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Impact of climate change on agriculture in Agatu local government area Benue state

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Abstract

Climate change poses a serious threat to agricultural productivity and food security in Nigeria, particularly in rural communities that depend heavily on rain-fed farming systems. This study examines the impact of climate change on agriculture and food security in Agatu Local Government Area of Benue State. Agatu is predominantly agrarian, with smallholder farmers relying on crops such as yam, cassava, maize, rice, and millet for subsistence and income. Using a mixed-method research design, the study combined household surveys, key informant interviews, and focus group discussions to assess farmers' experiences, adaptation strategies, and food security status. Quantitative data were analyzed using descriptive and inferential statistics, while qualitative data were examined through thematic analysis. The findings reveal that erratic rainfall, flooding, drought, and increased pest infestations are the most significant climate-related challenges affecting agricultural productivity in the area. Results further indicate widespread food insecurity, with the majority of households experiencing inadequate food availability, limited access, poor utilization, and unstable food supply throughout the year. Although farmers have adopted coping strategies such as crop diversification, early-maturing crop varieties, agroforestry, and cooperative farming, the use of improved irrigation systems remains limited due to high costs and lack of technical support. The study concludes that climate change has significantly undermined agricultural sustainability and food security in Agatu. It recommends the promotion of climate-smart agricultural practices, expansion of irrigation infrastructure, improved access to extension services, and supportive policies aimed at strengthening farmers' adaptive capacity and resilience to climate change.

Citation

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Introduction

1.1 Background of the Study

Climate change has become a global phenomenon with significant implications for various aspects of human and environmental systems. The agricultural sector, a vital component of human survival, is particularly vulnerable to the impacts of climate change due to its dependence on climatic factors such as rainfall, temperature, and humidity. According to the Intergovernmental Panel on Climate Change (IPCC, 2014), climate change poses serious risks to agricultural productivity, especially in developing countries where technological advancements and adaptive capacities are limited. In many developing countries, including Nigeria, agriculture forms the backbone of the economy, providing food, employment, and raw materials for industries (FAO, 2021).

The impacts of climate change on agriculture include changes in the timing and intensity of rainfall, increased frequency of extreme weather events such as droughts and floods, and a rise in average global temperatures (World Bank, 2018). These changes disrupt planting and harvesting cycles, reduce crop yields, and exacerbate food insecurity (UNEP, 2019). Nigeria, as one of the most populous nations in Africa, is particularly at risk due to its reliance on rain-fed agriculture and the limited availability of irrigation systems (IFPRI, 2017).

Agatu Local Government Area, located in Benue State, Nigeria, is predominantly agrarian, with the majority of its population engaged in subsistence farming. The area is known for its cultivation of crops such as yam, cassava, maize, and rice, which serve as staple foods for both the local population and other parts of the country (Benue State Ministry of Agriculture, 2020). Despite its agricultural potential, Agatu has not been immune to the adverse effects of climate change, which have led to declining crop yields, food insecurity, and economic instability. The erratic nature of rainfall, prolonged droughts, flooding, and rising temperatures have exacerbated the challenges faced by farmers in the region (NIMET, 2020).

Agatu Local Government Area (LGA) in Benue State, Nigeria, is predominantly agrarian, with most residents engaged in subsistence farming. The region is renowned for producing crops such as yam, cassava, maize, rice, beans, soybeans, sorghum, millet, beniseed, and melon, which serve as staple foods locally and nationally. Additionally, Agatu accounts for over 80% of fish production in Benue State's Zone 'C' (Achanya, 2021).

Despite its agricultural potential, Agatu faces significant challenges from climate change. Farmers in the area have reported irregular rainfall patterns, heavy floods, severe sunshine, high temperatures, and changes in the timing and duration of seasons. These climatic variations have adversely affected agriculture, resulting in flooded farmlands, crop failures, poor harvests, increased livestock mortality, and heightened pest and disease prevalence (Okoye et al., 2020).

To mitigate these challenges, there is a pressing need to utilize available water resources for irrigation, enabling year-round farming and enhancing crop yields and income. The region's floodplain, covering approximately 25,000 hectares underlain by recent alluvial deposits, offers opportunities for irrigation development (Ogunwale, 2018).

Furthermore, resource conflicts, particularly between farmers and herders, exacerbate the situation. Disputes over access to land and water often escalate into violence, worsened by climate-induced resource scarcity. For example, the cutting of trees for fish-smoking ovens threatens the local ecosystem, making shared resources even scarcer (Adebayo & Ayodele, 2019).

While Agatu LGA has significant agricultural potential, climate change and resource conflicts threaten food security and economic stability in the region. Addressing these challenges requires a multifaceted approach, including irrigation infrastructure development, sustainable land management practices, and conflict resolution mechanisms.

1.2 Statement of the Problem

The agricultural sector in Agatu Local Government Area faces mounting challenges due to climate variability and change. Farmers are grappling with declining crop yields, erratic growing seasons, and a surge in pests and diseases, which collectively undermine food production. These issues are further exacerbated by limited access to modern farming technologies, insufficient extension services, and a lack of adoption of climate-smart agricultural practices.

The reduced productivity of staple crops has led to widespread food shortages, increased dependence on imported food, and escalating food prices. These developments are straining the local economy and contributing to broader challenges in maintaining the nation's food supply.

Although the impact of climate change on agriculture is widely acknowledged, there is limited empirical research specifically addressing its effects on crop yields and food security in Agatu Local Government Area. This study seeks to

address this gap by conducting an in-depth analysis and providing actionable recommendations to mitigate the challenges faced by the region.

1.3 Aim of the Study

This research aims to examine the effects of climate change on agriculture and food security in Agatu Local Government Area, identify challenges faced by farmers, and propose strategies to improve agricultural resilience and ensure sustainable food security.

1.3 Objectives of the Study

The primary objective of this study is to evaluate the impact of climate change on crop yield and food security in Agatu Local Government Area. The specific objectives are:

1. To assess the effects of climate change on crop production and food security in the area.
2. To analyze the relationship between key climate variables (e.g., rainfall, temperature) and agricultural productivity.
3. To identify the major challenges faced by farmers as a result of climate change.
4. To propose strategies for mitigating climate change impacts and improving agricultural resilience and food security.

1.4 Research Questions

1. What are the major climatic factors influencing crop production in Agatu Local Government Area?
2. How have climate change and variability impacted crop yields and food security in the region?
3. What challenges do farmers face due to climate change in Agatu?
4. What strategies can be implemented to mitigate the effects of climate change and improve agricultural resilience?

2.1 Literature Review

Climate Change:

A long-term alteration in temperature, precipitation, wind patterns, and other elements of the Earth's climate system.

Crop Yield:

The amount of crop harvested per unit area of land.

Food Security:

The state of having reliable access to sufficient, safe, and nutritious food to meet dietary needs and preferences.

Adaptive Strategies:

Measures taken to adjust to the effects of climate change and reduce its adverse impacts.

2.2 Conceptual Framework

2.2.1 Climate Change

Climate change refers to long-term alterations in temperature, precipitation, wind patterns, and other elements of the Earth's climate system. According to the Intergovernmental Panel on Climate Change (IPCC, 2021), these changes are primarily driven by increased greenhouse gas emissions from anthropogenic activities, such as fossil fuel combustion, deforestation, and industrial processes. The accumulation of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), has led to a rise in global temperatures, a phenomenon commonly referred to as global warming (NASA, 2023).

In Nigeria, the adverse effects of climate change are increasingly evident and pose significant challenges to socioeconomic stability and environmental sustainability. Erratic rainfall patterns have disrupted agricultural cycles, affecting crop yields and food security (Federal Ministry of Environment, Nigeria, 2020). Prolonged droughts, particularly in the northern regions, have exacerbated desertification and reduced water availability for both domestic and agricultural use (United Nations Convention to Combat Desertification, 2019). Additionally, coastal areas, including Lagos and the Niger Delta, face frequent flooding due to rising sea levels and extreme weather events, resulting in displacement and loss of livelihoods (World Bank, 2021).

Climate change also impacts public health, as heatwaves and changing disease vectors contribute to the spread of illnesses such as malaria and cholera (World Health Organization, 2020). The compounding effects of these challenges underscore the need for robust mitigation and adaptation strategies, including investments in renewable energy, climate-resilient infrastructure, and community-based initiatives to build resilience against climate-related risks (IPCC, 2022).

2.2.2 Food Security

Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2020). It is a critical component of global development and human well-being, and it is commonly assessed through four interconnected dimensions

Availability

The presence of sufficient quantities of food produced domestically or imported to meet population needs. In many developing countries, including Nigeria, food availability is affected by factors such as climate change, poor agricultural

productivity, and post-harvest losses. For instance, erratic rainfall and prolonged droughts disrupt farming activities, leading to reduced crop yields (World Bank, 2021). Additionally, inadequate infrastructure for storage and transportation exacerbates food waste, with up to 30% of food produced in sub-Saharan Africa lost before it reaches consumers (FAO, 2019).

Access

Economic and physical ability to obtain food. Economic access depends on household income and food prices, while physical access is influenced by infrastructure and market systems. Rising poverty rates and inflation in Nigeria have made food less affordable for many households (National Bureau of Statistics, Nigeria, 2021). Furthermore, conflict in regions such as the Northeast has disrupted food supply chains, limiting access to markets and increasing food insecurity (World Food Programme, 2020).

Utilization

Proper biological use of food, supported by adequate nutrition, sanitation, and healthcare. Even when food is available and accessible, malnutrition can persist due to inadequate diets and poor health services. Nigeria faces a significant burden of malnutrition, with high rates of stunting, wasting, and micronutrient deficiencies among children under five years old (UNICEF, 2021). Poor access to clean water and sanitation further compromises food utilization by increasing vulnerability to foodborne illnesses and diseases like cholera (World Health Organization, 2020).

Stability

Consistency of the other three dimensions over time. Seasonal variations, economic shocks, and extreme weather events can destabilize food systems, undermining food security. For example, the COVID-19 pandemic disrupted supply chains and exacerbated vulnerabilities in global and local food systems, leading to temporary spikes in food insecurity (FAO, 2021). Additionally, the impacts of climate change, such as flooding and desertification, continue to pose long-term threats to food stability in Nigeria (IPCC, 2022).

Efforts to address food security require an integrated approach, including investments in sustainable agriculture, poverty alleviation programs, nutrition education, and policies to mitigate the effects of climate change. Strengthening local food systems and building resilience to shocks will be essential to achieving food security for all.

2.3 Agricultural activities in Agatu Local Government Area

Agatu LGA, located in Benue State, Nigeria, is predominantly agrarian, with most of its population engaged in farming. Major crops cultivated include maize, rice, yam, cassava, and millet. The region is highly vulnerable to climate-related shocks such as flooding, which affects farmlands annually. Additionally, unpredictable rainfall patterns disrupt planting and harvesting schedules, threatening both subsistence and commercial farming.

2.4 The Relationship Between Climate Change and Agriculture

2.4.1 Climate Variability and Crop Production

Climate variability, characterized by changes in rainfall patterns, temperature extremes, and unexpected weather events, significantly impacts agricultural productivity. Lobell et al. (2011) found that global maize and wheat production declined by 3.8% and 5.5%, respectively, due to increased temperatures and water scarcity. Similarly, Adejuwon (2004) highlighted that prolonged droughts in Nigeria have led to decreased soil moisture and reduced crop yields.

2.4.2 Effects of Temperature Changes

Temperature fluctuations affect the growth cycles of crops. High temperatures during critical growth phases, such as pollination, can cause stress, reducing yields. For instance, Schlenker and Lobell (2010) reported that temperature increases above 30°C reduce maize yields by 1% for every degree Celsius rise.

2.4.3 Impact of Rainfall Patterns

Rainfall variability is particularly critical in rain-fed agricultural systems like those in Agatu. Studies by Nwafor (2007) show that erratic rainfall leads to poor germination, waterlogging, and nutrient leaching, all of which negatively affect crop productivity.

2.5 Climate Change and Food Security

Climate change poses a significant threat to food security by impacting all four dimensions—availability, access, utilization, and stability. The complex interplay between climate variability and food systems exacerbates existing vulnerabilities, particularly in regions reliant on subsistence farming.

Availability

Declines in crop yields due to changing climate conditions, such as rising temperatures, erratic rainfall patterns, and extreme weather events, reduce food availability. Research indicates that staple crops like maize, wheat, and rice are

particularly sensitive to heat stress, with projected yield declines of up to 10% for every 1°C rise in temperature in tropical regions (IPCC, 2021). In Nigeria, unpredictable rainfall disrupts planting and harvesting schedules, leading to reduced agricultural output and food shortages (FAO, 2020).

Access

Climate change reduces access to food by lowering agricultural income and increasing food prices. Smallholder farmers, who comprise the majority of Nigeria's agricultural workforce, are particularly vulnerable as extreme weather events, such as floods and droughts, destroy crops and livestock (Oxfam, 2020). The resulting reduction in income limits their ability to purchase food, while higher market prices further exacerbate food insecurity for low-income households (World Bank, 2021).

Utilization

The quality and safety of food are compromised by climate change. Floods can lead to waterlogging and contamination of crops, increasing the risk of foodborne illnesses. Similarly, drought conditions can reduce the availability of water for irrigation and sanitation, affecting both crop quality and human health (World Health Organization, 2020). Studies also highlight that changing climatic conditions alter the nutritional content of crops, such as reductions in protein and micronutrients in grains like rice and wheat under elevated CO_2 conditions (Myers et al., 2014).

Stability

The frequency and intensity of climate-induced shocks, such as droughts, floods, and storms, destabilize food systems and make long-term planning difficult. These shocks disrupt supply chains, destroy infrastructure, and create uncertainty for farmers and policymakers. For example, the 2012 floods in Nigeria displaced millions and led to significant losses in agricultural production (National Emergency Management Agency, Nigeria, 2012). The unpredictability of such events further undermines food system stability and resilience (FAO, 2021).

Ozor and Nnaji (2011) emphasized that regions heavily dependent on subsistence farming, such as Agatu in Nigeria, are disproportionately affected by climate change due to limited resources and adaptive capacity. These regions lack access to technologies and infrastructure that could mitigate the effects of climate shocks, leaving them more vulnerable to food insecurity.

2.6 Empirical Studies

2.6.1 Impact of Climate Change on Crop Yield

Climate change significantly impacts food security in Nigeria, as evidenced by multiple studies. Ishaya and Abaje (2008) observed that climatic changes, including erratic rainfall and extreme weather events, have led to substantial reductions in crop yields. For example, millet and sorghum yields in northern Nigeria dropped by 20% due to prolonged droughts. Similarly, Anuforom et al. (2007) documented a devastating trend in Benue State, where flooding destroyed over 40% of farmlands in low-lying areas, resulting in severe food shortages and increased reliance on food imports.

Eboh et al. (2006) investigated the broader economic implications of climate change on food security. Their findings revealed that climate-induced reductions in agricultural productivity caused food prices to rise by an average of 30%, disproportionately affecting low-income households. The price surges not only reduced access to nutritious food but also heightened food insecurity in urban and rural areas alike (World Bank, 2021).

Further evidence from the International Food Policy Research Institute (IFPRI, 2020) corroborates that food insecurity is exacerbated by the compounded effects of climate change, such as the increased frequency of droughts, floods, and pest outbreaks. These factors collectively threaten the livelihoods of smallholder farmers, who form the backbone of Nigeria's agricultural sector, and contribute to regional instability.

2.6.2 Local Perspectives on Climate Change

Understanding local perceptions of climate change is critical for designing effective adaptation strategies. Studies specific to Agatu, such as those by Ogwumike and Obadeyi (2018), reveal that farmers perceive climate change through increased rainfall variability, prolonged dry spells, and frequent flooding events. These disruptions affect planting schedules, crop maturation, and post-harvest storage, exacerbating food insecurity.

Farmers in Agatu have also reported that traditional farming practices and indigenous knowledge are increasingly insufficient in addressing climate-related challenges (Nnaji et al., 2019). For instance, the shift in planting seasons due to unpredictable weather patterns has led to reduced crop yields and higher post-harvest losses. These challenges are further compounded by the lack of access to climate-resilient seeds, modern farming equipment, and early warning systems (IFAD, 2020).

Efforts to mitigate these impacts require integrating local knowledge with scientific approaches. Studies such as Adetayo and Suleiman (2021) emphasize the importance of community-based adaptation programs that empower farmers with training in climate-smart agricultural practices, improved irrigation techniques, and agroforestry. Additionally, expanding access to microfinance and crop insurance can provide financial security for farmers dealing with climate-induced shocks (CGIAR, 2021).

2.7 Challenges Posed by Climate Change in Agatu

Farmers in Agatu face numerous challenges arising from climate change, which severely impact agricultural productivity and food security. These include:

Flooding:
Regular flooding, particularly during the rainy season, leads to soil erosion, nutrient leaching, and loss of arable land. This is exacerbated by the region's low-lying topography, which makes it prone to waterlogging. Flooding events in 2012 and 2018 destroyed significant portions of farmland, displacing farmers and reducing food availability (National Emergency Management Agency, 2019).

Erratic Rainfall: Unpredictable rainfall patterns disrupt traditional farming schedules, affecting planting, maturation, and harvesting. Rainfed agriculture, which dominates the region, is particularly vulnerable, as prolonged dry spells or unexpected rainfall can devastate crops like rice and millet (Nnaji et al., 2019).

Pests and Diseases: Changing climate conditions, such as increased temperatures and humidity, have led to a surge in pests like locusts and diseases such as maize streak virus. These factors further reduce yields and increase the financial burden on farmers, who must invest in pest control measures (FAO, 2020).

Lack of Awareness and Resources: Many farmers in Agatu lack access to climate adaptation information and techniques. This knowledge gap limits their ability to implement effective strategies to mitigate climate impacts. Additionally, limited access to credit, modern equipment, and resilient seeds exacerbates their vulnerability (IFAD, 2020).

3.1 **Research Methodology**

3.1.1 Research Design This study adopts a mixed-method approach, combining quantitative and qualitative methods to gather comprehensive data. The quantitative component involves surveys to collect numerical data, while the qualitative component includes interviews and focus group discussions to understand local perceptions and practices in-depth. This approach allows for triangulation, enhancing the validity and reliability of the findings.

3.2 Study Area Agatu Local Government Area (LGA) is situated in Benue State, Nigeria. It lies within the Guinea Savanna ecological zone, characterized by a tropical climate with distinct wet and dry seasons. The area is primarily agrarian, with residents depending on subsistence farming. Agatu's vulnerability to climate change is heightened by its low-lying terrain, making it prone to flooding, and its reliance on rain-fed agriculture.

3.3 Population of the Study The study targets smallholder farmers in Agatu, who constitute the majority of the population. These farmers are key stakeholders, as they directly experience the effects of climate change on agriculture. Additionally, local leaders, agricultural extension officers, and representatives from governmental and non-governmental organizations involved in climate and food security initiatives form part of the study population.

3.4 Sampling Techniques A multistage sampling technique was used to select respondents:

Stage One: Stratification of Agatu into five major zones based on geography and farming practices.

Stage Two: Random selection of three communities from each zone to ensure diverse representation.

Stage Three: Systematic sampling of households within the selected communities, targeting at least 30 households per community.

Stage Four: Purposive sampling of key informants, such as community leaders and extension officers, for qualitative interviews.

A sample size of 300 households was determined using Cochran's formula for sample size calculation, adjusted for the finite population of the study area.

3.5 Data Collection Methods

3.5.1 Quantitative Data Quantitative data were collected through structured questionnaires administered to household heads. The questionnaire covered topics such as farming practices, climate change impacts, adaptation strategies, and food security indicators. The tool was pre-tested in a neighboring LGA to ensure clarity and reliability.

3.5.2 Qualitative Data Qualitative data were gathered through:

Key Informant Interviews
Semi-structured interviews were conducted with local leaders, extension officers, and NGO representatives to gain insights into climate adaptation policies and practices.

Focus Group Discussions (FGDs):
FGDs were held with farmers to explore community-level perceptions and coping strategies. Each discussion comprised 8-10 participants, ensuring diversity in gender, age, and farming experience.

3.6 Data Analysis

3.6.1 Quantitative Analysis

Quantitative data were analyzed using descriptive and inferential statistics. Descriptive statistics, such as frequencies, percentages, and means, were used to summarize demographic and farming data. Inferential analysis, including regression and correlation, was applied to examine relationships between climate variables and food security indicators.

3.6.2 Qualitative Analysis

Qualitative data were analyzed using thematic analysis. Recorded interviews and FGDs were transcribed verbatim, coded, and categorized into themes. This process allowed for the identification of recurring patterns and insights into local adaptation strategies.

3.7 Ethical Considerations

Ethical approval was obtained from the relevant institutional review board. Participants were informed of the study's purpose, assured of confidentiality, and provided with the option to withdraw at any time. Consent forms were signed by all participants before data collection commenced.

Results and Discussion

4.1 Demographic Characteristics of Respondents

Table 4.1 summarizes the demographic characteristics of the respondents. The majority of the respondents were smallholder farmers, reflecting the agricultural dependency of the Agatu population.

Demographic Variable	Frequency	Percentage (%)
Gender		
Male	180	60
Female	120	40
Age Group (Years)		
18-30	50	16.7
31-50	170	56.7
Above 50	80	26.6
Educational Level		
No Formal Education	70	23.3
Primary Education	110	36.7
Secondary Education	90	30.0
Tertiary Education	30	10.0

The demographic characteristics of respondents in Agatu show that 60% are male and 40% are female, reflecting a common gender gap in agricultural communities, where men typically dominate labor and decision-making (FAO, 2011). Despite this, women play a crucial role in food production, household agriculture, and family nutrition (Quisumbing et al., 2014). Gender dynamics must be considered when designing agricultural policies to ensure both male and female farmers have equitable access to resources and opportunities.

In terms of age, the majority of respondents (56.7%) fall within the 31-50 years category, reflecting an experienced and productive agricultural workforce. However, older farmers (26.6% above 50 years) may face challenges in adapting to new agricultural technologies, while the smaller group of younger farmers (16.7% aged 18-30) suggests issues such as migration, lack of interest, or limited access to resources (FAO, 2014). Engaging youth in agriculture through education, training, and financial resources is essential for long-term sustainability.

Educationally, 36.7% of respondents have primary education, 30% have secondary education, 23.3% have no formal education, and 10% have tertiary education. This distribution suggests that many farmers have basic literacy skills, which helps in accessing information on agricultural practices and climate adaptation strategies. However, the 23.3% with no formal education and the low percentage with tertiary education highlight barriers to technological adoption and modern farming techniques, underscoring the need for educational initiatives to improve agricultural resilience.

4.2 Impacts of Climate Change on Agriculture

Table 4.2 illustrates the key impacts as reported by respondents.

Climate Change Impact	Frequency	Percentage (%)
Erratic Rainfall	250	83.3
Flooding	210	70.0
Drought	190	63.3
Increased Pest Infestation	150	50.0

Erratic rainfall is the most commonly reported climate change impact, with 83.3% of respondents highlighting it as a major concern. This unpredictable distribution of rainfall can severely affect agricultural productivity, disrupting planting and harvesting schedules, leading to reduced yields or crop failure (IPCC, 2021). Erratic rainfall exacerbates water scarcity, particularly in areas with limited irrigation infrastructure (Lobell et al., 2014), and is a significant stressor for food security and agricultural resilience.

Flooding, reported by 70.0% of respondents, is another major impact. Flooding, caused by excessive rainfall or rising sea levels, leads to crop submergence, infrastructure damage, and water contamination. It also results in long-term soil degradation and reduced agricultural land fertility (UNFCCC, 2018). The financial burden of rebuilding and recovery from floods further challenges smallholder farmers, and the increasing frequency and intensity of floods align with global trends linked to climate change (Field et al., 2014).

Drought is also a significant concern, reported by 63.3% of respondents. Droughts, characterized by prolonged periods of low precipitation, cause water shortages that threaten crop production, livestock, and food security (Shukla et al., 2017). As droughts become more frequent and severe due to climate change, agricultural systems face greater vulnerabilities, compounding the challenges for farmers.

Increased pest infestation, reported by 50.0% of respondents, is another climate change impact. Warmer temperatures and altered rainfall patterns create favorable conditions for pests and diseases, leading to crop damage and reduced productivity (Chakraborty et al., 2019). The frequency of pest infestations in the region mirrors global trends of pests and diseases becoming more serious threats to agriculture in the face of climate change.

4.3 Food Security Status

Table 4.3 summarizes Food security availability, access, utilization, and stability.

Food Security Dimension	Status	Frequency	Percentage (%)
Availability	Adequate	80	26.7
	Inadequate	220	73.3
Access	Sufficient	100	33.3
	Insufficient	200	66.7
Utilization	Optimal	70	23.3
	Suboptimal	230	76.7
Stability	Stable	60	20.0
	Unstable	240	80.0

The dimension of food availability shows that 73.3% of respondents experience inadequate availability, while only 26.7% report adequate availability. Inadequate food availability can result from factors such as low agricultural productivity, poor infrastructure, or limited access to global markets (FAO, 2003). This challenge is exacerbated by climate change, economic instability, or poor agricultural practices, making consistent food supply a significant concern. Inadequate availability leads to food insecurity, forcing households to rely on less nutritious or insufficient food sources (Barrett, 2010).

Regarding food access, 66.7% of households report insufficient access, while 33.3% have sufficient access. Access is influenced by economic factors like household income, food prices, or the lack of social safety nets (Sen, 1981). In rural or low-income settings, even when food is available, it may not be accessible due to poverty or poor infrastructure, leading to food insecurity. The high percentage of insufficient access in the region suggests that economic and market-related barriers are major contributors to food insecurity.

For food utilization, 76.7% of households report suboptimal utilization. Optimal food utilization requires proper food processing, storage, and consumption to meet nutritional needs (Maxwell, 1996). Suboptimal utilization can result from poor dietary diversity, improper food preparation, or lack of access to clean water and sanitation. This highlights the need for better food education, improved dietary practices, and addressing malnutrition and undernutrition.

Food stability is reported as unstable by 80.0% of respondents, indicating inconsistency in food availability, access, and utilization over time. Food security is stable when households have consistent access to nutritious food despite fluctuations in production or income (FEWS NET, 2015). Instability can arise from seasonal variations, economic shocks, climate change, or political instability, leading to periods of food surplus followed by scarcity (Tschirley et al., 2015). This instability impacts long-term nutrition and health, preventing individuals from consistently meeting their dietary needs.

4.4 Adaptation Strategies Farmers in Agatu employed

Table 4.4 provides Adaptation Strategies.

Adaptation Strategy	Frequency	Percentage (%)
Crop Diversification	190	63.3
Improved Irrigation	100	33.3
Early Maturing Varieties	160	53.3
Agroforestry	120	40.0
Cooperative Farming	140	46.7

Crop diversification is the most widely adopted strategy in Agatu, with 63.3% of farmers using it. This strategy reduces the risk of crop failure due to pests, diseases, or adverse weather, and stabilizes income, particularly in regions with unpredictable environmental conditions (Altieri, 2002). It enhances resilience to climate variability and improves food security (Lobell et al., 2014).

Improved irrigation systems were adopted by 33.3% of farmers. Efficient irrigation, such as drip or sprinkler systems, can increase crop yields, especially in areas with irregular rainfall or water scarcity (Rodriguez et al., 2015). Despite its benefits, the adoption rate is lower due to high initial costs and limited access to resources and technical knowledge.

Early maturing crop varieties were adopted by 53.3% of farmers. These varieties are useful for regions with shortened growing seasons or unpredictable weather, as they ensure crops mature before adverse conditions can cause damage (Behnassi et al., 2016). This strategy helps stabilize yields and improve food security in the face of climate change.
Agroforestry, adopted by 40.0% of farmers, combines agriculture with tree planting, improving soil fertility, reducing erosion, and providing additional income from tree products (Nair, 1993). This strategy is valuable in regions with degraded soils, offering ecological benefits and increasing resilience to climate change.
Cooperative farming was adopted by 46.7% of farmers, enabling them to pool resources, labor, and equipment, thus increasing productivity and reducing individual costs (Moyo, 2010). It enhances access to markets, technical knowledge, and bulk purchasing, while fostering social cohesion and improving profitability.

5.1 Conclusion

The study highlights the vulnerability of smallholder farmers in Agatu to climate change impacts, including irregular rainfall, flooding, drought, and pest infestations. These challenges threaten food security and agricultural sustainability. Adaptation strategies like crop diversification, early maturing varieties, cooperative farming, and agroforestry demonstrate resilience, but adoption of improved irrigation systems remains limited due to high costs and technical expertise. The demographic data reveals a predominantly middle-aged male farmer population with low education, affecting the adoption of advanced agricultural practices. Understanding this context is crucial for designing targeted interventions.

5.2 Recommendations

Based on the findings of this study, the following three key recommendations are made:

- There is a need to promote climate-smart agricultural practices, such as improved irrigation systems and the adoption of drought-resistant crop varieties. Providing training and technical support to farmers on these practices can help improve productivity and resilience to climate change.
- The adoption of irrigation systems should be promoted by reducing the initial costs through subsidies or micro-financing options. Farmers should also be provided with technical knowledge on sustainable irrigation practices to maximize water use efficiency.
- Policies should be designed to ensure that both male and female farmers have equal access to resources and opportunities. Addressing gender disparities in access to land, credit, and training can improve overall agricultural productivity and resilience

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