of agricultural production.

The results highlight how crucial it is to comprehend demographic features when evaluating farmers' attitudes and methods of adaptation to climatic unpredictability. Farming communities in Bauchi State may become more resilient with a more inclusive strategy that incorporates people of all ages and genders. By encouraging cooperation among various groups, local farming methods can benefit from a range of viewpoints and experiences, increasing a region's overall ability to adapt to climate change. This evaluation concludes that resolving demographic inequalities is critical to developing successful adaptation strategies among farmers confronting climate variability and that ensuring that the voices of women and men are heard, as well as the perspectives of various age groups, can result in sustainable farming practices that are adapted to reduce climate impacts. The relationships between marital status and farmers' perceptions of climate variability, as well as their adaptation strategies, constitute a significant area of inquiry in agricultural studies. Table 1 indicates that 58.9% of the respondents were married, whereas 33.3% identified as single; the minority were divorced (4.4%), widowed (1.1%), and separated (2.2%).

Understanding how these demographic factors influence adaptation strategies is crucial for formulating effective policies aimed at enhancing resilience among farming communities. Married individuals often possess a more extensive support network, which can facilitate information sharing and collaborative adaptation efforts in response to climatic changes (Hassan & Nhemachena, 2008). A married couple may decide to allocate resources for climate-resilient crops and technologies together or adopt more varied agricultural methods because of their shared responsibilities. On the other hand, single farmers could experience difficulties that limit their ability to adapt. Their capacity to put effective solutions against climate variability into practice may be hampered by limited access to networks and resources (Bryan et al., 2013). The sample's high percentage of widows and divorces emphasizes the different levels of vulnerability that people experience based on their marital status. Additionally, research to date indicates that social cohesiveness is essential to community-level responses to environmental stresses (Adger, 2000). Stronger social links that facilitate access to vital knowledge about climate trends and adaptation measures, as well as emotional support, may be advantageous for married respondents.

The relationship between educational attainment and farmers' perceptions of climate variability plays a significant role in shaping effective adaptation strategies, as shown in Table 1. The findings indicate diverse educational backgrounds among respondents, with 58.9% possessing secondary education, 22.2% holding tertiary or university qualifications, 15.6% having no formal education, and only 3.3% having completed primary education. The predominance of individuals with secondary education suggests that this level of schooling may provide essential knowledge about agricultural practices and environmental issues (Davis et al., 2017). Secondary education typically equips individuals with critical thinking skills, enabling them to assess climate-related challenges effectively and adopt informed strategies for adaptation (Mastrorillo et al., 2016). Compared with those without formal education, this group is likely better positioned to access information on sustainable practices because of their foundational knowledge. In contrast, the small percentage of respondents with tertiary or university qualifications (22.2%) highlights an opportunity for advanced training in agricultural science and climate-related studies, as observed by Wheeler and von Braun (2013). These individuals may have more extensive exposure to research-driven approaches toward adaptation strategies, an essential factor as agriculture increasingly grapples with the impacts of climate change.

Moreover, the findings revealed a concerning proportion of participants lacking formal educational credentials, 15.6% without any formal schooling, indicating potential barriers to accessing crucial information about the effects of climate variability on farming activities (Hassan & Nhemachena, 2008). This gap underscores the need for targeted interventions that educate underprivileged communities on sustainable agricultural practices amid changing climatic conditions.

The farming activities of the respondents were split, with 52.2% engaged in commercial farming and 47.8% practicing subsistence farming, suggesting varying economic objectives among respondents. Commercial farmers typically focus on producing crops or livestock for sale rather than personal consumption; this distinction is crucial from both an economic development perspective and a rural policy formulation. Engagement in commercial agriculture can lead to increased income opportunities, while subsistence farmers often operate under different constraints, whereby their primary goal is meeting household food needs (Barrett et al., 2001).

The split between these two types may suggest a transition phase within this demographic's approach toward agriculture; a move toward commercialization could signify broader trends in market access or infrastructural support from local governments or NGOs aiming at enhancing food security through diversified income sources. In terms of farming experience, over half (54.4%) had 1-10 years, 36.7% had 11-20 years, and 8.9% had over 20 years of experience. This distribution raises questions about continuity within family farms versus new entrants into agricultural practices, factors often tied closely to generational shifts, as younger individuals adopt more modern techniques than older generations do, who may rely on traditional methods (Raghuvanshi et al., 2010).

Figure 3 presents the respondents' awareness of the climate effects and variability in the climate in the study area.

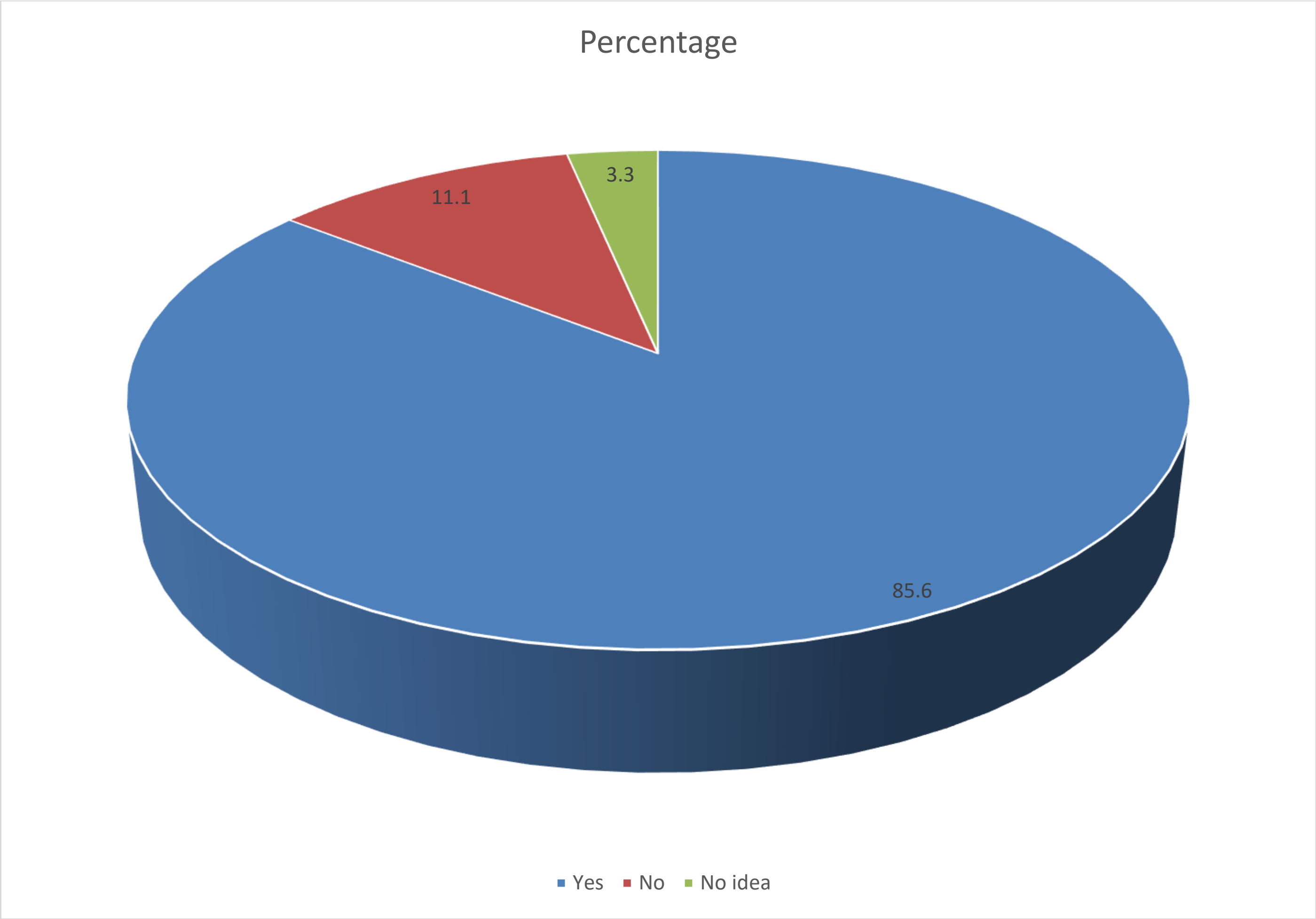

Figure 3: Respondent awareness of changes, effects, and variability in climate in the study area

The results in Figure 3 show that most respondents (85.6%) believe that human activities can cause climate variability. Only 11.1% of the respondents said "no," indicating that they do not think that human activities can cause climate variability. A small percentage (3.3%) reported having "no idea" about this issue. These findings suggest a high level of awareness among the respondents regarding the role of human activities in driving climate variability. This finding is in accordance with those of the Center for Climate and Social Transformations (CAST, 2023), where a multicountry survey (UK, Brazil, China, Sweden) revealed that a large majority of participants support climate action and recognize human influence on climate change, reinforcing high awareness.

Table 2 presents the respondents' views regarding climate variability in the study area.

Table 2: Perceived effects of climate variability on agricultural production

Influence of climate variability on crop production	Frequency (f)	Percentage (%)
Decrease yield	67	74.4
Increase yield	16	17.8
No idea	7	7.8

The results presented in Table 2 provide significant insights into farmers' perceptions of climate variability and its impact on agricultural productivity, with a particular focus on rice and maize production. The data indicate that a substantial majority, accounting for 74.4% of the respondents, believe that climate variability has adversely affected their crop yields. This perception aligns with the literature, which underscores the detrimental effects of climate change on agriculture, including shifts in precipitation patterns, increased temperatures, and extreme weather events (Lobell et al., 2011). The consensus among farmers about declining yields reflects a broader concern within the agricultural sector about food security, as changing climatic conditions pose challenges to traditional farming practices. Conversely, only 17.8% of the respondents noted increased crop yields attributed to climate variability. This statistic suggests that while some farmers may benefit from specific climatic changes, such as extended growing seasons or enhanced carbon dioxide (CO_2) levels, leading to higher photosynthesis rates (Long et al., 2006), the majority remain skeptical about whether such advantages outweigh the negative impacts they experience owing to unpredictable weather patterns. It is critical to recognize this disparity in perceptions, as it highlights varying adaptive capacities among different farming communities and questions the generalizability of positive outcomes associated with climate change.

A notable portion (7.8%) of the respondents expressed uncertainty regarding how climate variability has impacted their production capabilities, underscoring a potential gap in knowledge or awareness related to climatic influences among specific farmer demographics. Similar findings have been reported, where limited farmer awareness of climate dynamics highlights the need for targeted educational initiatives (Maddison, 2007).

4 Conclusion

This study highlights that while rainfall patterns in Bauchi are shifting under climate change pressures, sociodemographic imbalances and uneven adaptive capacities compound vulnerability. Strengthening resilience will require inclusive, education-driven, and socially networked strategies that integrate women, youth, and marginalized farmers into sustainable adaptation policies. Most farmers perceive climate variability as a major driver of declining rice and maize yields, underscoring widespread concern about food security. While a minority of reports yield gains and some express uncertainty, the findings highlight uneven adaptive capacities and the urgent need for targeted education and inclusive resilience strategies.

To safeguard food security and livelihoods in Bauchi, policies must prioritize inclusive, education-driven, and socially networked adaptation strategies. By integrating women, youth, and marginalized farmers into climate-smart agriculture, strengthening social networks, and investing in education and ecosystem management, Bauchi can build resilience against climate variability and ensure sustainable agricultural productivity.

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