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ADAPTATION STRATEGIES OF FOOD CROP FARMERS IN RESPONSE TO CLIMATE VARIABILITY IN NDU SUB-DIVISION, NORTHWEST REGION-CAMEROON

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ABSTRACT

Globally, climate variability posed significant challenges on agricultural activities, particularly food crop production which is predominantly rainfed. However, farmers employ multiple adaptation strategies to cope with the challenges. Ndu Sub-Division remains a perfect example where food crop farmers practice adjustments in adversity of climate variability. The aim of the study was to examine the adaptation strategies of food crop farmers to climate variability in Ndu Sub-Division. The study was investigatory and explanatory in nature, adopting the mixed research design. Through the clustered random sampling technique, food crop farming communities were delimited, with 200 farmers selected and administered structured questionnaires. Enormous primary data were collected through interviews, interrogations, focus group discussions and direct field observations which were supplemented by secondary data sources such as published related articles, online and offline libraries, data bases, and magazines. Results showed that farmers mostly practice mixed cropping (68%), intercropping (22%) and rotation farming (10%) which have severely been affected by climate variability manifesting through late onset of rainfall (40%) increasing temperatures (32%), false start of rainfall (18%) and decline rainfall (10%). Empirical analysis of early growing season's climate data revealed large seasonal Coefficient of variations for rainfall (39.4%) and temperature (32.4%), and low values of relative humidity (4.2%); indicating unprecedented climate variability trend. Such variability provokes agricultural pests, diseases, soil moisture, stunted growth of crops, which reduce crop quality and induces severe agricultural losses. Food crop farmers often practice irrigation (6%), application of gro-chemical and organic manure (28%), seed replanting (24.8%) and grow improve seed varieties (16.6%) as means of adaptation. Contrastingly, these practices often yield temporal success as they are affected by high poverty, increasing magnitude of climate variability, limited knowledge, inadequate extension services and limited inputs. This work draws conclusion that Ndu Sub-Division has been a "bread basket" to immediate and proximal regions of Cameroon, and recommends that, participatory, holistic and objective strategies and policies be implemented in order to revamp the state of food production in the area.

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INTRODUCTION

Climate variability refers to the short-term changes in climate that take place over months, seasons, and years. This variability is as a result of natural, large scale climatic events such as global warming, the El nino-Southern Oscillation (ENSO) phenomena, South Pacific Convergence Zone (SPCZ), Inter-Tropical Convergence Zone (ICTZ), and the West Pacific Monsoon (WPM). These events bring extensive warming of the central and eastern Pacific, weaker than normal trade winds (easterlies) leading to major shifts in weather patterns across the Pacific and the world (Hoeng-Guldber et al., 2007). According to the IPCC (2018), there has been an unprecedented warming trend during the 20th Century. Surface air temperature increased about 0.2-0.6°C during the last century and further investigations indicate that this climatic parameter may vary between 1.5 to 4.5°C by 2100 (Abaurrea & Cerian, 2001). Parry et al., (2004) demonstrated that most Sub-Saharan Africa (SSA) countries will experience decreased precipitation of about 20 %.

Climate variability generates considerable uncertainties about future water availability in many regions of the world. It influences precipitation, runoff, ice melt, with effects on hydrological systems, water quality and its temperature, as well as, ground water recharge (FAO, 2015). Globally, Climate change and climate variability have been projected to contribute to increased drought episodes, food insecurity, irreversible decline in herd sizes, and deepening poverty. Fluctuations in temperature, relative humidity and precipitation are expected to shift production seasons, pest and disease patterns, and modify the set of feasible crops affecting crop yields, their prices, income and ultimately, livelihoods and lives (Cline, 2007). According to Perkins (2017), in Toronto, Canada, the effects of climate change have been noted particularly through high amounts of summer rainfall and sudden storms with intense winds and heavy rain, which is becoming more frequent. These changes posed multiple challenges to livelihoods and live, especially to the women who are more vulnerable to the emerging effects.

Crop yields in many parts of Africa will fall 10–20 % by 2050 because of severe warming. The burden of climate oscillation will be enormous on those already poor and food-insecure regions, particularly in the Arid and Semi-Arid Lands (ASALs). Over 5.7 million hectares of both subsistence and commercial farmlands have been inundated by flood water in East African region with 1.7 million hectares in Somalia and provoking about 180,000 refugees whereas, approximately 4.35 million people are now in dire need of humanitarian assistance (FAO & United Nations, 2023). Rainfall in Sub-Saharan Africa is characterized by strong variability (Faustin et al., 2017); countries such as Chad, Nigeria, Sudan, and Niger have experienced a decrease in rainfall, erratic rainfall patterns, and increased temperatures over the years. Noami (2002) and UNEP (2003), indicated that climate variability and change around the Lake Chad Basin have resulted to a 50% reduction in agricultural activities, approximately 30-50% decline in annual yields, and 5 million farmers directly affected in countries like Chad, Nigeria, Niger, and Cameroon resulting to food insecurity. The FAO (2023) reported that, approximately 733 million people faced hunger, equivalent to one in 11 people globally and one in five people in Africa. They further indicated that 2.33 billion people are facing food insecurity with a greater proportion in Africa

Agriculture incorporates about 70% of the total population in Cameroon and contributes to about 35% of the country's GDP (Molua & Lambi, 2006). Thus, it is considered the mainstay and main sustainer of the Cameroonian economy and a greater proportion of her livelihoods. Majority of the population in the country are agriculturally dependent and often described as "the wretched of the earth" (Fanon, 1961). Cameroon's rainfall in recent years has largely become inconsistent. It is characterized by a decreasing trend in the number of rainy days and the total amount of rainfall at a rate of 43mm per decade for the country. This has already been foretold in about 80% of the country, with a reported increasing trend in mean temperature of about 0.91°C (Ayonghe, 2001). The changing weather conditions over the years have been a setback to the perennial benefits farmers derived from these activities (Balgah et al., 2017). However, the recurrent effects of climate variability have also spurred agricultural innovation, that is, when subsistence farmers experience high pre-harvest and post-harvest losses induce by climate variability, they harness their indigenous knowledge such as crop rotation, fallowing, the adoption of improved seeds, irrigation and apply agrochemicals in order to reverse the situation (Yinkfu et al., 2025, Ngwani et al., 2024, Fordham et al., 2001). Ndu Sub-Division is part of Cameroon; characterized by a tropical highland climate shaped by its altitude, with distinctive agricultural systems which have over the years been affected by the observed unprecedented climate variability. Farmers' response strategies to this variability in Ndu Sub-Division, formed the basis of investigation.

Statement of the Problem

Amongst the five Sub-Divisions in Donga-Mantung Division, Ndu Sub-Division accounts for the largest share of agricultural activities; characterized by intense cultivation of food crop such as maize, bean, cocoyam and potatoes. Food crop production has overtime been a panacea to the hunger and starvation that most household in this Sub-Division usually faced. It has remained a source of food security, improved living conditions and local employment opportunities to the indigenous population in the area. However, these diverse benefits have been short-lived by the unprecedented climate variability happening in the area. The skewedness in the patterns of precipitation, and its late onset have resulted into recurrent dry spells and soil moisture deficiency which hinder crop growth. More so, increasing temperature conditions have amplified heat-waves on farmlands that affect plants' reproduction, flowering, development and maturity, couple with increasing agricultural pests and diseases which are recipes for crop failure. Climate variability has degraded well-to-do areas like wetlands, thereby hampering striving agricultural activities. There are however, contentions that the rapid population increased in the area would be subjected to severe and recurrent food security issues if climate variability challenges are not timely address. Therefore, with respect to the fact that agricultural activities remain rainfed in this area, likewise, being a rainfed activity and the dominant livelihood option to most households, this paper highlights the key and current climate issues, and examine the various adaptation strategies employment by farmers.

Location of the Study Area

Ndu Sub-division was created by presidential decree No. 93/322 of 25/11/1993. It is one of the five Sub-divisions of Donga-Mantung Division. It covers a total surface area of 1625km². Ndu Sub-Division has a total population of 90,136 inhabitants (BUCREP, 2025). Ndu Sub-Division lies between Longitudes 10°.50´48´´ east of the Greenwich Meridian and Latitudes 6°.20´25´´ north of the Equator. Ndu Sub-division has its headquarters in Ndu (Fig. 1).

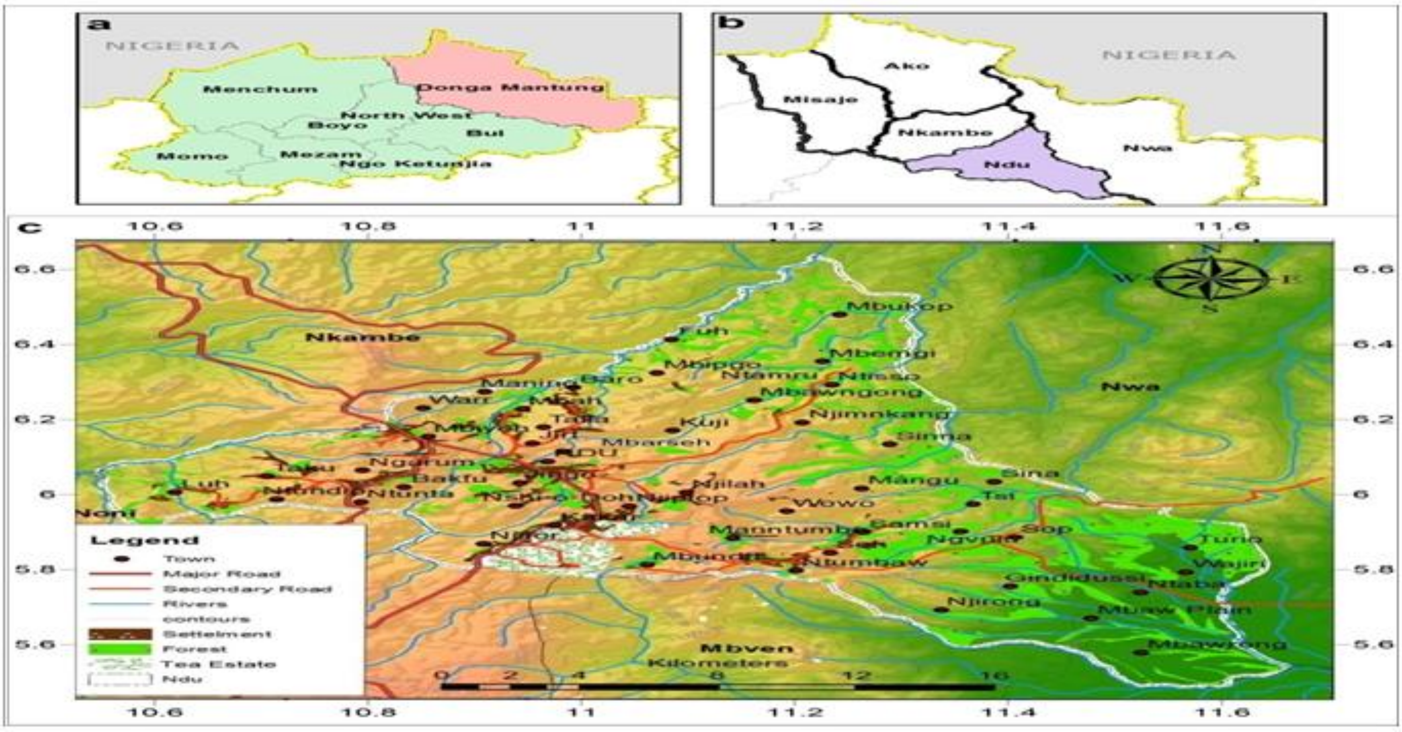


Figure 1: THE LOCATION OF NDU SUB-DIVISION
A=Donga Mantung Division in North West Region
B=Ndu Sub-Division in Donga Mantung Division
C=Layout Map of Ndu Sub-division
Source: Ndu Council (2023)

It shares common borders to the North with Nkambe Sub-division, to the south with Mbiame (Bui division), to the south-west with Nkum Sub-division (Bui division), west with Noni Sub-division (Bui division) and to the East with Nwa Sub-division. Its position is central to Nwa, Kumbo and Nkambe Sub-divisions

Research Methods

The study was descriptive and investigatory in nature, adopting the mixed research design, involving the qualitative and quantitative techniques. The investigatory approach necessitated inquiries on the types of crop cultivation, techniques, analysis of climate variability trends and effects on food crop production, while the descriptive approach facilitated enquiries on the adaptation strategies, challenges and recommendations. The mixed research design was adopted so as to tap the advantages enshrined in both qualitative and quantitative methods, thereby reducing their inherent biases.

The Targeted populations for this study were households within Ndu Sub-Division, agro-based institutions, NGOs, and workers of the Ndu Tea Meteorological stations, as well as, the local council. During the preliminary field survey, there were transact walks within farming communities in order to identify the communities mostly affected by climate variability such as, storms, heat-waves and floods. Thereafter, through a cluster random sampling technique, 200 food crop farmers were randomly selected to administer questionnaires. Added to these primary data source, were direct field observation, focused group discussions and interviews conducted with 8 key informants of the aforementioned institutions. The Ndu Tea Meteorological station was a reliable source of climatic data which was complemented with the data downloaded from NASA. More so, GPS tools helped in capturing the coordinates of targeted communities, thus, easing the production of cartographic maps. Secondary data sources, magazines, online and offline libraries, published related articles and monthly and annual data of agricultural outputs from institutions such as MINADER collected and integrated with the primary data.

The collected data were analyzed using two main statistical techniques. qualitative data were analyzed through content analysis while for the quantitative data, the descriptive statistical technique analysis was employed in order to establish the frequencies, standard deviations, ranges and percentiles from the quantitative data. Added to this, inferential statistical technique helped in establishing correlations, regression and projections. The analyzed results were presented on tables, figures, histograms and pie-charts whereas; photographs taken during fieldwork were displayed to show the realities on farmlands. Ethic-wise, the responses of the respondents were kept confidential and candid field observations were highly practice.

Results

Results have been analyzed and presented from the types and techniques of crops cultivated by farmers, climate variability trend, climate related challenges, adaptation strategies, and challenges.

Techniques of food cropping in Ndu Sub-Division

Analysis of the techniques of food crop cultivation practiced by farmers revealed that 64% engage in mixed-cropping, a practice whereby, many crops are crown on a single ridge without defined patterns, and 22.5% confirmed that they do practiced intercropping where many crops are crown on a single ridge following a particular pattern (Figure 1).

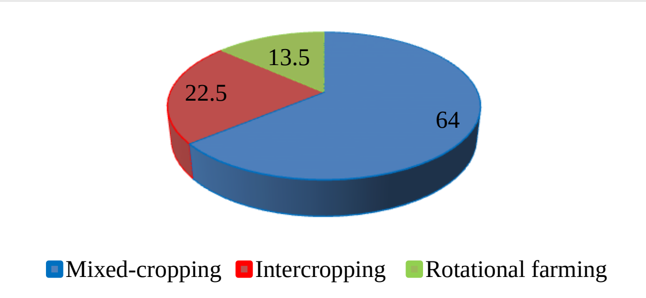


Figure 1: Techniques of food crop production in Ndu Sun-Division

Source: Fieldwork (2025)

From Figure 1, 13.5% of farmers agreed that they practice crop rotation, an agricultural practice where different types of crops are grown on the same piece of land in a planned sequence over successive seasons, instead of planting the same crop continuously. Plates 1 show sample of cropping systems in Ndu Sub-Division.

Plate 1: Food cropping techniques practiced by farmers in Ndu Sub-Division

Source: Fieldwork (2025)

Plate 1A shows a sample of mixed-cropping techniques practiced by farmers in Jirt village while plate 1B shows an intercropping field in Mbah village, all in Ndu Sub-Division.

Methods of farm preparation in Ndu Sub-Division

Farm preparation is one of the most significant activity involve in food crop production in Ndu Sub-Division. Data analysis revealed that most (52%) of the farmers prepare their farmlands by directly clearing grasses with machetes, 23.5% practice manual weeding with bare-hands while 18% openly set fire on their farmlands (Figure 2).

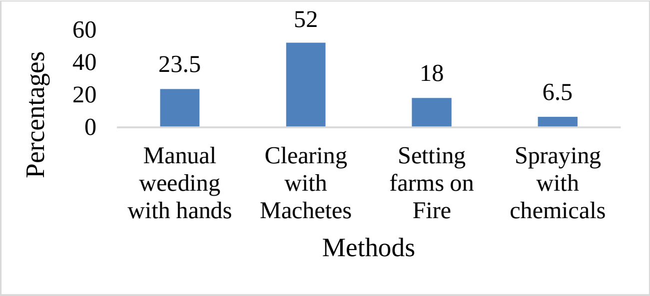


Figure 2: Farm Preparation techniques in Ndu Sub-Division

Source: Fieldwork (2025)

From Figure 2, 6.5% of farmers acknowledged that they do spray their farmlands with chemicals. This practice is rare in the area due to the high cost of chemicals which most farmers find it difficult to afford.

Climate variability trend in the Ndu Sub-Division

Climate variability trend has been analyzed in considering the overall trend (inter-annual basis) which is significant for understanding year-to-year variability, detecting long-term trends which further helps in supporting agricultural planning and management of climate related risks. Additionally, climate variability has been analyzed on seasonal basis, that is, with respect to the growing windows of different crop species. This helps in aligning climate data with crop growth stages, identifies the onset, length of the growing season, and shift in patterns as well as, revealing the actual climate conditions farmers experience as compared to the generic information provided by meteorological stations.

Inter-annual trend of rainfall and temperature conditions in Ndu Sub-Division

On inter-annual basis, rainfall conditions in the Ndu Sub-Division show an irregular distribution pattern, with some years recording high amounts of rainfall, while some records very low amounts. The years 1981, 1982, 2001, 2016, and 2017 recorded high amounts of rainfall above 300mm while 1991, 1999, 2009, 2013 and 2014 recorded very low amounts of rainfall below 150mm (Figure 3).

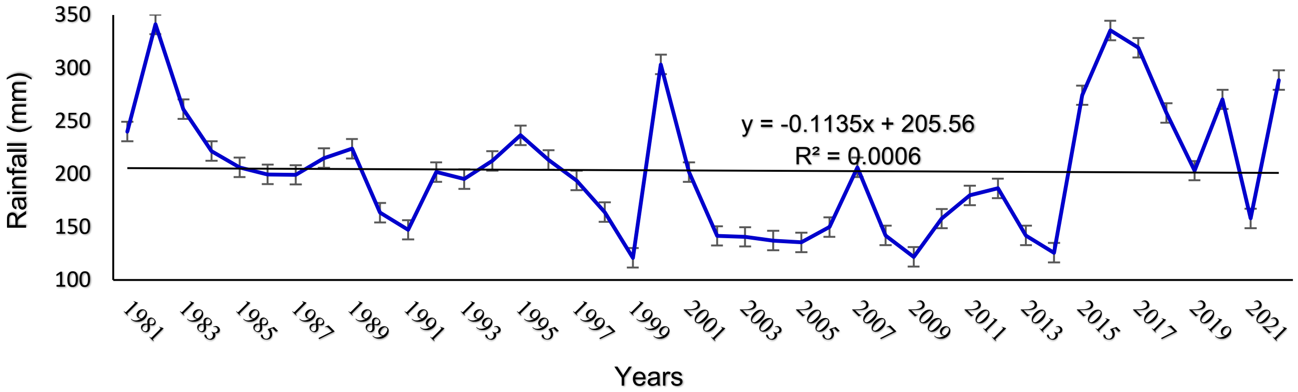


Figure 3: Inter-annual trend of rainfall in Ndu Sub-Division

Source: NASA Climate Data (2024)

From Figure 3, analysis revealed an uneven distribution of rainfall patterns which reflect the erratic nature of rainfall in the area. Such variability has direct implications for agricultural planning and food crop production. It shows the level of uncertainty farmers face due to changing weather conditions in Ndu Sub-Division. Conversely, results also revealed an inconsistent pattern in temperature distribution patterns from year-to-year in Ndu Sub-Division. Temperature conditions are crucial for crop germination, development and maturity but deviations from optimal values are detrimental to crops. Temperature conditions exhibit notable fluctuations with alternate increase and decrease, highlighting the variable nature of the climate. For instance, from 1981 to 1986, temperature trend shows favorable conditions averaging below 21oC, while the year 1988, 1998, 2003, 2004 and 2021 show increasing temperature trends above 21oC. Generally, the inter-annual temperature trend of Ndu Sub-Division shows a fluctuating pattern with an overall increased in the trend (Figure 4)

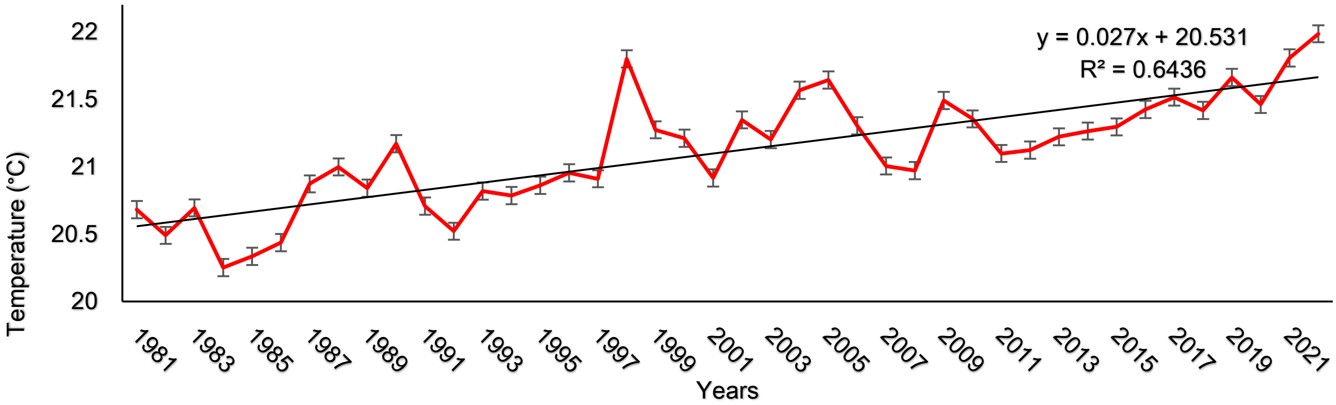


Figure 4: Inter-annual trend of temperature conditions in Ndu Sub-Division

Source: NASA Climate Data (2024)

From Figure 4, the irregularities in the trend of temperature condition create uncertainty in planting and harvesting schedules. Overall, temperature variability reduces the reliability of agricultural production and threatens food crop production.

Seasonal climate variability in Ndu Sub-Division

With respect to the fact that the study targets seasonal crops such as beans and a long seasonal crop like maize, analysis has been done on seasonal basis, that is, considering the growing window of beans; cultivated from march to June and maize production; cultivated from March to October. The analysis of patterns provides meaningful insights for crop production as compared to the overall totals.

Seasonal rainfall variability in Ndu Sub-Division

Rainfall analysis for the early growing season (march to October) shows a progressive increase from March (111.6mm), to June (310mm). indicating a typical seasonal build-up of rains. This pattern reflects intra-seasonal climate variability, which influences planting decisions, crop establishment and overall food crop production. Figure (5)

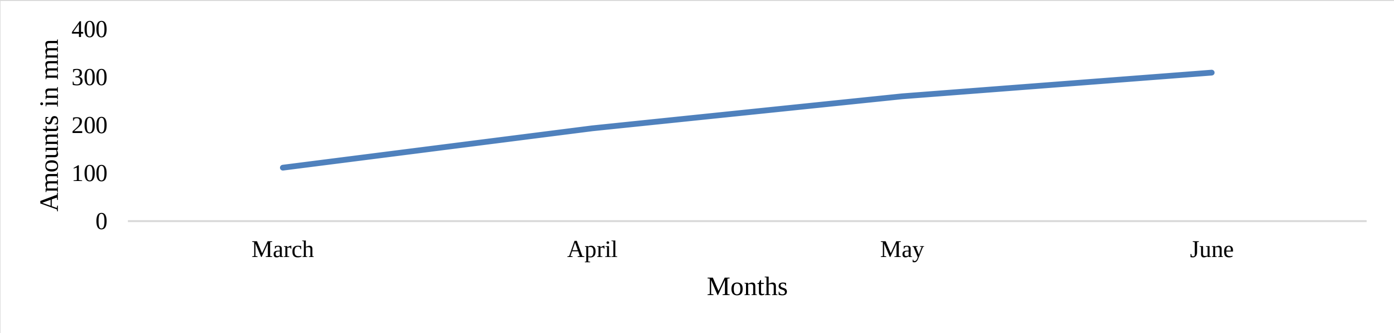


Figure 5: Seasonal Rainfall variability from March to June

Source: NASA Climate Data (2024)

The decrease in rainfall, particularly in March limits the available soil moisture for the germination of beans and maize. It delays seed planting and instigates uneven seed emergence. Early moisture stress may reduce plant vigor and eventual yields, while the increasing values in June may make things difficult for farmers to preserve harvested beans while maize will develop more faster but may suffer from diseases such as root rust and water lodging on farmlands.

Conversely, rainfall conditions fluctuate with minimal trends during the main growing season which runs from July to October. Rainfall amount is recorded at 300mm in July which encourage fast maize growth and gain filling, increases above 350mm to 400mm in September while dropping below 350mm in October (Figure 6)

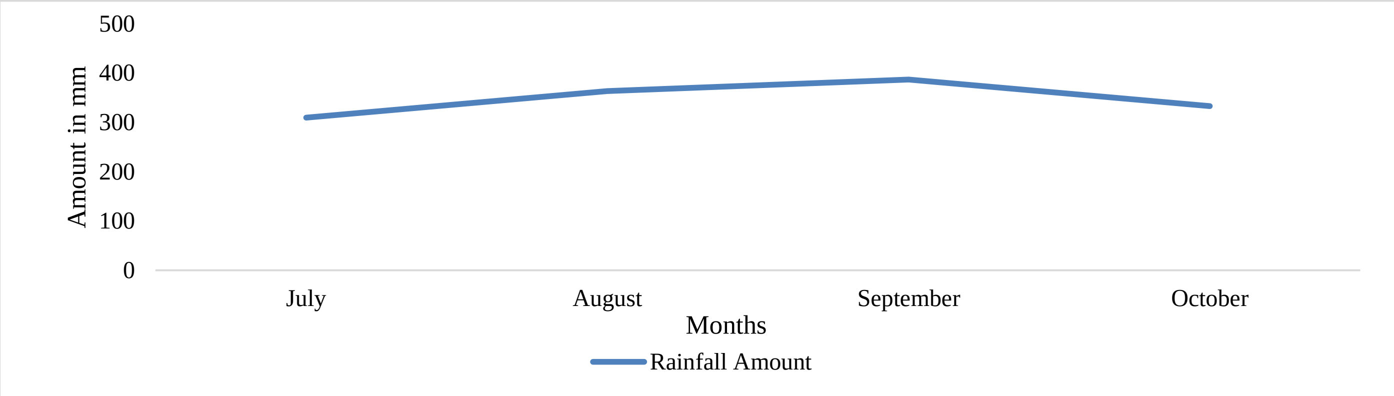


Figure 6: Seasonal rainfall variability from July to October

Source: NASA Climate Data (2024)

From Figure 6, excessive rain in August and September, can cause waterlogging, increase pest and diseases incidence, ad hinder timely field operations. The slight decline in October helps reduce the risk of harvest delays. Overall, the rainfall pattern is generally favorable but requires careful crop management to avoid negative effects.

Seasonal temperature variability in Ndu Sub-Division

During the early growing season that runs from March to June, mean temperatures gradually decreases from 23oC in March to 21.4oC in June, indicating a slight but consistent decline from March to June. This indicate cooling as the season progresses, and this favors beans and maize cultivation. However, increasing trends in March may affect seed sowing and germination as it encourages rapid evapotranspiration and consequently, moisture deficiency (Figure 7)

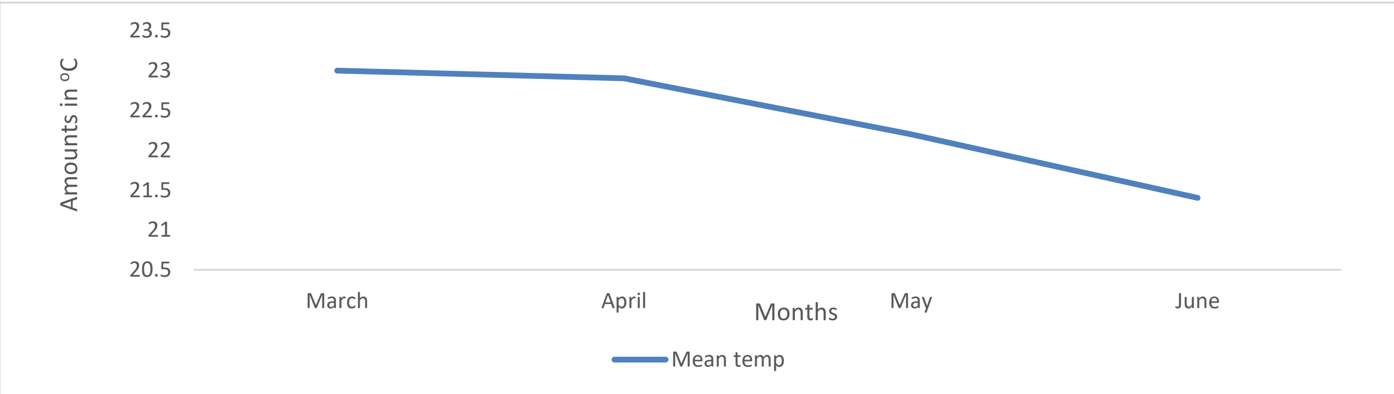


Figure 7: Seasonal temperature variability from March to June

Source: NASA Climate data (2024)

From Figure 7, overall, the cooling trend reduces heat stress and evaporation, supporting early crop growth. Combined with increasing rainfall, this temperature patterns creates favorable conditions for crop establishment during the early growing season.

Furthermore, temperature conditions show a fluctuating trend during the main growing season that runs from July to October. It shows slight fluctuation, ranging from 19.8oC in August and 20.7oC in October. The pattern indicates relatively stable and moderate conditions conducive for maize development growth and grain filling. Small variations help reduce heat stress while maintaining metabolic activity essential for crop development (Figure 8).

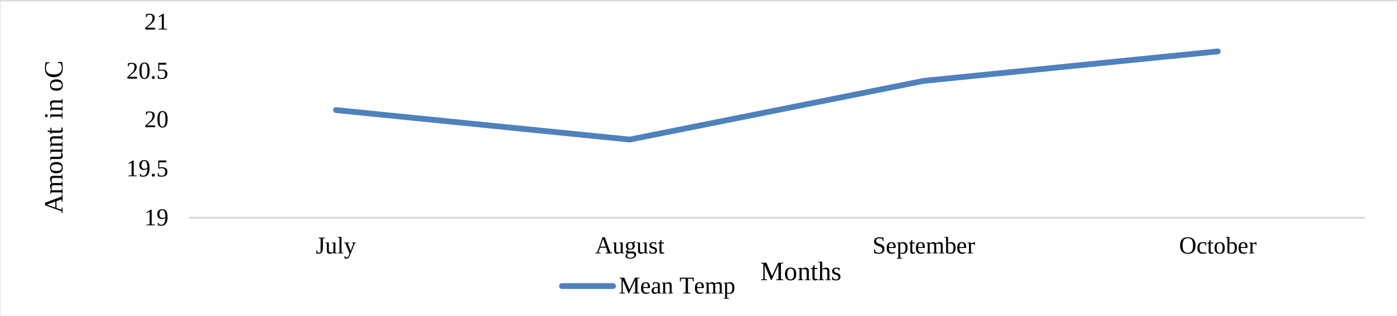


Figure 8: Mean Seasonal temperature from July to October

Source: Fieldwork (2024)

From Figure 8, combined with sufficient rainfall during this period, these temperature support high productivity. However, persistent cooler months may slightly slow crop maturation, requiring careful monitoring of the harvest period. The increasing temperature conditions in September and October encourage early harvest and late harvest in October is safe from preservation challenges.

Seasonal relative humidity trend (March to October)

Relative humidity trend across the entire growing seasons, that is, from March to October, shows a clear upward trend from 70% in March to a peak of 90% in August, followed by a slight decline to 88.1% in October. The increasing relative humidity during the early and main growing seasons, indicates a humid environment favorable for maize and beans growth, supporting germination, leaf development, and overall plant vigor. The relative humidity, especially between July and September, ensures adequate moisture in the atmosphere but may also increase the risk of fungal diseases such as maize rust and beans blight. (Figure 9).

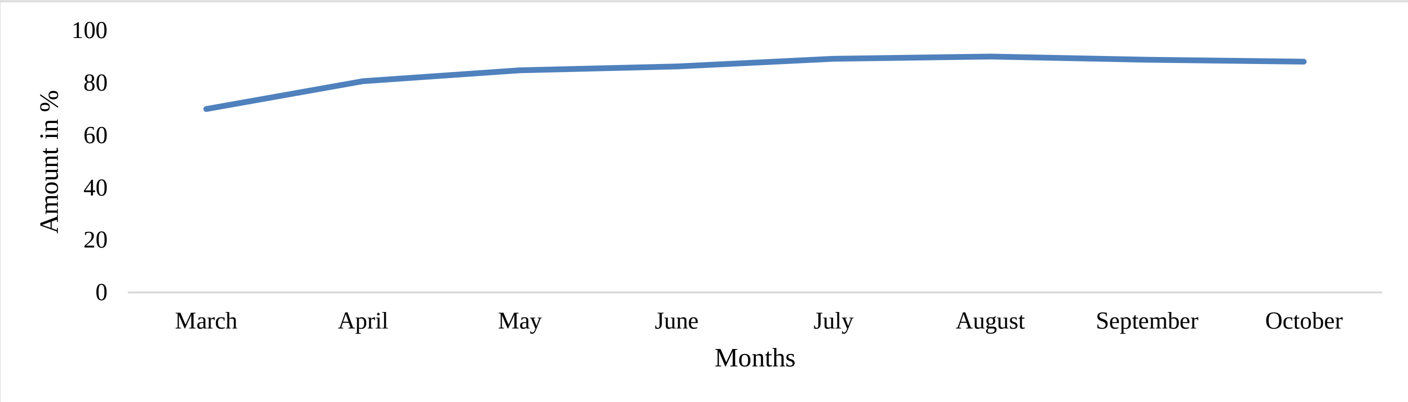


Figure 9: Seasonal relative humidity trend from March to October

Source: NSA Climate Data (2024)

From Figure 9, the slight decrease towards October, helps reduce excessive diseases pressure and facilitates crop maturation. Overall, the relative trend support crop production but requires attention to diseases management during the peak humidity months.

Summary of climate characteristics of Ndu Sub-Division

The overall climate characteristics of Ndu Sub-Division for the early and growing season are as presented on Table 1.

Parameter	**Season**	**Mean**	**SD**	**CV (%)**
Rainfall (mm)	Early growing season	218.9	86.0	39.3
	Main growing season	348.5	32.2	9.9
Temperature (^{o}C)	Early growing season	22.4	0.53	32.4
	Main growing season	20.2	0.28	17.8
Relative Humidity (%)	Early growing season	80.5	6.9	4.2
	Main growing season	89.0	0.8	0.1

Source: Generated from NASA Climate Data (2024)

In Ndu Sub-Division, the early growing season experience a mean rainfall of 218.9mm with a standard deviation of 86.0 (CV=39.3%), indicating moderately high but variable rainfall. temperatures are relative warm at 22.4oC (SD=0.53, CV=32.4%), while relative humidity average 80.5% (SD=6.9, CV=4.2%), showing moderately stable moisture conditions. During the main growing season, rainfall increases to 348.5mm with lower variability (SD=32.2, CV=9.3%), temperature cool to 20.2oC (SD=0.28, CV=17.8%), and relative humidity becomes very high and stable at 89.0% (SD=0.8, CV=0.1%). Overall, these patterns indicate that while the early growing season is variable and may pose risks for planting, the main growing season provides cooler, wetter, and highly stable conditions, favorable for crop growth and yield reliability.

Correlation between rainfall, maize and beans production in Ndu Sub-Division

Correlation between rainfall and beans production has been analyzed using rainfall data recorded from the month of March to June, which is the actual period when farmers cultivate beans (Figure 10).

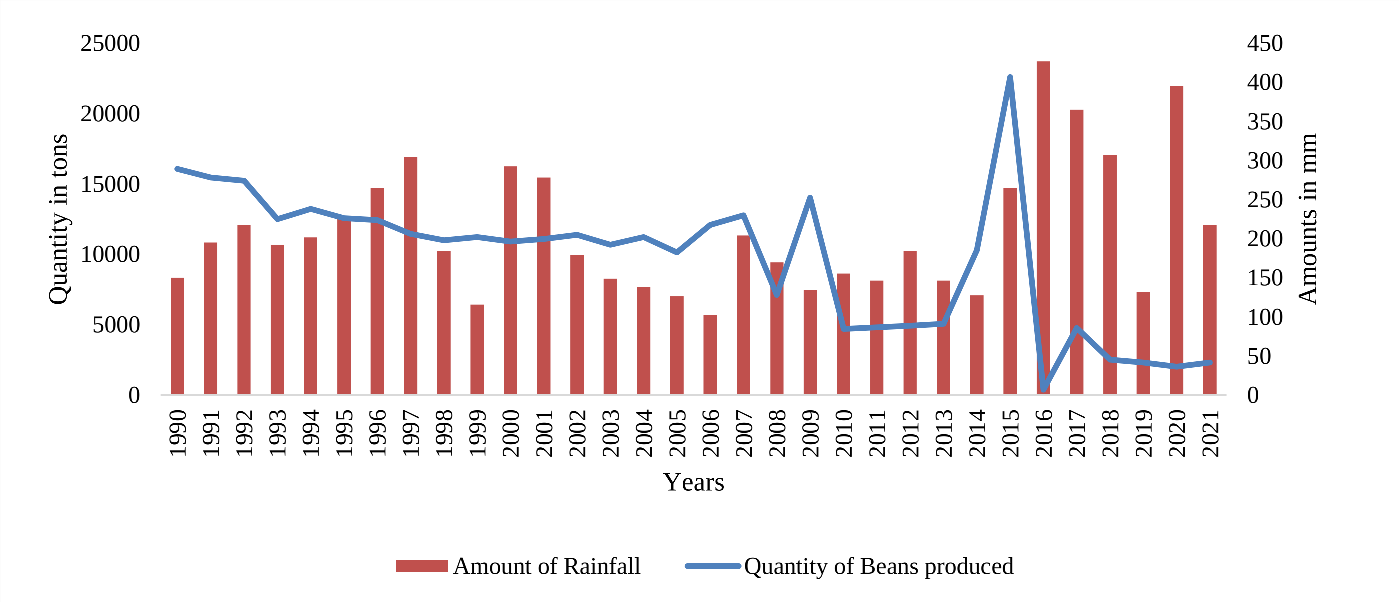


Figure 10: Relationship between rainfall and beans production

Source: Fieldwork (2024)

From Figure 10, a direct relationship exists between rainfall and beans production in Ndu Sub-Division, that is, increasing rainfall leads to improvement and increase in beans production. For instance, the period 1990 to 1997 depicted a fairly distribution in the amount of rainfall (above 200mm), which resulted to little fluctuation; exhibiting an increasing trend. The increased in the amount of rainfall in the year 2000 and 2001, led to an increased in the production of beans (1097.36 and 1105,46 tons, respectively). Contrastingly, from 2010 to 2014, rainfall dropped below 200mm and less than 5000 tons of beans were produced through these years. However, an inverse trend occurred from 2016, 2017, 2018, 2020 and 2021, whereby, a general increase in the amount of rainfall (above 300mm), resulted to a drastic dropped in the quantities of beans production. This phenomenon is simply explained by the fact that, although there have been massive increased in the amount of rainfall, the patterns have been shifted from the normal trend and occurring during flowering and harvesting period unlike the planting and germination stages that it is highly needed. Torrential rains during flowering result to the abortion of flowers, while that during harvesting instigate beans blight.

A similar relationship exists between rainfall and maize production, that is, increasing rainfall encourage high production of maize. Rainfall data has been analyzed from March to October, which is the actaul period when farmers grow maize. Typical cases are those of 1995 (340,8mm, 5673.4 tons) and 2000 (427.1mm, 50388.2 tons (Figure 11).

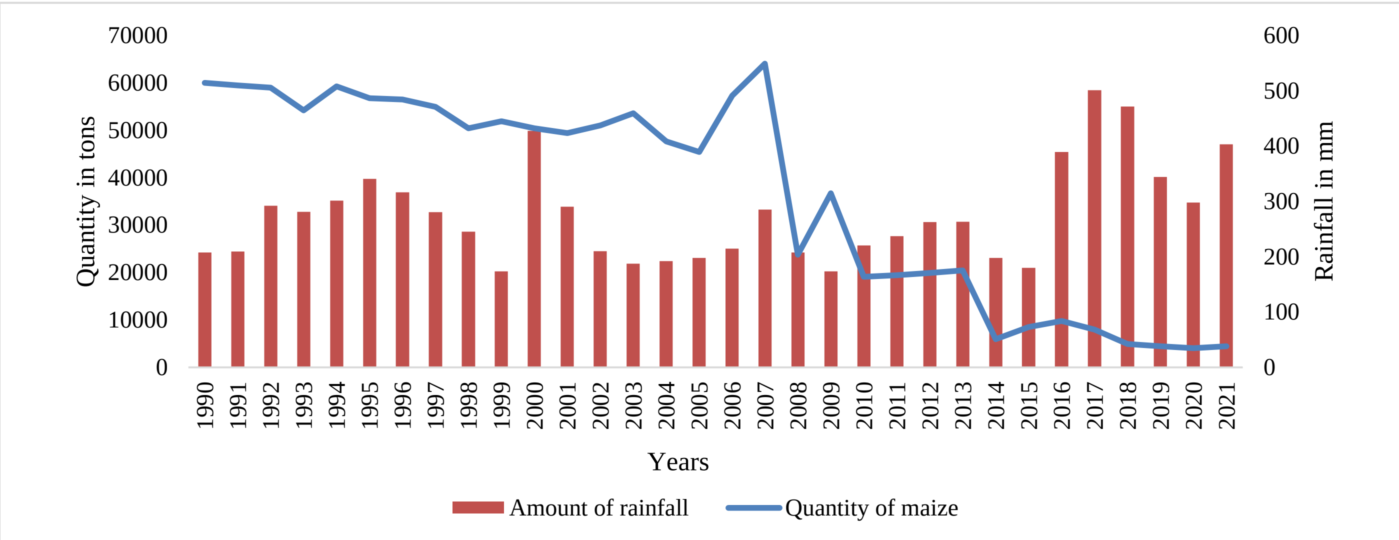


Figure 11: Relationship between rainfall and maize production

Source: Fieldwork (2024)

Due to the skewedness in the patterns of rainfall which has been very common from 2016 to 2021, maize production continue to decline amidst increasing rainfall trend due to drastic destructions from heavy rains, storms, flood, severe preservation challenges, as well as, agricultural pest and diseases. It should however, be noted that, the massive increase in maize and beans from 2006 to 2008 amidst rainfall deficiencies were due to agricultural intervention programs launched by the government that resulted to the provision of high yielding varieties of seed and inputs to farmers.

Correlation between temperature, maize and beans production in Ndu Sub-Division

With respect to bean production, the recordings of temperature conditions were extracted and analyze from March to June when beans are actually cultivated by farmers. analysis shows an inverse relationship between temperature conditions and beans production. As temperature increases, the quantity of beans produced, drop drastically. This is a similar case of 1998 with temperature conditions observed at 23.2oC, (11.000 tons), 2002 (Temp 22.9oC, 11383.4 tons), and 2010 (temp 22.9, beans=4696 tons), while low temperatures encourage high production of beans like the cases of 1990 to 1994 with temperature conditions below 21.5oC and all recorded above 15000 tons of beans (Figure 12).

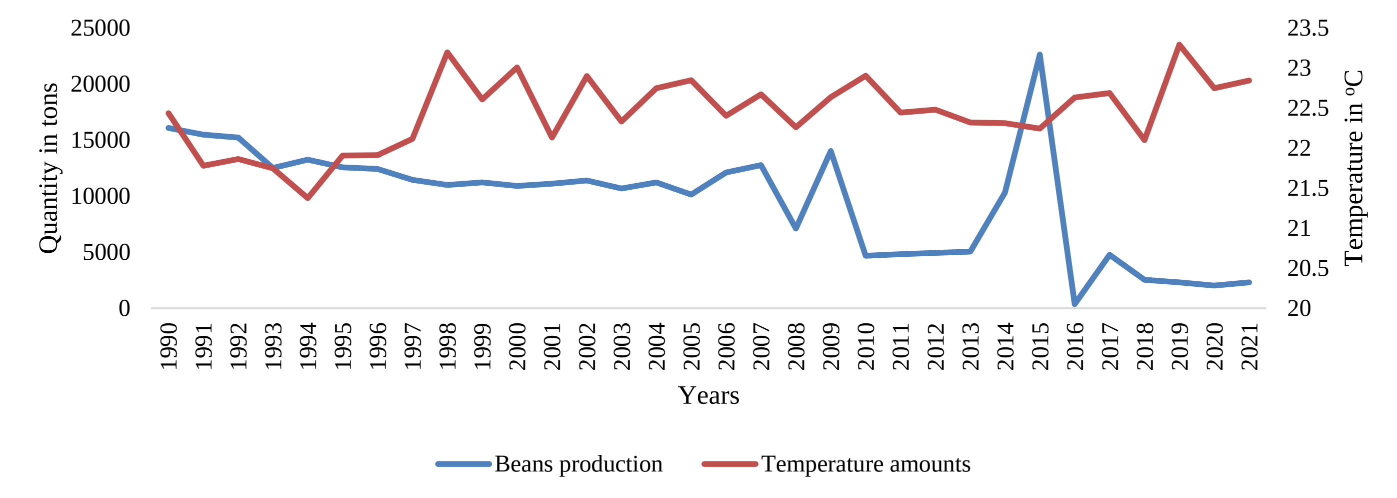


Figure 12: Relationship between temperature and beans production

Source: Fieldwork (2024)

From Figure 12, a real situation of increased temperature conditions with decreased beans production was observed from 2016 to 2021. This shows how farmers in Ndu Sub-Division are currently grappling with issues generated by increasing temperature conditions. Conversely, temperature variability also influences the quantity of maize production in Ndu Sub-Division. From 1991 to 1994, temperature conditions were normal and recorded below 22oC and a minimum of 54139.1 tons of maize and above were produced by farmers during this period, and 2005, mean temperature condition was 22.8oC and just 45422 tons of maize were produced (Figure 13).

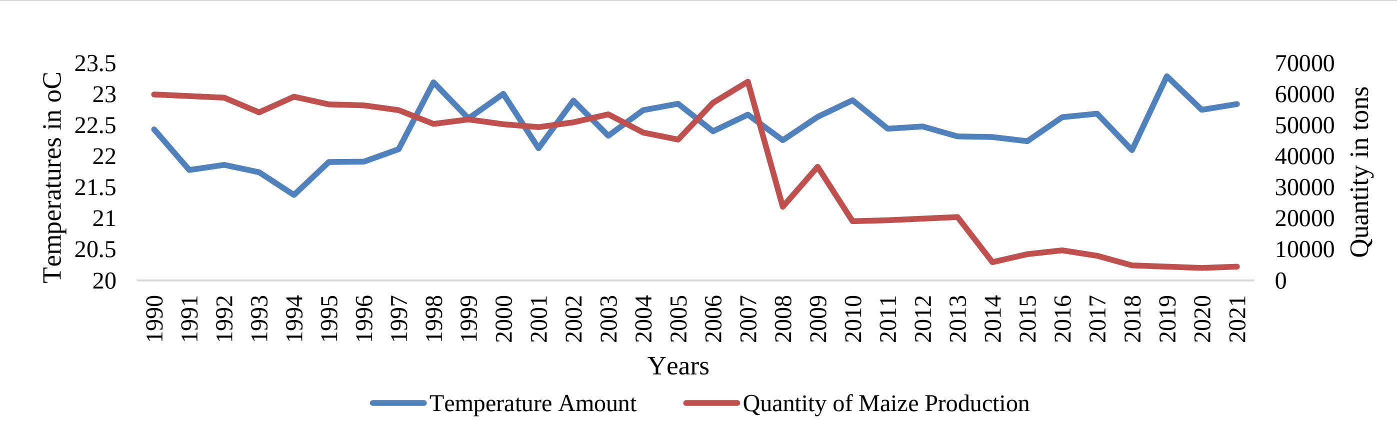


Figure 13: Relationship between temperature and maize production in Ndu Sub-Division

Source: Fieldwork (2024)

From Figure 13, there have been clear indications of the adverse effects of increasing temperature on maize production from 2010 to 2021 whereby, average temperature conditions generally go above 22.8oC, with a generally maximum production recorded at 20,400 tons and minimum recorded at 4,431 tons.

Pre-harvest and Post-harvest Climate Variability Challenges in Ndu Sub-Division

Climate variability poses multiple pre-harvest challenges on food crop production in Ndu Sub-Division. 25% of the farmers complained of moisture deficiency which is experience mostly during seed planting and germination, 20% pointed at intensive soil erosion, affecting mostly farmers operating of steep slopes, while 18.5% acknowledge the proliferation of pests and diseases that attack maize, potatoes and maize (Figure 14).

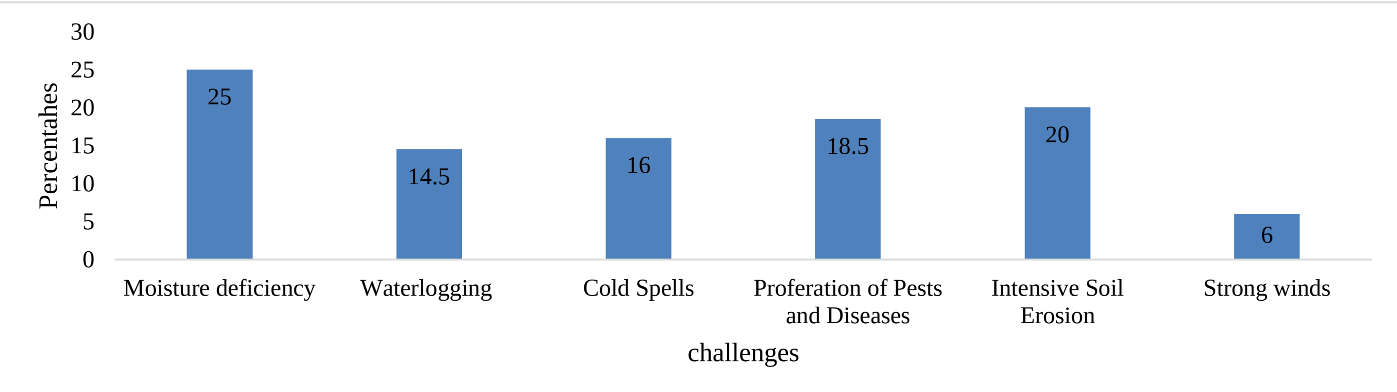


Figure 14: pre-harvest climate variability challenges

Source: Fieldwork (2024)

From Figure 14, 16% of the farmers revealed the prevalence of cold spells especially in the month of June and July that retard plant growth by causing them to be stunted, 14.5% complained of waterlogging on farmlands especially those operating on wetlands while 6% acknowledged crop damages caused by strong winds.

Further field investigations also revealed that farmers grapple with many issues after farm produce have been harvested. A majority (28%) of farmers complained of suffering with high and intense rain that makes the preservation of harvested yields challenging, 22.5% acknowledge the prevalence of pests and diseases such as weevils and fungi in storage facilities, and 18.5% pointed out at transportation challenges which make it difficult to transfer farm yields to storage areas and market centers (Figure 15).

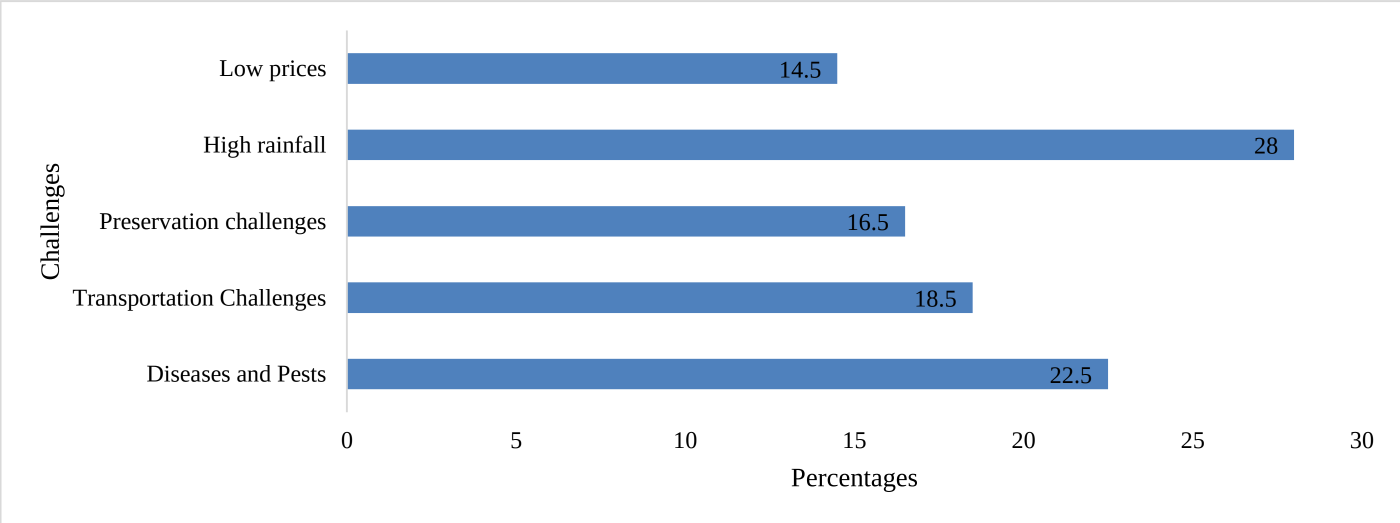
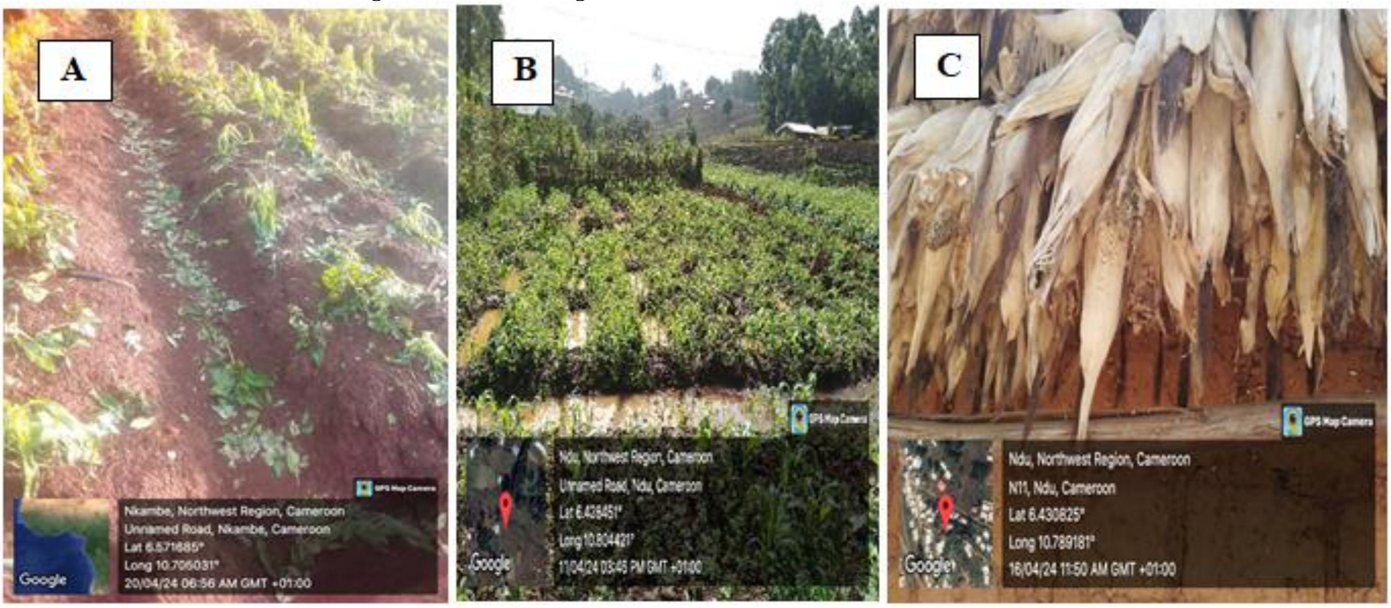


Figure 15: Post harvest challenges face by farmers in Ndu Sub-Division

Source: Fieldwork (2024)

From Figure 15, 16.5% of farmers said that they usually face preservation challenges as most of the preservation infrastructures like wooden huts and barns are destroyed by heavy rains and storms and the limited hours of sunlight makes it challenges for farm yields to get dry, and 14.5% pointed out that because of climate variability, the quality of farm yields remains very low and thus, commanding lower prices. Plates 2 show samples of pre and post-harvest challenges induce by climate variability in Ndu Sub-Division



Plates 2: Pre and post-harvest climate induce challenges in Ndu Sub-Division

Source: Fieldwork (2024)

Plate 2A shows a farmland destroyed by hailstorms in Ngarum village, plate 2B shows waterlogging on farmlands in early growing season caused by torrential rainfall, and Plate 2C shows preserved maize attacked by weevils and rodents in a storage area.

Farmers adaptation strategies to climate variability during pre-harvest period

Food crop farmers implement adaptation strategies both at the pre-harvest and post-harvest levels. At the pre-harvest level, 28% of the farmers confirmed that they do apply agrochemicals and organic manure to improve soil fertility and accelerate crop development, 24.8% pointed out that they do replanting of seed during period of poor seed germination and failure, and 16.6% acknowledge that they usually adopt improved agricultural seeds (Figure 16).

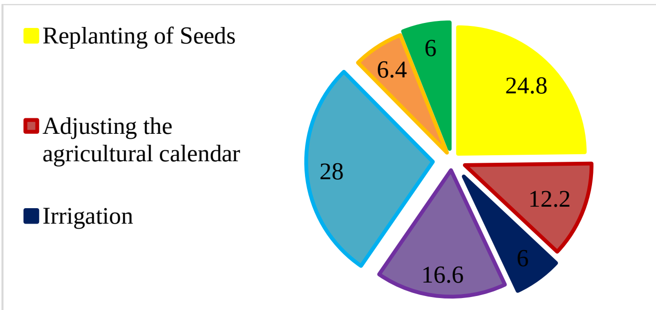


Figure 16: Pre-harvest adaptation strategies to climate variability

Source: Fieldwork (2024)

From Figure 16, 12.2% confirmed that they adjust their planting sessions to suit the agricultural calendar which is often upset by climate variability, 6.4% said that they do practice extensive farming systems to increase overall farm yields, and 6% acknowledge that they practice diversification by planting other crop species and keeping domestic animals. Conversely, concerning the post-harvest issues, farmers adapt to torrential rainfall by doing early and timely harvesting of farm yields as supported by 30.8%, 24.2% adapt by doing open dry of farm yields in the sun, while 16% said they apply pesticides in storage facilities to control pest and diseases (Figure 17).

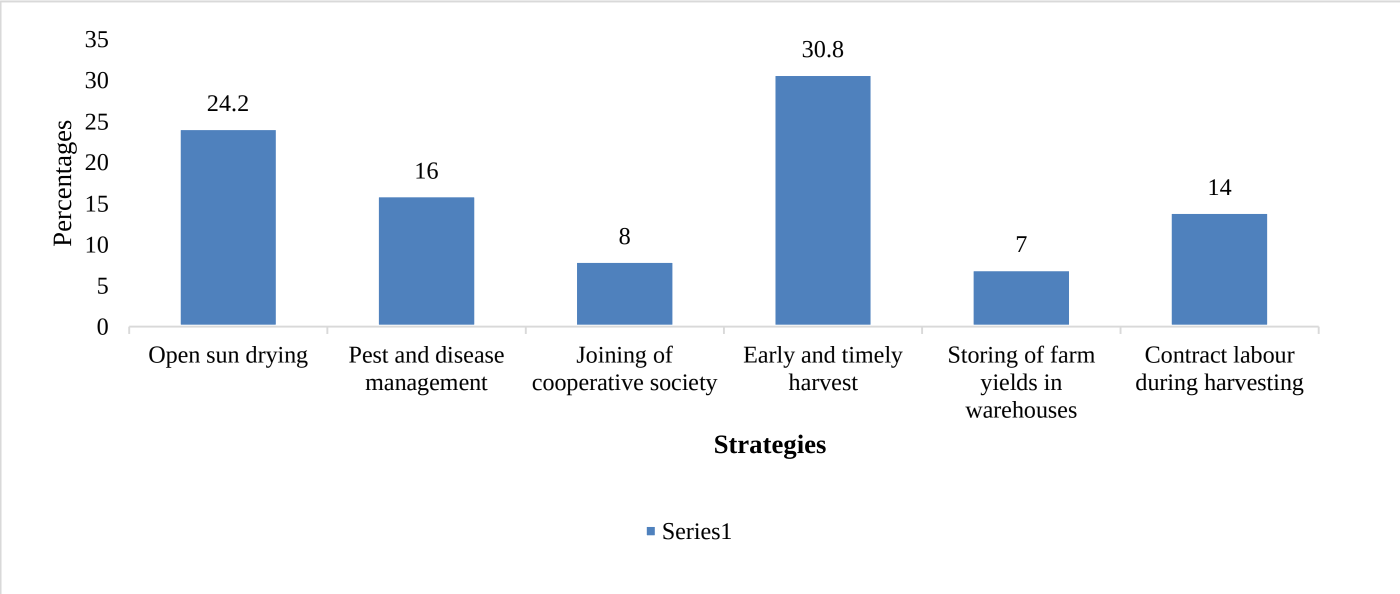


Figure 17: Post-harvest adaptation strategies to climate variability

Source: Fieldwork (2024)

From Figure 17, 14% acknowledge that they employ contract labour to facilitates crop harvesting and transportation to storage areas during torrential rainfall, 8% said that they do work in collaboration with cooperative societies to demand for higher prices and improve farming techniques, while 7% pointed out that they do store farm yields in warehouse in market areas into to prevent lower prices and fluctuation. Contrastingly, focused group discussions with farmers revealed that most of the adaptation strategies are affected by poverty, limited government support, limited knowledge and extension services, conservative and poor adoption of innovations by farmers, farmer-grazier conflicts, ageing seed and farmlands, as well as, increasing magnitudes of climate variability. Plates 3 show evidences of pre-harvest adaptation strategies to climate induced challenges in Ndu Sub-Division.

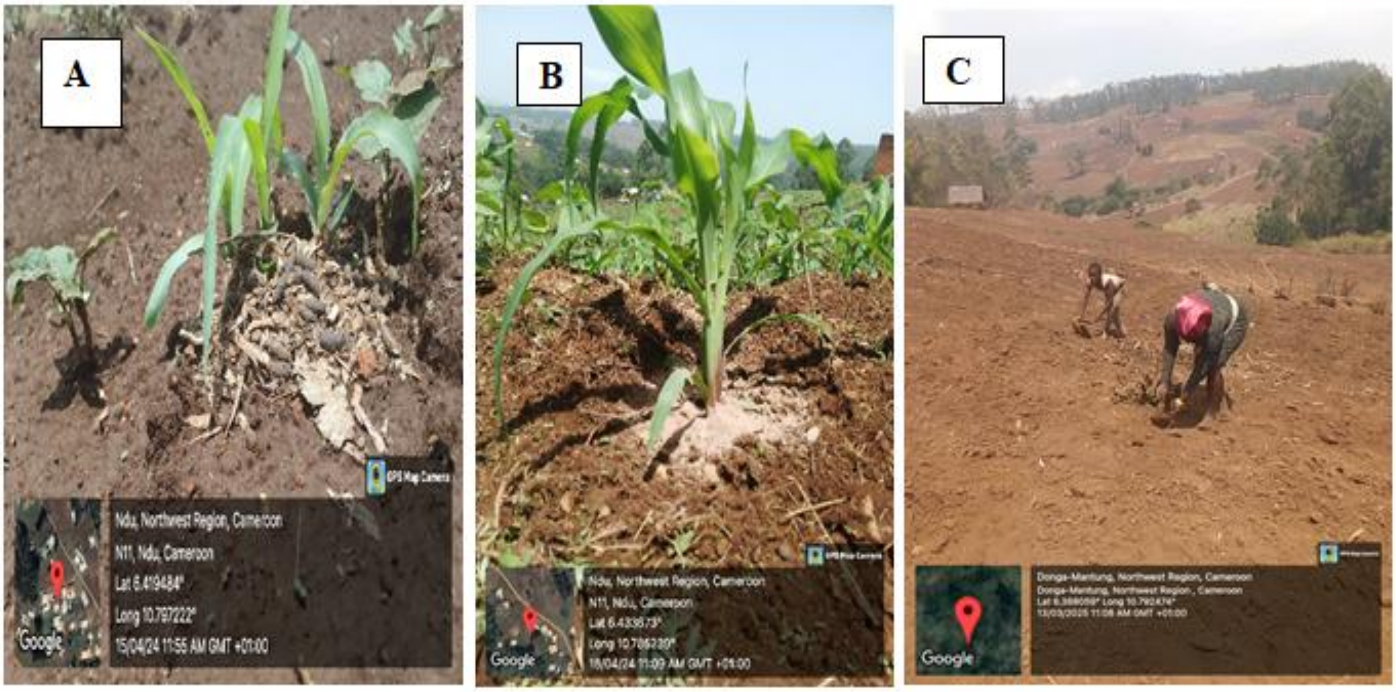


Plate 3: Samples of pre-harvest and post-harvest adapatation strategies in Ndu sub-Division

Source: Fieldwork (2025)

Plate 3A shows a sample of animal manure applied by a farmer on maize and beans to improve soil fertility, Plate 3B shows wood ashes applied on maize by a farmer to limits the spread of agricultural pest and diseases while Plate 3C shows farmers practicing risks farming by planting seed while waiting for the onset of rainfall. This is often done when there is delay in the onset of rainfall. Plates 4 further show the post-harvest adaptation strategies implemented by farmers

Plates 4: Post-harvest adaptation strategies implemented by farmers IN Ndu Sub-Division

Source: Fieldwork (2025)

Plate 4A shows maize hanged on sticks by the wall of a house to facilitates dryness through ventilation and sunlight, Plate 4B shows beans hanged on the walls of a domestic kitchen to enhance they dryness while Plate 4C shows a direct drying of husked beans in sunlight.

Discussion of findings

Investigations found that farmers in Ndu sub-Division cultivate multiple species of food crops which range from cereals, tubers and perennial crops. The selection of these species depends on the prevailing environmental conditions, farmer's choice, market demand and adaptation resilience. The analysis also shows that in growing these crops, farmers employed different cultivation techniques such as mixed farming, intercropping and crop rotation with the central issues of diversifying risks, manage soil nutrients and promote nutritional diversity. It was also observed that farmers implement different strategies in preparing their farmlands with manual clearing with machetes, hoes, spraying and the setting of farmlands on fire being the major practices. These findings tight with that of FAO (2015) and 1PCC (2018) who have stressed in their scientific publications that the diversification of agricultural production systems could be remedies for crop failure and nutrient deficiency.

Empirical evidence highlights that Ndu Sub-Division is experiencing climate variability which is evident on inter-annual basis. precipitation patterns have been erratic from 1981 to 2021, with some agricultural years recording very high amounts of rainfall while some record very low amounts. The statistical results also confirmed that the same trend emerge for temperature and relative humidity conditions, depicting recurrent non-uniform distribution which negatively influence agricultural activities. The data demonstrated that years with clear climatic deviations where 1998, 1999, 2016, 2017 and 2020. These results are replica of Molua and Lambi (2006) who observed that rainfall amounts were decreasing within the agricultural landscapes of Cameroon, while temperature conditions were increasing with steady trends.

clear climate trends emerge within growing season exhibiting recurrent fluctuations in the amounts and patterns of rainfall, temperature and relative humidity which are crucial for the cultivation of food crops. With respect to rainfall variability, the early growing season which runs from march to June experience more deviations with higher coefficient of variations indicating unreliability for crop cultivation while the main growing season which spans from March to October, experiences steady fluctuation with increasing rainfall trend which encourages seed germination and emergence, development, flowering and maturity. Contrastingly, increasing rainfall amounts was observed to be detrimental to crop as it encourages fungi diseases, waterlogging and delay crop maturity. The trend of relative humidity was irregular with increasing values which are recipes for soil moisture availability. Analysis also revealed that temperature conditions are skewed and the increasing conditions in March and April affect seed germination and emergence while its decrease in August and September negatively affects crop preservations. Overall, data analysis confirmed that the early growing season is characterize by more agricultural risks as compared to the main growing season. These results were confirmed in an investigation by Balgah et al., (2017), who noted that there were unequal distributions of climate parameters across Buea Municipality which interrupted most agricultural activities.

Rainfall exhibited a positive relationship with maize and beans production, that is, increasing amounts of rainfall across growing season was directly followed by an increase in the quantity of maize and beans production. However, an assessment of temperature relationship with maize and beans productions shows a negative relationship with production recurrently declining with increasing temperature conditions, with typical cases in 2002, 2010, 2016, 2019, and 2020. Optimal rainfall amounts are crucial for stable and thriving crops, the same for temperature and relative humidity. Any deviations affect crops either through moisture deficiency, prevalence of pest, disease, flood and soil erosion. These results are true with that of Noami and UNEP (2002) who observed that climate variable has led to declining quantities of food production on farmlands in proximal community of Lake Chad.

Investigations revealed that climate variability affect pre-harvest production by instigating soil moisture deficiency and heat stress which affect seed germination, emergence, poor development and growth, poor grain fillings, diseases and pests while during post-harvest crops are affected by fungi, blight, instigated by torrential rains which prevent timely field operations, coupled with the affected transportation systems which make things difficult for farmers to transport farm yields to market center and storage areas. This result is consistent with that of Balgah et al., (2017), who brought to light that farmers in Buea Municipality were suffering from pest, diseases, moisture deficiency and soil erosion instigated by climate variability.

Findings revealed that food crop cultivation plays crucial roles to farmers providing them sustainable livelihoods. With respect to this, farmers occasionally implement adaptation strategies in order to reverse the frequent climate variable effects which do dwarfed the perennial benefits they derive from the activity. The common adaptation strategies are: seed replantation during poor germination, application of agrochemicals and organic manure, irrigation, crop diversification and extensive farming practice.

However, these practices are cut-short by poverty, limited knowledge, limited supports, increasing magnitudes of climate variability and amplifying rate of pest and diseases. These findings on adaptation measures and their challenges have appeared severally in the scientific papers of Tume & Ngwa (20232) and Ngwani et al., (2024)

Conclusion

Ndu Sub-Division harbors a greater proportion of human population whose livelihoods depend on agricultural activities. Worthwhile agricultural practices were recorded by farmers down the memory lane through diverse production techniques such as mixed-cropping and intercropping systems, but today, these systems have been vulnerable to the intensifying effects of the unstable weather conditions such as irregular distribution of rainfall, unstable temperature conditions and the spatial distribution of relative humidity which are recipes for declining agricultural activities and production failures. The incidences of sporadic rainfall and frequent dry spells have become the new normal Ndu Sub-Division, affecting the agricultural production chain and negatively influencing crop yields. The onset of rainfall has shifted from what existed before; subjecting farmlands to recurrent moisture deficiency characterize by frequent replanting of seeds at the early stage of production by farmers which is costly on farmers. More so, timely harvest is often upset, which subject most households to food shortage and insecurity. Farmers grappled with adaptation strategies during pre and post-harvest periods to reverse the effects, but their high poverty, limited government supports, inadequate trainings, land tenure and conflicts, limit the successes of these adaptation strategies, thus, making them temporary. However, in considering the fact that agricultural activities remain the predominant and perennial livelihood option to the population in the Ndu Sub-Division, farmers are recommended to adopt modern farming practices like agroforestry, organic farming, and mulching, while stakeholders should support farmers with improved seeds, faring tools and inputs, organize training for farmers and promote tree conservation. NGOs should encourage alliance farming systems, sponsor agricultural researches. The government should create more agro-based institutions, develop land use plans and resolve farmer-grazier conflicts.

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