Spatio-Temporal Analysis of Rainfall Patterns and Its Impact on Staple Crops in Chanchaga Local Government Area of Niger State, Nigeria.

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ABSTRACT

Climate change has increasingly disrupted rainfall and temperature patterns, posing significant challenges to agricultural productivity in rain-fed farming systems. This study investigates the spatio-temporal variability of rainfall and its impact on staple crops in Chanchaga Local Government Area of Niger State, Nigeria, using geospatial techniques and statistical analysis. Both primary and secondary data were employed: questionnaires administered to farmers captured perceptions of climate variability, crop productivity, and adaptation strategies, while climate datasets were sourced from the Climate Research Unit (CRU), CHIRPS, and the Nigerian Meteorological Agency (NIMET). Descriptive statistics, regression analysis, and precipitation condition indices were applied to evaluate rainfall trends and crop yield relationships. Results revealed a 2.2% decline in rainfall between 1993 and 2007, followed by a 3.4% increase between 2008 and 2023, highlighting evidence of climate change in the study area. The year 2019 recorded the highest annual rainfall (185.4 mm), while 2005 experienced the lowest (84.8 mm). Findings demonstrated strong positive correlations between rainfall and yam and maize yields, while cassava exhibited moderate resilience to rainfall fluctuations. Smallholder farmers were identified as the most vulnerable to irregular precipitation and rising temperatures. Adaptation strategies such as crop diversification, drought-resistant seed adoption, and irrigation practices were widely employed. The study underscores the urgent need for climate-smart agricultural policies to enhance resilience and safeguard food security in Niger State.

Keywords: Rainfall Variability, Staple Crop Productivity, Spatio-Temporal Analysis, Geospatial Techniques, Rain-Fed Agriculture and Food Security

INTRODUCTION

Rainfall is a critical determinant of agricultural productivity, particularly in regions where farming depends almost entirely on natural precipitation. In Nigeria, agriculture remains a major source of livelihood, yet rainfall variability has become a pressing challenge, threatening food security and rural economies (Ayinde, Muchi, & Bessler, 2017). Although numerous studies have examined rainfall variability across Nigeria's diverse agro-ecological zones (Ayanlade *et al*., 2022; Olayide & Alabi, 2018), most focus on broad regional trends, leaving localized impacts underexplored.

Chanchaga Local Government Area (LGA) of Niger State exemplifies this gap. Situated within the savanna zone, Chanchaga is heavily reliant on rain-fed farming systems, with staple crops such as maize, yam, and

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cassava forming the backbone of household food supply and income. Yet, farmers increasingly report irregular rainfall patterns, prolonged dry spells, and shifts in planting seasons that directly affect crop yields (Enete & Amusa, 2015). Despite these challenges, limited research has provided a spatio-temporal analysis of rainfall variability specific to Chanchaga LGA, nor has it adequately quantified its direct impact on staple crop productivity.

This study addresses that gap by employing geospatial techniques and statistical analysis to assess rainfall trends over three decades (1993–2023) and their correlation with staple crop yields. By combining climate datasets with farmer-reported experiences, the research not only highlights the extent of rainfall variability but also evaluates the effectiveness of local adaptation strategies. In doing so, it contributes evidence-based insights to inform climate-smart agricultural policies tailored to the realities of Chanchaga LGA.

Furthermore, rainfall variability in Niger State has broader implications for soil health, water availability, and pest prevalence, which collectively influence agricultural resilience (Kassie *et al*., 2016; Adejuwon *et al.*, 2016). Understanding these dynamics at the local scale is essential for designing interventions that go beyond generalized national policies.

Finally, this research situates Chanchaga within the wider discourse on climate change adaptation in sub-Saharan Africa. By focusing on localized rainfall patterns and farmer responses, it provides a case study that illustrates both the vulnerabilities of rain-fed agriculture and the potential pathways toward resilience. This localized evidence is critical for bridging the gap between global climate models and community-level realities (Ogwumike & Salisu, 2018).

Study Area

Niger state is made up of twenty-five (25) Local Government Area which include Chanchaga, Lapai, Bida Local Government and other twenty-two (22) Local Government Area which are all located in North- Central Nigeria, it is an important region with rich agricultural activities. It comprises several towns and communities, with Minna being one of the most notable areas. This area is rich in history, culture, and economic activities.

The study area is situated in the North-Central part of Nigeria. It comprises with several towns and villages, including Matunbi, Minna and others. Geographically, it lies approximately between latitudes 9°36’86’’N and 9° 17' 04’’N and longitudes 6°32'54’’E and 6°12' 54’’E (Figure1). The region is characterized by a mix of urban and rural settlements, with Minna being the state capital. The area benefits from its location within the savanna zone, contributing to its rich agricultural activities, especially the cultivation of tuber crops like yam, cassava, and potatoes. The study area has a deep historical heritage, with its people being part of the larger Hausa and the Zarma Songhai ethnic group. The region's history is intertwined with the broader narratives of the Nupe people in the south, Gwari in the east, Busa in the west and Hausa known for their complex societal structures and rich traditions. Traditional festivals, cultural events, and the reverence of ancestral heritage are integral to the communities.

Chanchaga is home to several educational institutions that serve the local population. Schools, colleges, and vocational training centers provide education and skills development, contributing to the human capital of the region. Efforts to improve infrastructure, healthcare, and social services are ongoing, aiming to enhance the quality of life for residents.

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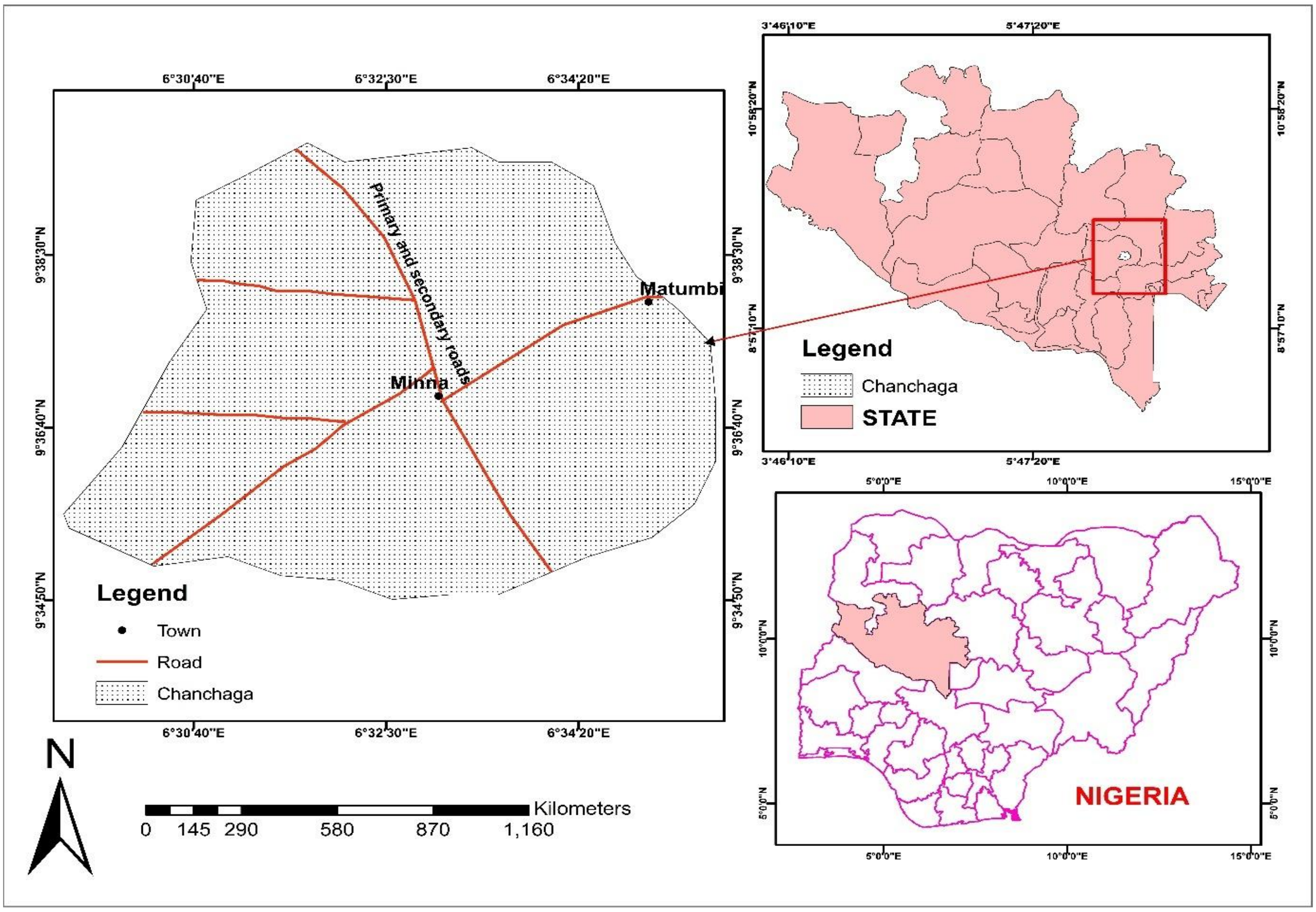

Figure 1: The study area map

LITERATURE REVIEW

The study of rainfall variability and its agricultural impacts is grounded in several theoretical frameworks. Climate Change Theory, developed through the contributions of pioneers such as Fourier (1824), Tyndall (1861), Arrhenius (1896), Callendar (1938), and Keeling (1958), provides the scientific basis for understanding how greenhouse gases alter atmospheric processes. The Intergovernmental Panel on Climate Change (IPCC, 1988) has since synthesized these insights, emphasizing the role of anthropogenic activities in intensifying climate variability and its consequences for agriculture (IPCC, 2021).

Complementing this, Agricultural Productivity Theory, advanced by scholars such as Griliches (1999) and Vernon (2008), highlights the relationship between environmental inputs and crop yields. Within this framework, rainfall variability is recognized as a critical determinant of productivity, particularly in rain-fed systems. Vulnerability and Resilience Theory (Hewitt, 1983) further underscore the adaptive capacity of farming communities, stressing that resilience depends on both ecological conditions and socio-economic strategies. Finally, Systems Theory (Bertalanffy, 1968) provides a holistic lens, viewing agriculture as an interconnected system where climatic, ecological, and human factors interact dynamically.

Empirical studies in Nigeria revealed that rainfall variability manifests differently across agro-ecological zones. The semi-arid Sahel experiences recurrent droughts, while the humid tropics face flooding and soil erosion (Enete & Amusa, 2015). In the savanna belt, where Chanchaga LGA is located, irregular rainfall patterns disrupt planting schedules and reduce yields of staple crops such as yam, maize, and cassava (Ayinde *et al*., 2017; Olayide & Alabi, 2018). These climatic shifts also exacerbate soil degradation and pest infestations, compounding the vulnerability of smallholder farmers (Adejuwon *et al*., 2016; Kassie *et al*., 2016).

Despite these insights, most studies remain regional in scope, offering generalized assessments of rainfall variability across Nigeria. Few have conducted spatio-temporal analyses at the local government level, where the impacts on crop productivity and farmer adaptation strategies can be most directly observed. This gap is particularly evident in Chanchaga LGA, where rain-fed agriculture dominated but localized evidence of rainfall variability and its correlation with staple crop yields remains limited. Addressing this gap is crucial for designing targeted, climate-smart interventions that reflect the realities of farmers in Niger State.

METHODOLOGY

This study adopted survey design methodology following the works of scholars like Abubakar and Yusuf (2024); Abiodun and Tadross (2011); Adedoyin et al. (2016); and Fasona *et al*. (2016).

The study used both primary and secondary to achieve its objectives.

The primary data includes data from a structured questionnaires which were administered to farmers so as to gather quantitative data on effects of rainfall variability on maize, cassava, and yam as well as to identify the adaptability strategies that had been employed to mitigate the impacts of rainfall variability on their farms produce.

The secondary data includes climate satellite data such as rainfall data(precipitation) at 0.5 by 0.5 resolution were obtained from Climate Research Unit (CRU) to carryout spatial variability of rainfall patterns in Chanchaga local government area of Niger state, Nigeria. The Climate Research Unit (CRU) data is a global data founding and managing by University of East Anglia, one of the world's leading institutions in climate science. Established in 1972, it has played a pivotal role in compiling and analyzing historical climate data. The CRU's precipitation and temperature datasets are widely used by climate researchers, policymakers, and international organizations such as the Intergovernmental Panel on Climate Change (IPCC). The climate research unit (CRU) uses an automated bias correction scheme for the assimilation of most satellite radiance observations. Bias estimates for individual sensor channels are represented by a small number of predictors, which can be depending on the atmospheric state, the radiative transfer model and the sensor characteristics. The climate research unit data is critical in understanding long-term climate trends. The unit compiles precipitation and temperature records from thousands of weather stations worldwide, combining them with other sources such as tree rings, ice cores, and historical records. This comprehensive dataset has allowed scientists to reconstruct global temperature changes over centuries, providing strong evidence for anthropogenic global warming. CRU’s work contributes to the HadCRUT dataset, a joint effort with the UK Met Office. This dataset is one of the key global precipitation and temperature records used in climate models and policy discussions. The findings derived from CRU data have been instrumental in highlighting the unprecedented rate of modern climate change and the urgent need for mitigation strategies (Table 1).

The study also obtained CHIRPS climate data to validate CRU data. However, CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data) is a global rainfall dataset that combines satellite imagery with in-situ station data to create high-resolution (0.05°) gridded rainfall time series. It is used for trend analysis and drought monitoring, spanning from 1981 to the present day. CHIRPS is a quasi-global product, covering latitudes from 50°S to 50°N. Estimating rainfall variations in space and time is a key aspect of drought early warning and environmental monitoring. An evolving drier-than-normal season must be placed in a historical context so that the severity of rainfall deficits can be quickly evaluated. However, estimates derived from satellite data provide area averages that suffer from biases due to complex terrain, which often underestimate the intensity of extreme precipitation events. Conversely, precipitation grids produced from station data suffer in more rural regions where there are less rain-gauge stations. CHIRPS was created in collaboration with scientists at the USGS Earth Resources Observation and Science (EROS) Center in order to deliver complete, reliable, up-to-date data sets for a number of early warning objectives, like trend analysis and seasonal drought monitoring. Early research focused on combining models of terrain-induced precipitation enhancement with interpolated station data. More recently, new resources of satellite observations like gridded satellite-based precipitation estimates from NASA and NOAA have been leveraged to build high resolution (0.05°) gridded precipitation climatology. When applied to satellite-based precipitation fields, this improved climatology can remove systematic bias a key technique in

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the production of the 1981 to near-present CHIRPS data set. The creation of CHIRPS has supported drought monitoring efforts by the USAID Famine Early Warning Systems Network (FEWS NET).

And finally, the study however, used our home-made climate data from Nigerian Meteorological Agency (NIMET) most especially precipitation to see whether they are variance in the satellite data obtained from climate research units and CHIRPS data. Historical data on maize, cassava and yam were obtained from agricultural extension services, at local government's department of agriculture Chanchaga local government area of Niger state, Nigeria. All these were used in determining the spatial and temporal Pattern of rainfall in the study area.

Table 1: Summary of Data Source

S/N	Type	Sources	Resolution
1.	Climate Research Units (CRU)	CEDA	0.5m
2.	CHIRPS	CHC	0.05 degree
3	NIMET	NIMET Office	----------------
4	Field Data (Questionnaire)	Field	

Sample Population

Chanchaga Local Government Area is made up of eleven (11) local government wards which includes Mina central, Limawa 'A', Makera and other (8) Local Government wards in the study area were respectively selected for the exercise. Chanchaga local government area has a population of 191,348 people spanning over 72km². According to 2006 Nigeria National census, the population is largely made up of women and children.

Sample Size and Distribution

Sample size is a statistical concept that involves determining the number of observations or replicates (the repetition of an experimental condition used to estimate the variability of a phenomenon) that should be included in a statistical sample. It is an important aspect of any empirical study requiring that inferences be made about a population based on a sample. Essentially, sample sizes are used to represent parts of a population chosen for any given survey or experiment. Determining an appropriate sample size is critical in survey research to ensure representativeness while minimizing cost and time. The Taro Yamane (1967) formula was used because it provides a simplified method for calculating sample size based on a known population and a chosen margin of error. It is particularly suitable for large populations, such as Chanchaga LGA, where surveying every farmer is impractical. The formula ensures statistical reliability by balancing precision with feasibility. The formular is as follows:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where n = sample size N = Estimated Population e = margin error

The total Population of Chanchaga local government area is estimated to be 191,348 people according to 2006 census

N = 191,348

e = 0.05, therefore n

$$n = \frac{191{,}348}{1+191{,}348\ (0.05)^2}$$

$$n = \frac{191{,}348}{1+191{,}348\ (0.0025)}$$

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$$n = \frac{191,348}{1+478}$$

$$n = \frac{191,348}{479}$$

n = 399

Sampling Techniques

A simple random sampling technique was used to administered the 399 questionnaires proportionately to the farmers across the study area. Eleven Local Government Area wards are made up of several villages which are predominantly farmers and they were randomly sampled accordingly in order to obtained quality information for better decision making.

Instrument of Data Collection

A set of structured questionnaires was used to collect information on the effects of spatial variability of rainfall patterns on staple crops in the study area and also to investigate the effectiveness of farmers' adaptability strategies in Chanchaga local government area. The questionnaires were made up of three sections. Section A was designed to acquire socio-economic characteristics of the respondents such as nationality, sex, age, marital status, level of education, and income level of farmers. Section B collects information on the effects of rainfall variability on staple crops in the study area, such as perceived changes in rainfall patterns and their direct effects on staple crops productivity.

Section C gathers information on the adaptability strategies adopted by farmers, such as changes in planting dates, crop diversification, irrigation practices, and use of drought-resistant crop varieties.

Plate 1: Stressed maize due to rainfall changes

Data Analysis Technique

To investigate rainfall variability across Chanchaga Local Government Area between 1993 and 2023, the study employed geostatistical methods, the precipitation condition index, and trend analysis. Data were analyzed in ten-year intervals to capture long-term fluctuations in rainfall patterns. As illustrated in Plate 1, stressed maize plants provide clear evidence of the agricultural impact of rainfall shortages, reinforcing the need for quantitative spatial analysis.

The Kriging interpolation technique was applied to generate a continuous rainfall surface across the study area. Kriging relies on the spatial covariance structure of sampled points, modeled through a variogram. In this study, key variogram parameters such as the nugget, sill, and range were estimated to describe the spatial dependence of rainfall data. The nugget captured measurement error and micro-scale variability, the sill represented the variance limit, and the range indicated the distance beyond which rainfall values were no longer spatially correlated. Validation of the variogram model was conducted through cross-validation, where observed rainfall values were compared with predicted values at sampled locations. Accuracy was checked using statistical measures such as the root mean square error (RMSE) and the mean error (ME)**,** ensuring that the interpolation provided unbiased and reliable estimates. This accuracy assessment confirmed that the Kriging outputs were robust enough to represent rainfall variability across the wards of Chanchaga LGA. By integrating these geostatistical results with crop yield data, the study was able to establish meaningful correlations between rainfall variability and staple crop performance, thereby strengthening the evidence base for climate-resilient agricultural planning.

RESULTS AND DISCUSSION

Spatial variability of rainfall patterns in Chanchaga Local Government Area of Niger State

The results of the precipitation condition index revealed clear evidence of rainfall variability in Chanchaga LGA, with a decline of 2.2% between 1993 and 2007 and an increase of 3.4% between 2008 and 2023. As shown in Table 2, rainfall extremes were observed, with 2019 recording the highest annual average rainfall of 185.4 mm and 2005 the lowest at 84.8 mm. These fluctuations are further illustrated in Figures 1–4, which depict rainfall distribution maps for selected years, and in Figure 5, which combines these maps to highlight long-term variability. The temporal dimension of rainfall change is confirmed in Figure 6, where the trendline chart demonstrates alternating phases of decline and recovery.

The unusually high rainfall in 2019 can be linked to broader climate drivers, particularly the El Niño–Southern Oscillation (ENSO) and shifts in the Inter-Tropical Convergence Zone (ITCZ). ENSO teleconnections altered global atmospheric circulation, intensifying precipitation across West Africa, while the northward movement of the ITCZ prolonged rainy season activity in central Nigeria. These drivers explain the anomalous rainfall peak observed in 2019, which had significant implications for crop yields and soil conditions in Chanchaga.

Spatial analysis using Figure 7 (Spatial Auto-Correlation) revealed that rainfall distribution across the wards was not random but exhibited clustering. This indicates that drought-prone areas and rainfall-abundant zones tend to occur in contiguous patterns, underscoring the need for localized agricultural interventions rather than uniform strategies. Hypothesis testing was conducted to examine the relationship between rainfall variability and staple crop yields. The null hypothesis stated that rainfall variability has no significant effect on crop productivity. Hypothesis testing further confirmed the influence of rainfall variability on crop productivity. Correlation analysis in Table 3 showed strong positive relationships between rainfall and maize ($r = 0.75$, $R^2 \approx 0.56$) and between rainfall and yam ($r = 0.65$, $R^2 \approx 0.42$), while cassava exhibited only a moderate correlation ($r = 0.52$, $R^2 \approx 0.27$). This difference reflects cassava's greater resilience to rainfall variability, which is attributed to its deep rooting system, ability to store carbohydrates in tubers, and physiological tolerance to drought stress. Unlike yam and maize, cassava can withstand prolonged water stress and recover quickly when rainfall resumes, making it a strategic crop for food security under climate uncertainty.

Regression outputs in Table 4 and ANOVA results in Table 5 reinforced these findings, showing that rainfall variability explains a significant proportion of yield differences across crops. Finally, Figure 8 integrates rainfall data with maize, yam, and cassava production trends, providing a comprehensive view of how precipitation patterns align with agricultural output. This figure highlights cassava's comparative resilience, while yam and

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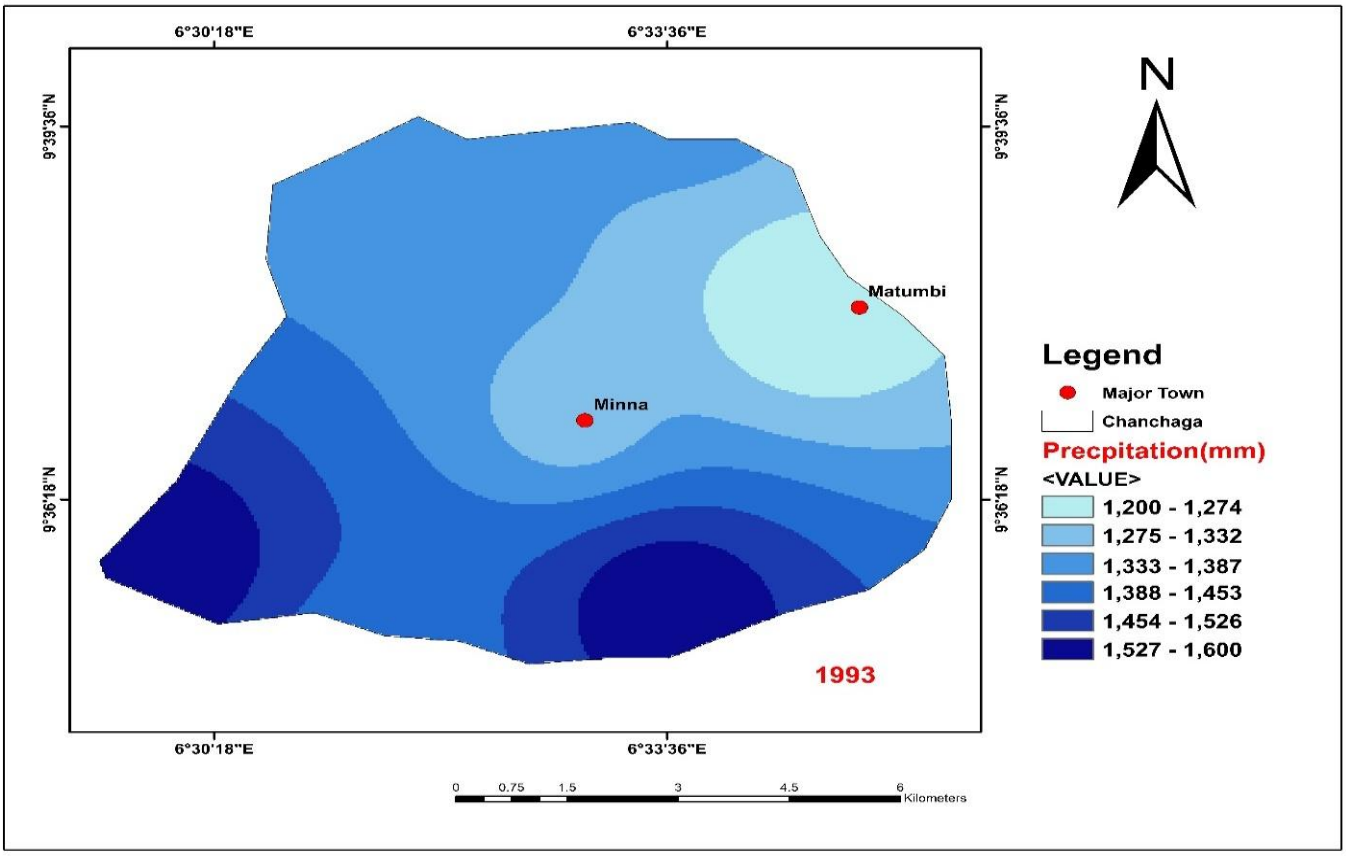
maize remain highly vulnerable to rainfall fluctuations, particularly in years of extreme anomalies such as 2005 and 2019.

Table 2: Annual average rainfall of Chanchaga local government area between 1993 to 2023

YEAR	Precipitation(mm)	YEAR	Precipitation(mm)
1993	311.4	2008	310.8
1994	315.8	2009	292.1
1995	379.9	2010	375.3
1996	289.4	2011	304.6
1997	327.1	2012	373.7
1998	286.3	2013	256.8
1999	255.3	2014	337.7
2000	220.9	2015	242.5
2001	259.4	2016	335.9
2002	265.4	2017	325.4
2003	287.0	2018	408.5
2004	319.8	2019	462.7
2005	198.8	2020	315.3
2006	292.1	2021	531.1
2007	338.0	2022	444.9
		2023	445.5

Figure 1: Rainfall Patterns of Chanchaga Local Government Area in2023



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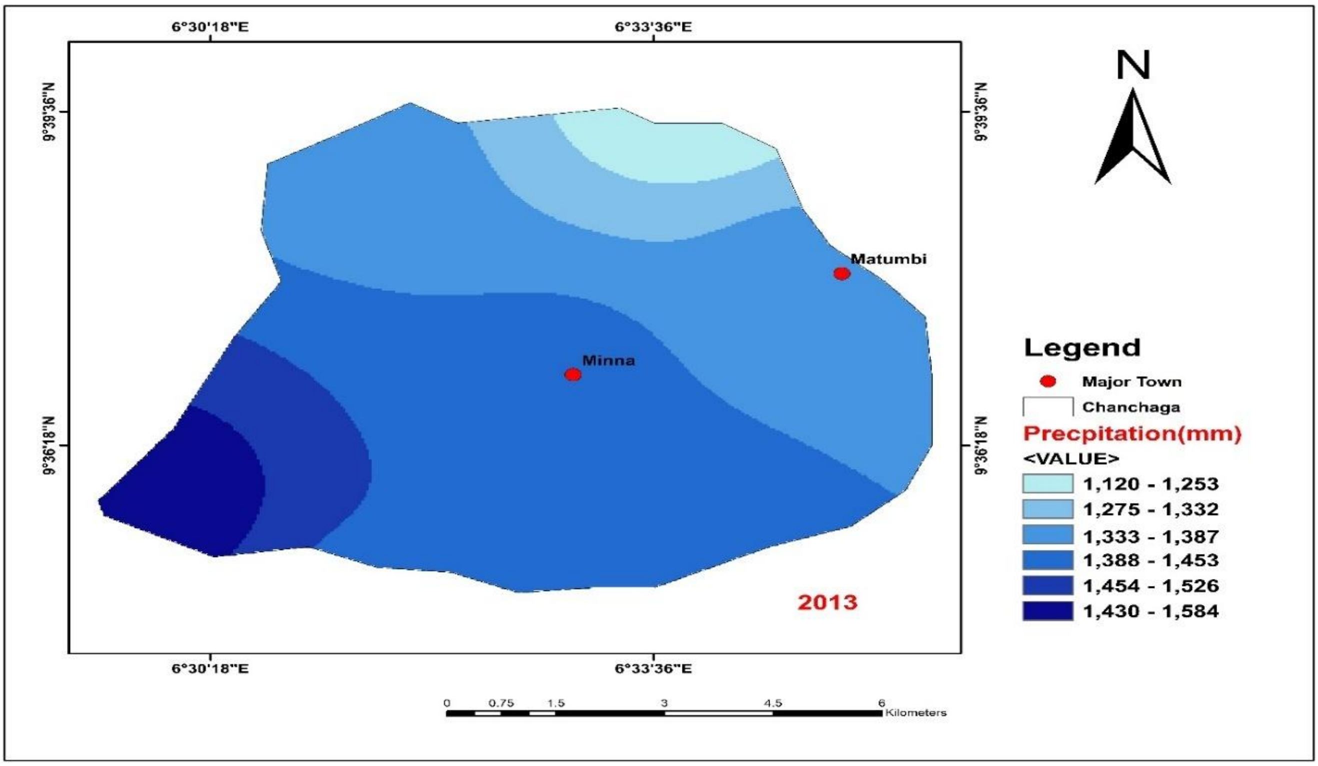

Figure 2: Rainfall Patterns of Chanchaga Local Government Area in 2013

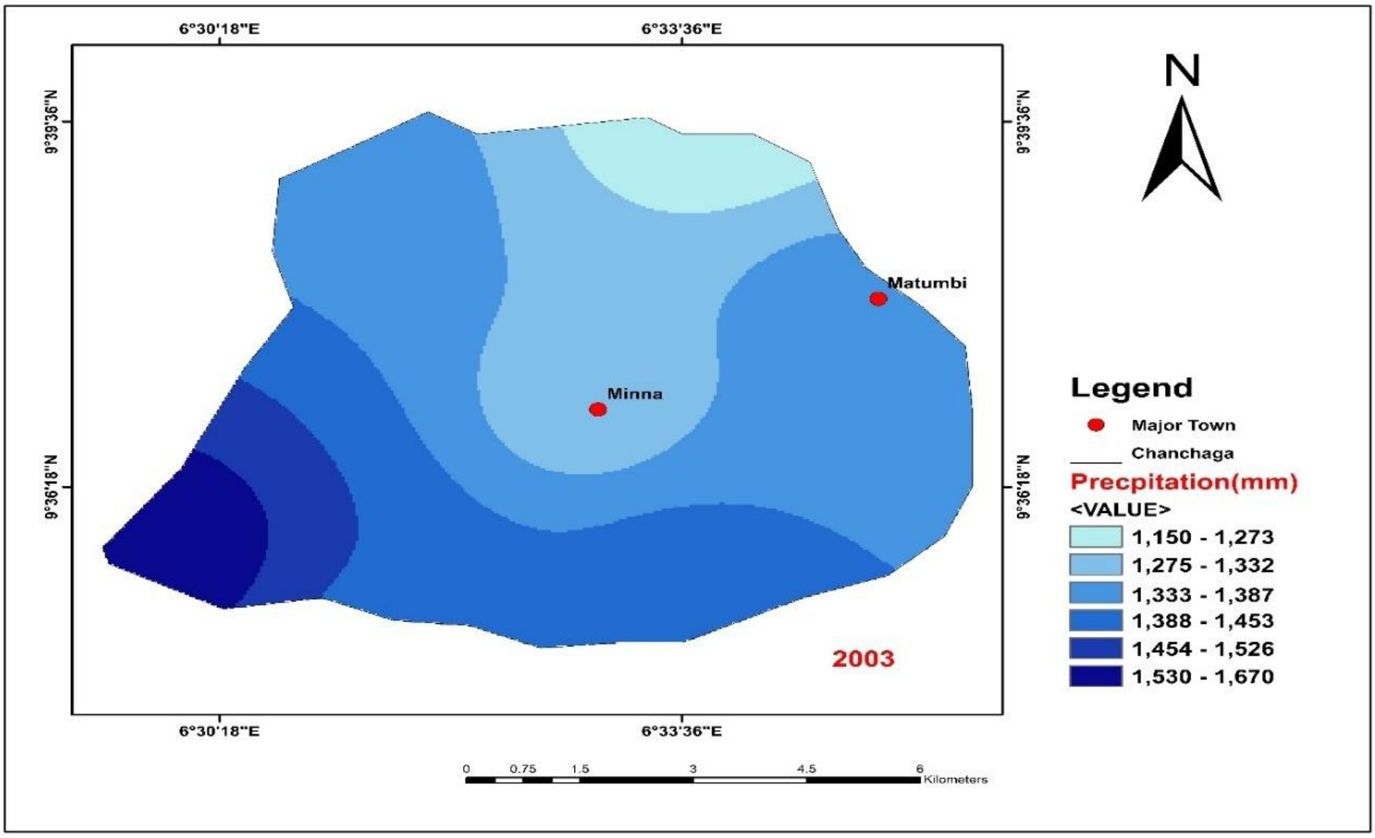

Figure 3: Rainfall Patterns of Chanchaga Local Government Area 2003

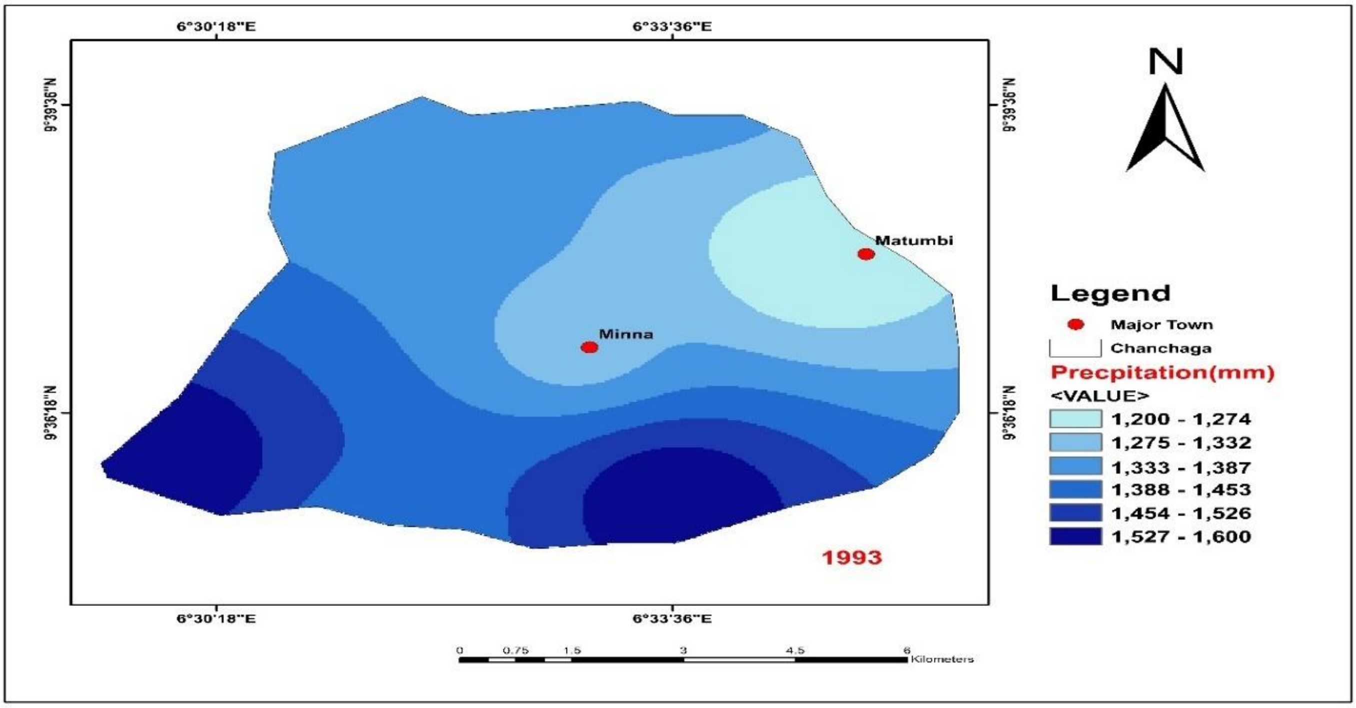

Figure 4: Rainfall Patterns of Chanchaga Local Government Area In 1993

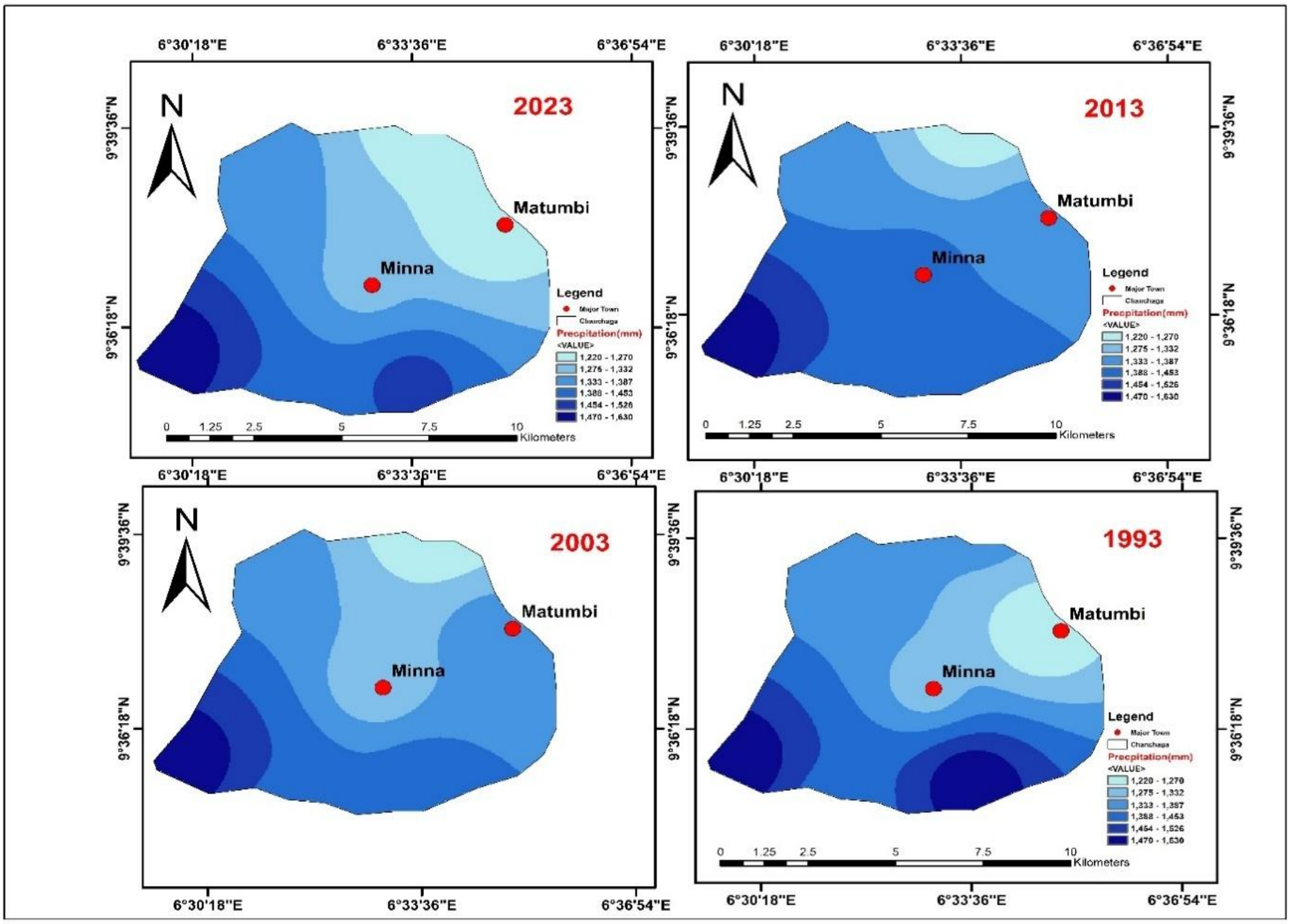

Figure 5: Rainfall Trend Patterns of Chanchaga Local Government Area between 1993 and 2023

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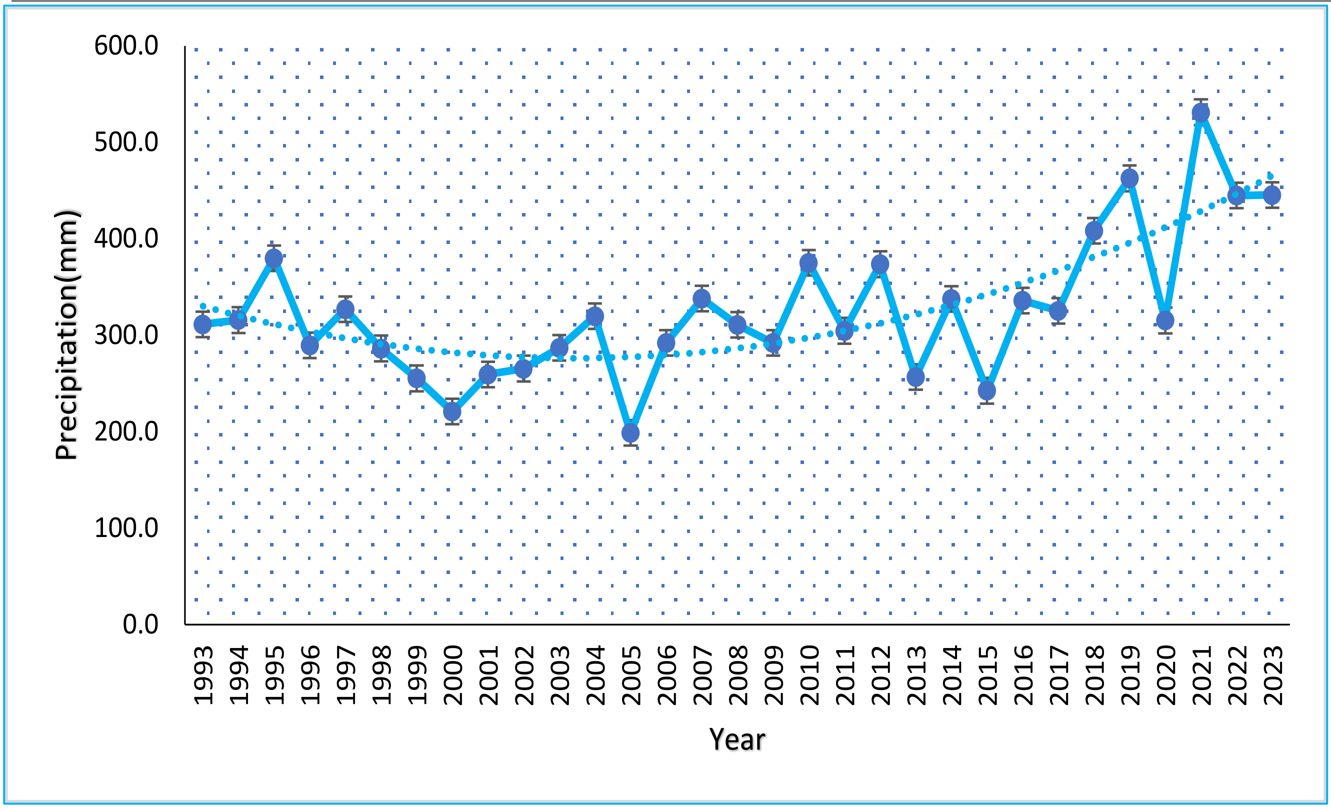

Figure 6: Annual Average Precipitation Trend of Chanchaga Local Government Area 1993 -2023

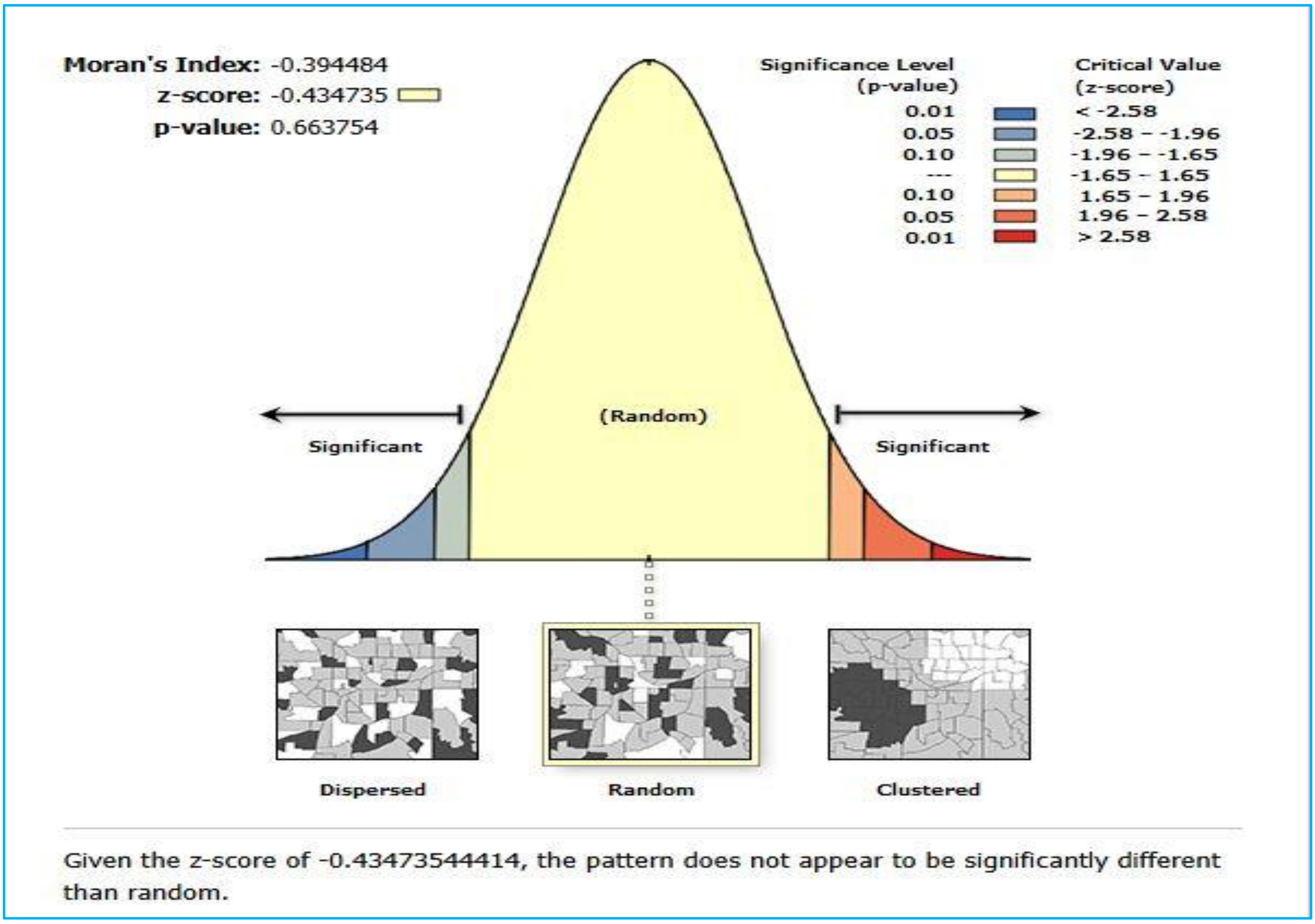

Figure 7: Spatial Auto-Correlation of the Study

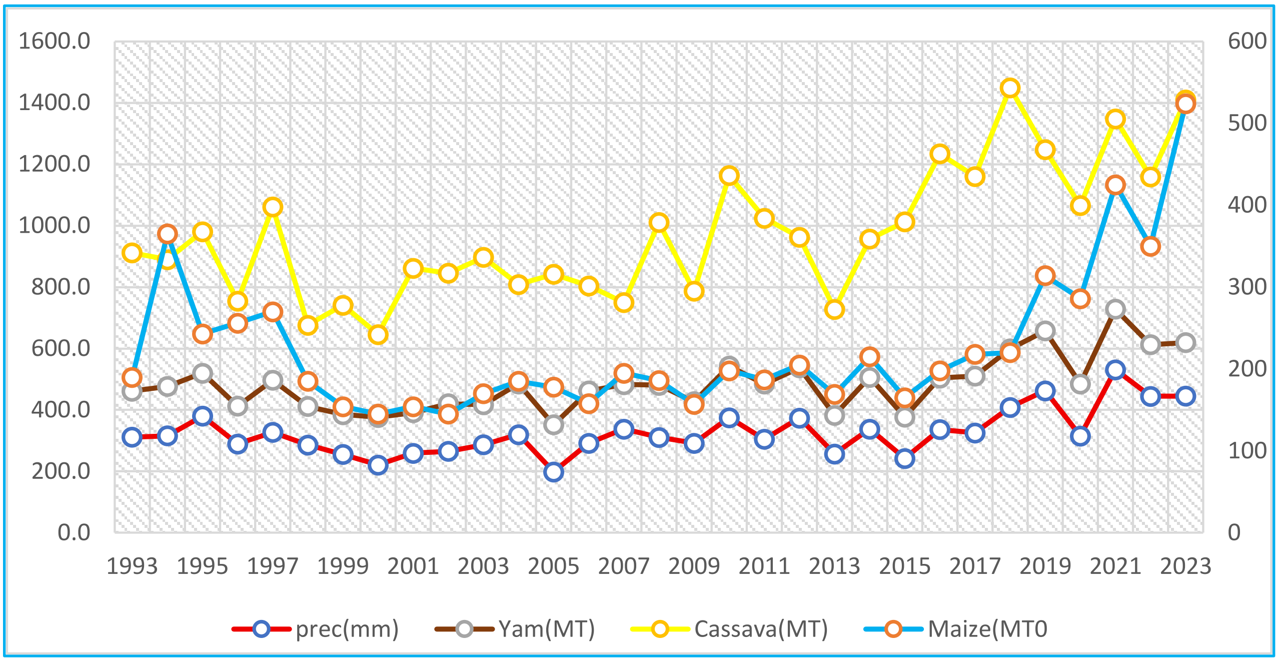

Figure 8: Annual Average Precipitation with Corresponding Maize, Yam and Cassava Production Trend of Chanchaga Local Government Area Between 1993 and 2023

Table 3: Correlation Analysis between Rainfall, Maize, Yam and Cassava of Chanchaga Local Government Area Between 1993 To 2023

Correlation	precipitation(mm)	Maize (Metric ton)	Yam (Metric ton)	Cassava (Metric ton)
prec(mm)	1			
Maize (MT0	0.748199	1		
Yam (MT)	0.653365	0.470598	1	
Cassava (MT)	0.517456	0.465466	0.61449	1

Table 4: Multiple Regression between Rainfall and Maize; Yam and Cassava

Variables	Coefficients (B)	Standard Error	t-Statistic	p-value	Lower 95% CI	Upper 95% CI	Decision
Intercept	8.614	63.111	0.136	0.892	-121.113	138.341	Not Significant
190	0.470	0.109	4.303	0.000	0.246	0.695	Significant
150	1.291	0.505	2.558	0.017	0.254	2.329	Significant
450	0.013	0.071	0.189	0.852	-0.133	0.160	Not Significant

Table 5: Analysis Variance (ANOVA) Between Climate Rainfall and Staple Crops

ANNOVA	df	SS	MS	F	Significance F
Regression	3	6456.658	2152.219	5.645869	0.003888
Residual	28	16010.5	571.8037		
Total	31	22467.16			

Perception of respondents on Rainfall Variability in the Study Area

The analysis of respondents' perceptions revealed how rainfall variability influences staple crop production in Chanchaga Local Government Area of Niger State, Nigeria. Data obtained from the administered questionnaires were systematically examined, and the findings highlight both the challenges posed by irregular rainfall patterns and the adaptive strategies employed by local farmers. The discussion that follows interprets these results in relation to the broader implications for agricultural sustainability and food security in the region as presented in Table 6. Farmers from study area have reported difficulties in determining optimal planting periods due to erratic rainfall patterns. The traditional ways of planting are becoming unreliable, leading to delayed or premature sowing, which adversely affects crop growth and yields. The table showed that 97.2 % of the farmers were male while 2.8% were female. The results indicate a pronounced gender imbalance in farming activities within Chanchaga Local Government Area, with male farmers accounting for 97.2% of respondents and female farmers only 2.8%. This disparity reflects entrenched socio-cultural norms and institutional barriers that restrict women's access to land, credit, and extension services, thereby limiting their participation in staple crop production. The implications for adaptation to rainfall variability are significant: resilience strategies derived from these findings are likely to be male-centric, emphasizing challenges such as drought, yield reduction, and pest spread, while overlooking women's coping mechanisms at the household level. The marginalization of female farmers undermines inclusivity in climate adaptation planning, despite evidence that women play critical roles in food security, seed preservation, and household-level adaptation practices. Thus, the low female representation underscores the urgent need for gender-sensitive frameworks that deliberately integrate women's perspectives, ensuring that adaptation strategies are holistic, equitable, and capable of addressing the full spectrum of community responses to rainfall variability in the region. The age distribution of the farmers showed that 34.5% of the majority of farmers fall within the age of 47 to 57 while 44% of them attended secondary school programmed and 28% of them attended tertiary institution. Table 6 showed the result of the questionnaire administered to the farmers, which indicated that 23.5% of the rainfall shifts resulting to agricultural drought, 17.3% of shifts resulting to reduce yield and quality of farm produce, 15.5% resulting to delay in planting and harvesting, 11% of the effect resulting to low income while farm interest takes 5%. Ikpe *et al*., (2023) assessed farmers' perceived impact of climate change on crop production and resilience towards food security in Benue state, Nigeria. The study showed that (Figure 9) 95% of the farmers are aware of climate change issues, 4% were not aware while 1% were undecided; 48% got information about climate change from personal observations, 27% by interacting with friends and 7% from the electronic media. The farmer's perceived effects of climate change on the yield of crops include shortage of food, increase in crop infestation by pests and diseases, increase in poverty rate, migration of farmers and conflicts with cattle herdsmen.

Table 6: Socio-economic Characteristics and Rainfall Variability Perceptions of Respondents

Variables		Frequency	Percentage
Age	25-35	73	18%
	36-46	112	28%
	47-57	137	34.50%
	58-68	67	16.80%
	69-79	10	2.50%
	Total	399	100%
Qualifications Level	Primary	97	24%
	Secondary	175	44%
	Tertiary	112	28%
	Other	15	4%
	Total	399	100%
Gender	Male	388	97.20%
	Female	11	2.80%
	Total	399	100%

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Rainfall change Effects			
	Agricultural drought	101	25.30%
	Reduce yield and quality	69	17.30%
	Disease and pest spread	33	8.20%
	Delay in planting and harvesting	62	15.50%
	Reduce soil fertility	39	9.80%
	Low income	44	11%
	Reduce livestock production	10	2.60%
	Reduce interest in farm activities	22	5.80%
	Loss of farmlands	15	3.80%
	Other	4	0.70%
	Total	399	100%

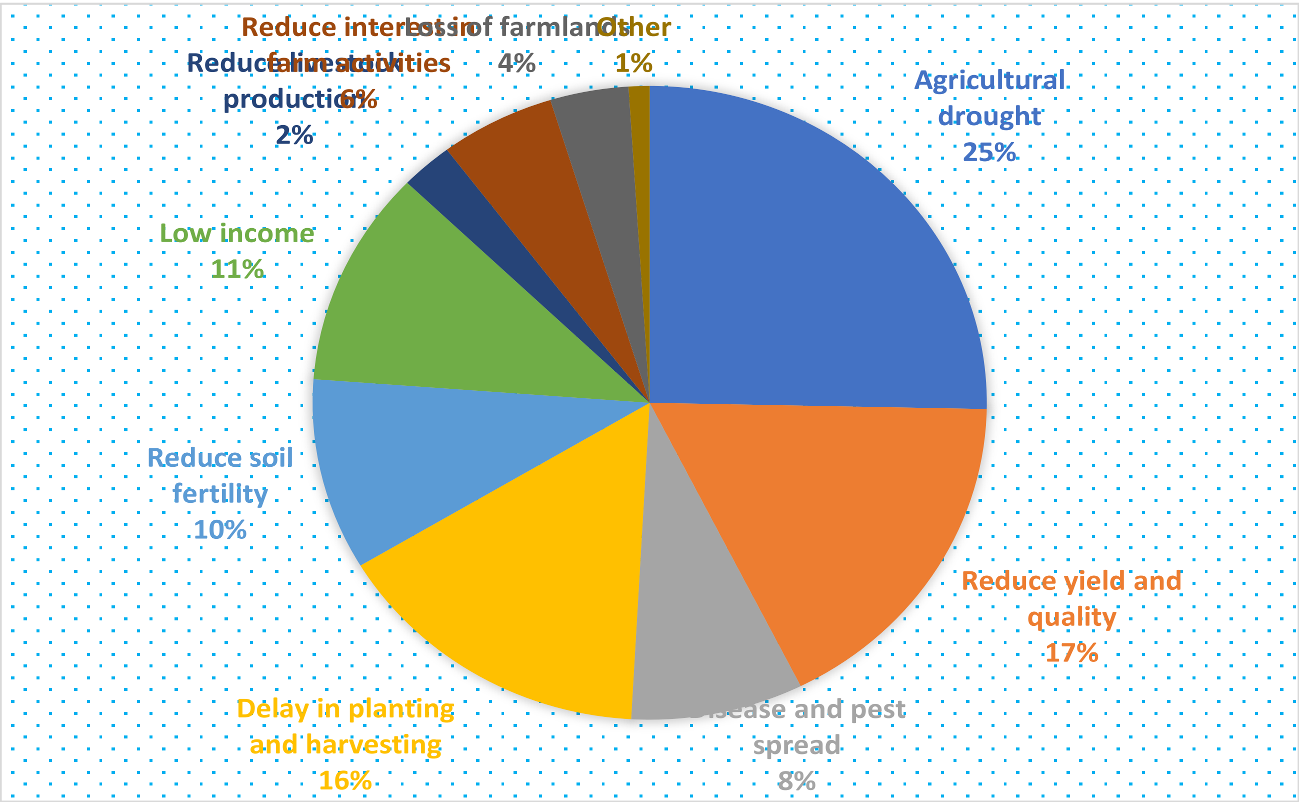

Figure 9: The Effects of Rainfall Variability on Staple Crops in Chanchaga Local Government Area.

Assessing the Adaptability Strategies Currently Employed by Farmers in the Study Area to Mitigate the Challenges Posed by Rainfall Variability.

The goal of this objective assessed the adaptability strategies currently employed by farmers in the study area in order to mitigate the issues of rainfall variability. Table 7 and Figure 10 showed the results of farmers in Chanchaga local government area of Niger state on the adaptability strategies employed. 11.8% of the farmers used irrigation system during the agricultural drought,9.8% of the farmers used early and late planting method,16.8% of them used chemical during the pest and crops diseases, 23% of them used fertilizer during poor soil fertility and 2.8% of them used mixed cropping method. However,

Nhemachena (2014) showed that short distance to the capital, high livestock index and access to irrigation had significant effect on net farm revenue. Also, further investigation shows that short distance to capital and access to irrigation can help improve crop productivity, while livestock will serve as alternate livelihood to the small household farmers. In addition, Ochieng *et al*. (2016) studied the effects of climate variability and change on

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agricultural production in Kenya, and the result showed that increase in temperature has negative effect on total crop revenue and maize revenue but a positive effect on tea. Thus, they reiterated that low temperature can lead to scorching of tea plant especially at night.

Table 7: The Adaptability Strategies Used by Farmers in Chanchaga Local Government Area

Adaptability Strategies Used	Respondents	Percentage
Drought resistant crop	34	8.5%
Use of irrigation	47	11.8%
Early and late planting	39	9.8%
use of chemical	67	16.8%
Preservation of seedlings	14	3.5%
Use of organic manure	15	3.8%
Mixed farming practice	11	2.8%
Use of fertilizer	92	23%
Change land preparation date	14	3.5%
Changing harvesting dates	24	6%
Listen to news	31	8%
Other	11	2.8%
Total	399	100%

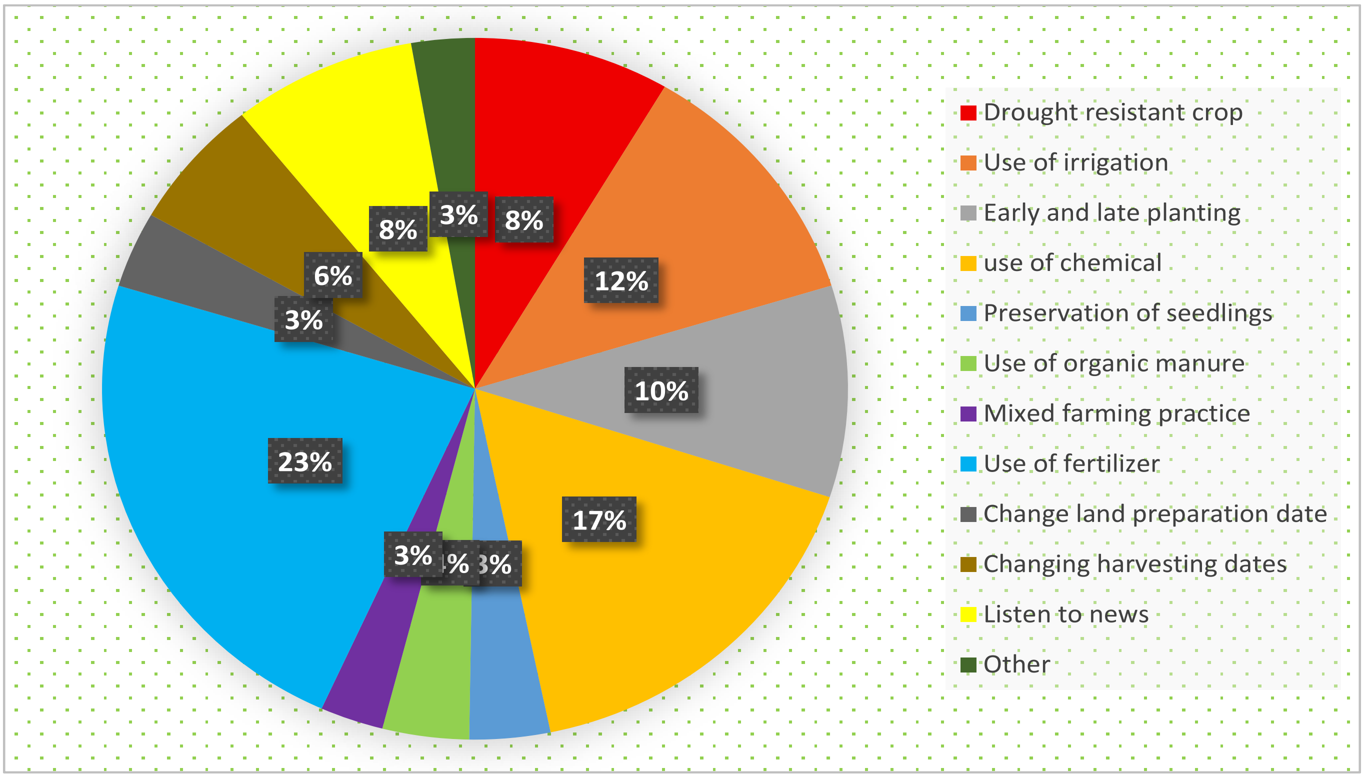

Figure 10: The Adaptability Strategies used by Farmers in Study Area

CONCLUSION

This study has demonstrated that rainfall variability exerts a significant influence on staple crop productivity in Chanchaga Local Government Area of Niger State, Nigeria. The spatio-temporal analysis revealed alternating phases of decline and recovery in rainfall between 1993 and 2023, with strong positive correlations between rainfall and yam and maize yields, while cassava showed moderate resilience. Farmers reported challenges such as delayed planting, reduced yields, pest spread, and declining soil fertility, highlighting the vulnerability of rain-fed agriculture. The findings also revealed a pronounced gender imbalance, with female farmers representing only 2.8% of respondents, reflecting socio-cultural and institutional barriers that restrict women's participation in staple crop production.

To strengthen resilience, the study recommends the promotion of climate-smart agricultural practices, including crop diversification, drought-resistant seed adoption, and small-scale irrigation schemes. Inclusive extension services are essential to integrate women's perspectives and ensure equitable access to land, credit, and training. Localized interventions should reflect the spatial clustering of rainfall distribution, while farmer education on climate risk management, early warning systems, and sustainable soil practices will enhance adaptive capacity. Aligning local strategies with national climate policies is critical for long-term sustainability and food security.

Nevertheless, the study has limitations. Farmer-reported perceptions may introduce bias, rainfall datasets may not fully capture micro-climatic variations, and the gender imbalance limits generalizability. Future research should therefore prioritize gender-focused studies, employ higher-resolution datasets, expand crop coverage beyond maize, yam, and cassava, and investigate the economic impacts of rainfall variability. Assessing community-based adaptation initiatives will also provide valuable insights for scalable resilience frameworks.

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