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ASSESSMENT OF THE PATTERN OF OCCURRENCE OF WET AND DRY SPELLS ON CROP YIELD IN KADUNA STATE

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ABSTRACT

Purpose. *To analyse historical rainfall patterns in Kaduna State to understand how frequent and prolonged wet and dry spells affect crop yields, using the Standardised Precipitation Index (SPI) for drought characterisation and Pearson Correlation to quantify the relationship between these spells and crop productivity, with the ultimate goal of improving agricultural planning and mitigating food insecurity*

Design/methodology/approach: *To achieve this aim, the study used secondary data, and these include daily rainfall data from the Nigeria Meteorological Agency (NIMET), and crop yield (Cowpea, Maize and Ginger) from Kaduna Agricultural Development Authority (KADA) for a period of 30 years (1994 – 2023). Purposive sampling was deployed to select the three local governments in the study area; thus Ikara, Chikun and Jema'a, ClimPACT2 Software, Standardised Precipitation index (SPI) and Pearson Correlation were used for the analyses.*

Findings: *The result reveals the pattern of rainfall **i**n Chikun, October 1999, was considered as a very dry month with a rainfall value of -1.693, while August 1995 is classified as an extremely wet month with a rainfall value of 2.626. September 1999 is described as a very dry month in Ikara with -1.647, while June 1997 is considered as an extreme wet month with rainfall of 2.086 as compare with the SPI table and in Jemaa, May 2005 is considered as a very dry month with -1.851, while June 2022 is considered as an extremely wet month with rainfall of 3.231. The correlation between consecutive wet days and cowpea yield is weakly positive (0.108), suggesting a slight tendency for more wet days to be associated with slightly higher yields, but the relationship is not strong. While the correlation between consecutive dry days and cowpea yield is weakly positive (0.003), it suggests a negligible relationship.*

Research limitations/Implications: *Assessing wet and dry spell patterns reveals their significant impact on crop yields in Kaduna State by affecting soil moisture. Focusing on the relationship between wet and dry spells on crop yield helps improve crop management, inform water resource planning, and enhance climate resilience.*

Originality/value: *The study revealed the result of SPI across the three LGAs is in line with the findings of the relationship between wet and dry spells on crop yield across the three locations*

Keywords: Wet Spells, Dry Spells, Precipitation, Drought and Temperature

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1.0 BACKGROUND

Rainfall is indeed a crucial factor influencing various human activities especially farming. Others are industrial, commercial work and in other human endeavors (Calmon and Barbieri 2019). Generally, farmers, pastoralists, civil and environmental engineers, and those who work in public health care are interested in its natural qualities. Unpredictable distribution and variability of seasonal rainfall has generally characterized agriculture in the Tropics. Climate plays a dominant role in agriculture having a direct impact on the productivity of physical production factors, for example the soil's moisture and fertility. Adverse climate effects can influence farming outputs at any stage from cultivation through the final harvest. Even if there is sufficient rain, its irregularity can affect yields adversely if rains fail to arrive during the crucial growing stage of the crops (WAZIRI, D. Z, 2016, Ideki, and Wali, 2019, Food and Agricultural Organization of United State, 2017; Tetty, Adedia, and Abaye 2017; Makinde, Eruola, Ufoegbune and Ojekunle, 2019).

Long dry spells incur heavy costs to the affected communities. In humid countries like Southeast Asian countries such as Singapore, Malaysia, Southern half of Vietnam, low altitude of Central America and Central Africa. For achieving maximum benefits from dry land agriculture, the knowledge of distribution of dry spells within a year is useful (Leona Maurer 2018 and Korbinian *et al,* 2020). An estimated 55 million people globally are affected by droughts every year, and they are the most serious hazard to livestock and crops in nearly every part of the world. Drought threatens people's livelihoods, increases the risk of disease and death, and fuels mass migration. Water scarcity impacts 40% of the world's population, and as many as 700 million people are at-risk of being displaced as a result of drought by 2030 (Jorge, Camilla, Roberto, Nicolo and Anna 2023). Between 80-90% of all documented disasters from natural hazards during the past 10 years have resulted from floods, droughts, tropical cyclones, heat waves and severe storms (WHO, 2023). The 1972/73 and 1984 droughts in Nigeria were a consequence of cumulative effect of dry spells of long duration that led to the droughts in the extreme northern states of Nigeria (Sawa and Adebayo, 2018).

Dry spells affect not only agriculture but also other activities such as fisheries, health and electricity. Long dry spells may physically weaken the people which could cause mental degradation due to the lowering of their status. The fish productivity from fresh water is likely to be stricken by longer dry spells. Longer dry spells also interrupt generating electricity using hydroelectric power Excessive increases in temperature results in low agricultural productivity and this may lead to depletion of soil nutrients and destruction of soil structure and organisms which contribute to the fertility of the soil. Ordinarily, rainfall can be considered to have positive effect on agricultural productivity except where it leads to flooding, erosion and leaching. Rainfall amount and high temperatures are the most important elements of weather that affect crop yield in Nigeria as a result the northern region of Nigeria is increasingly becoming an arid environment at a very fast rate occasioned by the fast reduction in the amount of surface water, flora and fauna resources on land (Sanchi, Alhassan, Sabo and Hamid, 2021; Kawu, 2019 and Oduwale, 2020). In attempts to fix this ever-growing problem, many have tried to form more effective methods of water management (WHO, 2020). Agriculture is also the most weather dependent of all human activities. Crop yield varies from season to season owing to variation in rainfall amount and other edaphic factors. Water scarcity has a huge impact on food production. Without water people do not have a means of watering their crops to provide food for the fast-growing population (Redane, Beketie, Fantahun, Feyisa, and Anose 2022). Overall, temperature and rainfall changes reduce the cropped area, production level and yield. This reduction or fluctuation in crop yield warrant

farmers 'adaptability to minimize these adverse effects. However, adaptation strategies at the farm level vary from area to area and from farm to farm. Farmers 'adaptive capacity is determined by their sociodemographic characteristics, farm characteristics and accessibility to institutional factors (Kawu, 2019). Some of the specific objectives of the paper are to: (i) Analysed the consecutive wet days (CWD) and consecutive dry days (CDD) with daily rainfall data in Kaduna State within the study period. (ii) assessed the pattern of occurrence of wet and dry spells (iii) examine the correlation between wet and dry spells and crop yield in the study area. Some of the research questions that this paper is trying to addressed are; What constitute wet and dry days in the study area? What is the correlation between wet and dry spells in the study area?

2.0 LITERATURE REVIEW

Globally, Zhi, Yanping, Xiaping and Linging (2017), carried out a study titled "The characteristics of wet and dry spells for the diverse climate in China". Using a large precipitation dataset from 692-gauge stations across China for the period of 1960–2013, this study analyses the characteristics of wet/dry spells related to four types of climates including arid, semi-arid, semi-arid to sub humid, and humid climate. The frequency of wet/dry spells, the contributions of wet/dry spells with different lengths to the total number of wet/dry days and total precipitation amount were analysed for different climate types. The wet/dry spells with the greatest contributions to the total wet/dry days or total precipitation amount vary with climate. For drier climate, long-duration dry spells contribute more to the total number of dry days, while short-duration wet spells contribute more to the total number of wet days and the total precipitation amount. The characteristics of wet/dry spells are closely related to local climate. Good regression relationships were obtained for the number of dry/wet spell versus spell length, and precipitation amount versus wet spell length. Although the correlation between precipitation amounts and wet spell length has rarely been considered in stochastic precipitation generation, the relationships identified in this study justify the necessity of taking it into account. Korbinian, Giuliano, Maurizio, David and Giulia (2020), carried out a study titled "Extreme dry and wet spells face changes in their duration and timing" in United States, Europe and Australia. The work assesses changes in the duration and within-year timing of extreme dry and wet spells over 60 years (1958–2017) using a consistent global land surface precipitation dataset of 5093 rain gauge locations. The results showed consistencies with observations and projections from state-of-the-art climate and water resources research. In addition, new insights were provided regarding trends in the timing of extreme dry and wet spells, an aspect equally important for possible future implications of extremes in a changing climate, which has not yet received the same level of attention and is characterised by larger uncertainty. According to the research, dry spells are sequences of days without precipitation. They can have negative implications for societies, including water security and agriculture. For example, changes in their duration and within-year timing can pose a threat to food production and wildfire risk. Conversely, wet spells are sequences of days with precipitation above a certain threshold. Changes in their duration and within-year timing can impact agriculture, flooding or the prevalence of water-related vector-borne diseases. Chinninba, Ngodo, Minoungou and Eneva (2023), Jean-Martial*, Mathias, Elliott and Kazukil* (2023), Omay, *Muthama, Oludheba and Kinama* (2023), Tegegn, Belie and Utallo (2023), Daouda, *Sacre, Kouakou, and Bamory* (2023) and Hillary,Tamuka, Dennis and Vimba (2023), provided insights into the impact of wet and dry spells on crop production and agricultural activities in North, South, East and West Africa. The literature covers different periods; Markov chain First Order, Mann-kendal test, Multiple

regression and application of remote sensing technology. Moreover, the impact of climate change on wet and dry spells and its effects on agriculture were briefly mentioned.

Daniel and Magaji Ibrahim (2024) analyse Spatiotemporal Variations of Rainfall Over Nigeria. The study focused on detecting trends in annual rainfall in six stations in Nigeria: Calabar, Lagos, Enugu, Abuja, Kano, and Maiduguri. Three different widely used nonparametric methods of Mann-Kendall, Innovative Trend Analysis, Sen's Slope Estimation, and a Linear Trend Analysis method were used on time series data for each of the stations for 50 years (1971 to 2020) to detect trends and estimate the magnitudes in annual rainfall at a 5% significance level. The study analysed trend values of annual rainfall and the result shows that the Innovative Trend Analysis (ITA) is more effective in detecting trends than the Mann-Kendall (MK) method. The results obtained from ITA, Sen's Slope Estimation (SSE), and Linear Trend Analysis (LTA) showed good agreement. The Sen's slope estimator determined the magnitudes of the trends. All stations except Abuja showed statistically significant increasing trends. The linear trend plot also indicated a decreasing trend for Abuja, while the other five stations had an increasing trend that ranged from 0.44 to 1.02 mm/year. The impact of climate change on annual rainfall has received significant attention from scholars worldwide. Many studies have been conducted to demonstrate that changes in annual rainfall are becoming evident globally. This agrees well with global climate model estimates which predict that increasing trends will continue throughout the 21st century in most West African countries

3.0 AREA STUDY

Kaduna state lies within (lat. 10° 36' 33.5484" N and 7° 25' 46.2144" E). The study area covers the three senatorial Zones of the State and each Zone is represented by a Local Government thus; Northern Senatorial Zone (Ikara), Central Senatorial Zone (Chikun) and Southern Senatorial Zone (Jema'a) Local Government respectively

4.0 METHODOLOGY

The paper used only secondary data. These include daily and monthly rainfall data from Nigeria Meteorological Agency (NIMET), Abuja, also Crop yield data (Cowpea, Maize and Ginger) were obtained from Kaduna State Agricultural Development Agency (KADA) for a period of 30 years (1994 – 2023). purposive sampling was used to select the three (3) local government in the study area (Chikun, Ikara and Jema'a LGA) respectively. The selection was based on rainfall variation across the three senatorial zones. ClimPACK 2 software was used to analyzed the Consecutive Dry Days and Consecutive Wet Days (CDD and CWD), from the daily records of rain fall and number of days with wet and dry spells were obtained from totals. Standardize Precipitation index (SPI) and Markov Chain Model were deployed to analysed the pattern and the Initial and Conditional Probability of wet and dry spells.

5.0 PRESENTATIONAND DISCUSSION OF RESULTS

5.1 Examine the pattern of occurrence of wet and dry spells in the study area

To achieved objective two in this paper the Standardize Precipitation index (SPI) was used for the analyses.

Table 5.1 SPI Analysis in Chikun, Ikara and Jema'a

Variable	Chikun	Ikara	Jemaa
Driest Month	-1.693 (October, 1999)	-1.647 (Sept., 1999)	-1.851 (May, 2005)
Wettest Month	2.626 (August 1995)	2.086 (June, 1997)	3.231 (June, 2022)

Source: Author's Analysis, 2025

Table 5.1; In Chikun the study reveals that October 1999 was consider as a very dry month with rainfall value of -1.693, compare it to the SPI table, the month is severely dry, while August 1995 is classified as extremely wet month with rainfall value of 2.626. So the extreme wet days and severely dry days tends to affect maize production in Chikun by causing water logging and water scarcity to plants during the period of germination and vegetative stage. Based on SPI classification, this is also illustrating on the graph, below, (Fig 5.1.1) the blue color stands for wet days while the red color is for dry days

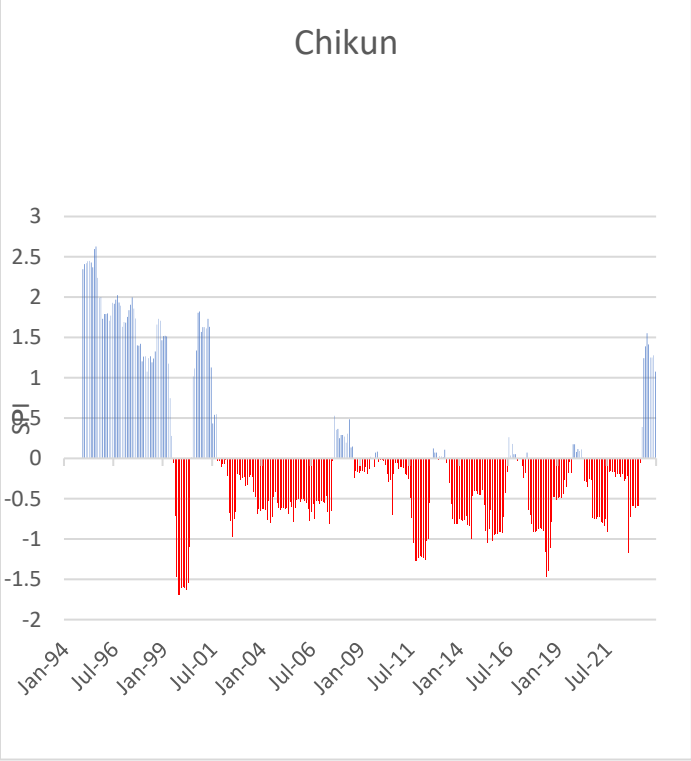

Fig.5.1.1: graph of SPI in Chikun LGA of Kaduna State

Source: Author's Analysis, 2025

In Ikara: The SPI result in table 1 Shows September, 1999 is described as a very dry month in Ikara with value of -1.647 while June 1997 is considered as an extreme wet month with rainfall value of 2.086 as compare to SPI classification. As it is cowpea does not need much precipitation, so severely extreme condition may affect cowpea compare to other crops, also severely dry moment will impact negatively on its germinating stage (Fig5.1.2)

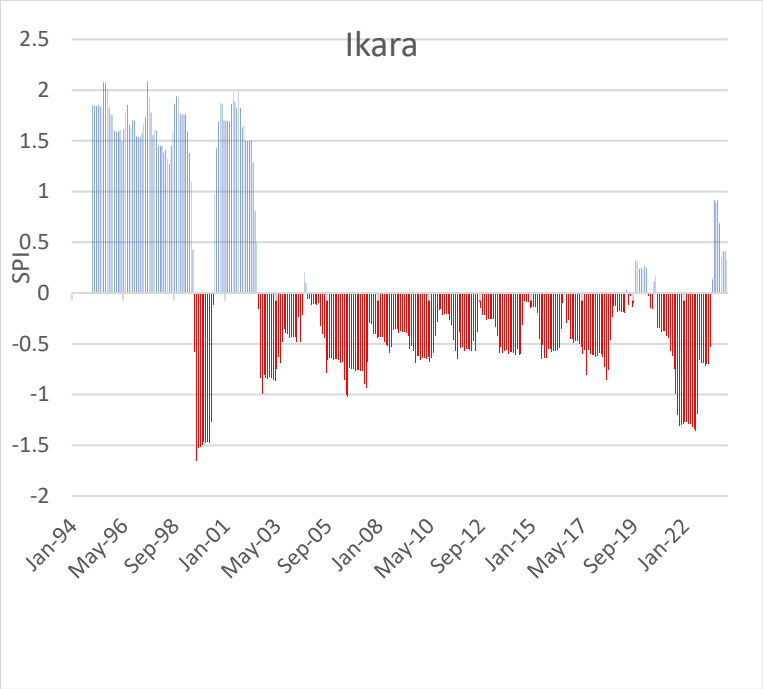

Fig.5.1.3: graph showing pattern of occurrence of wet and dry sapells in Ikara LGA of Kaduna State

Source: Author's Analysis, 2025

In Jemaa: Table 5.1 reveals May 2005 as a very dry month with a value ---1.851, while June 2022 is considered as an extremely wet month with a rainfall value of 3.231. Jema'a has the maximum value of rainfall among the three locations, as you can see it on the graph below (Fig5.1.3). The consecutive wet and dry days show variation across the three locations in the study area with which shows all the locations are classified as extremely wet with spatial variation in values in descending order, thus Jema'a **(**3.231), Chikun (2.626) and Ikara (2.086); So also is the distribution of rainfall received across the three locations (Jema'a, Chikun and Ikara). When traversing from the Southern Senatorial zone to the North Central through the Northern Senatorial Zone, there is a decrease on the rainfall received and vice versa, as compare with the SPI values. Prolonged dry spells can cause significant yield losses for all three crops. For example, maize, a major rain-fed crop, is particularly vulnerable to mid-season dry spells. Excessive rainfall or wet spells can lead to waterlogging, which can damage roots and hinder plant growth. Also, wet conditions can promote the spread of diseases, impacting cowpea and other crops, this is in agreement with a study carried out by Walsh et al (2020) in Northern High Latitudes including the Arctic, in India by Rashmita *et al* (2017), and in Southern Coast of Ghana a study by Tettey *et al* (2017)

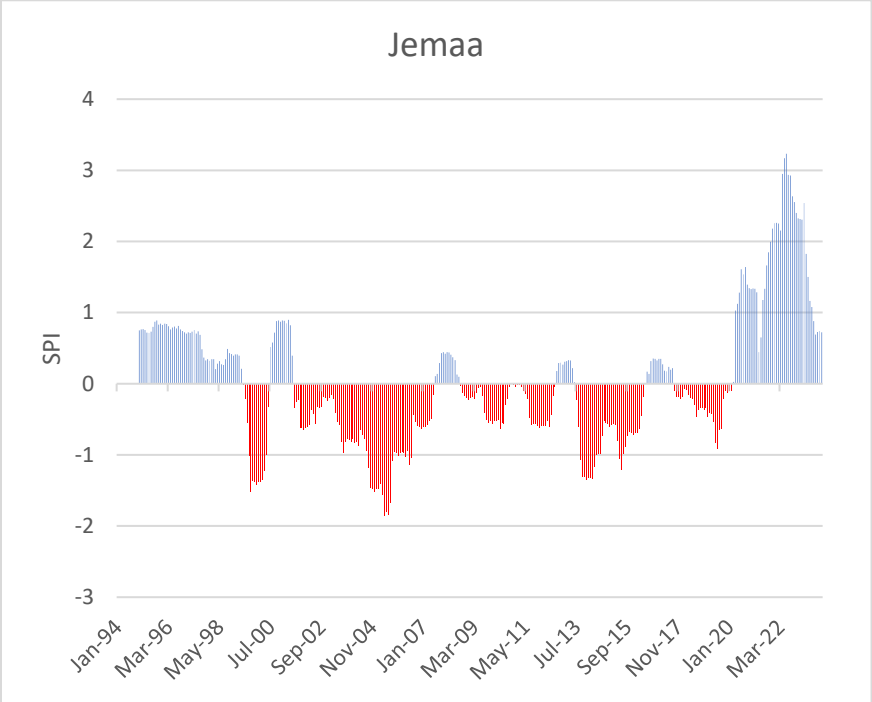

Fig. 5.1.3 graph showing pattern of occurrence of wet and dry spells in Jema'a LGA of Kaduna State

Source: Author's Analysis, 2025

(5.2) Relationship Between Wet and Dry Spells on Crop Yield
(a) Relationship between Wet and Dry Spells and Maize Yield\ Correlations

Table5.2.1: Pearson Correlation Coefficient

		Consecutive Wet Days	Consecutive Dry Days	Maize Yield
Consecutive Wet Days	Pearson Correlation	1	.079	-.065
	Sig. (2-tailed)		.680	.732
	N	30	30	30
Consecutive Dry Days	Pearson Correlation	.079	1	-.151
	Sig. (2-tailed)	.680		.427
	N	30	30	30
Maize Yield	Pearson Correlation	-.065	-.151	1
	Sig. (2-tailed)	.732	.427	
	N	30	30	30

Source: Author's Analysis, 2025

Table5.2.1 reveals that the Pearson Correlation indicated no statistically significant linear relationship between consecutive wet days and consecutive dry days on maize yield, as all correlation coefficients are weak and the p-values are high on maize yield in Chikun. The

Consecutive Wet days have a correlation coefficient of 1, that is a positive correlation and the p-value is not relevant in this case (Fig 5.2.1a)

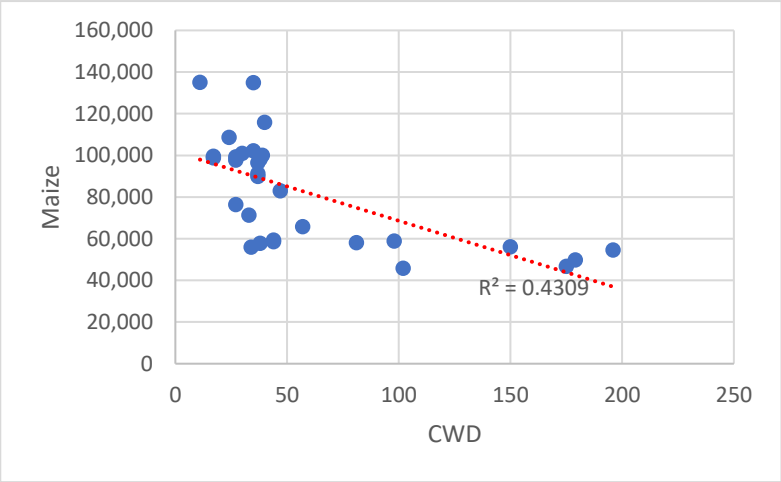

Fig. 5.2.1a: correlation between CWD and Crop Yields

Source: Author's Analysis, 2025

while the Consecutive Dry Days has a correlation coefficient of 0.079 (a very weak positive correlation), and the p-value is 0.680 (not statistically significant). And the correlation coefficient with Maize Yield is -0.065 (a very weak negative correlation), and the p-value is 0.732 (not statistically significant). The p-values (0.680 and 0.732) are both greater than the typical significance level of 0.05, meaning the observed correlations are likely due to random chance and not a real relationship (Fig 5.2.1b)

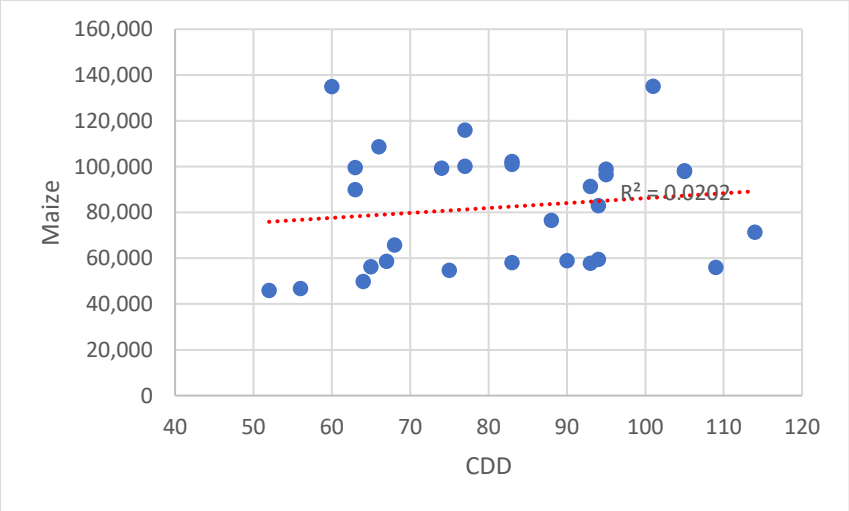

Fig. 5.2.1b: correlation between CWD and Crop Yields in Chikun

Source: Author's Analysis, 2025

Based on these results, we cannot conclude that consecutive wet days, consecutive dry days, or their combination, have a statistically significant impact on maize yield. This is in line with a study carried out in Thailand by Pharm *et al* (2024), also in Southern Africa by Wajiru (2021), in Semi-Arid Region of Nigeria by Sawa *et al* (2018) and in Kaduna by Pius *et al* (2020)

(b) Relationship Between Wet and Dry Spells and Cowpea Yield

Table 5.2.2: Pearson Correlation

		Consecutive Wet Days	Consecutive Dry Days	Cowpea Yield
Consecutive Wet Days	Pearson Correlation	1	.108	.003
	Sig. (2-tailed)		.576	.989
	N	29	29	29
Consecutive Dry Days	Pearson Correlation	.108	1	-.156
	Sig. (2-tailed)	.576		.418
	N	29	29	29
Cowpea Yield	Pearson Correlation	.003	-.156	1
	Sig. (2-tailed)	.989	.418	
	N	29	29	29

Source: Author's Analysis, 2025

Based on the provided data, table 5.2.2 Reveals that in here's the Pearson correlation analysis between wet/dry periods and cowpea yield in Ikara; The correlation between consecutive wet days and cowpea yield is weakly positive (0.108), suggesting a slight tendency for more wet days to be associated with slightly higher yields, but the relationship is not strong This also suggests a strong negative correlation between consecutive wet days and cowpea yield, with increased wet days leading to significantly lower yields. The provided data shows that with 1 consecutive wet day, the cowpea yield is 0.003, while with 29 consecutive wet days, the yield is 0.989. This indicates that as the number of consecutive wet days increases, the cowpea yield decreases significantly. Cowpea plants are sensitive to excessive moisture and waterlogging, which can lead to root rot and reduced nutrient uptake, ultimately impacting yield. This data highlights the importance of proper soil drainage and water management in cowpea production, especially in areas prone to prolonged wet periods (Fig. 5.2.2a)

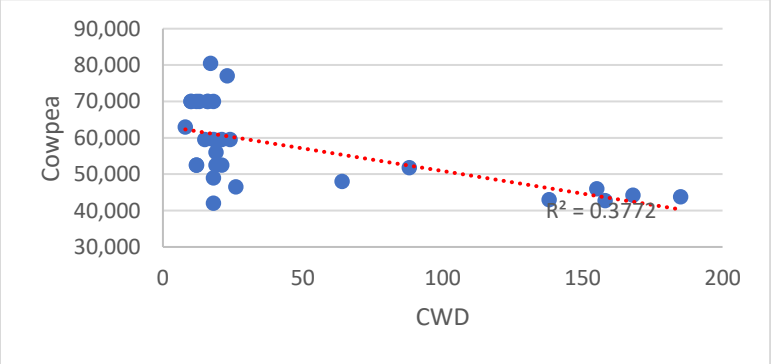

Fig. 5.2.2a: correlation between CWD and Crop Yields in Ikara

Source: Author's Analysis, 2025

The correlation between consecutive dry days and cowpea yield is weakly positive (0.003), suggesting a negligible relationship (Fig. 5.2.2b). This is in line with a study carried out in Thailand by Pharm *et al* (2024), also in Southern Africa by Sawa *et al* (2018) and in Kaduna by Pius *et al* (2020) and a study by Wajiru (2021), in the Semi-Arid Region of Nigeria

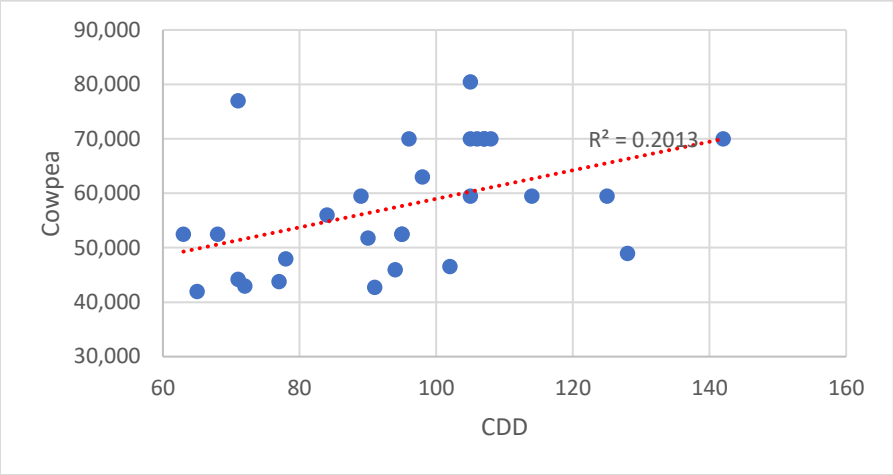

Fig. 5.2.2b: correlation between CDD and Crop Yields in Ikara

Source Author's Analysis, 2025

(c) Relationship between Wet and Dry Spells and Ginger Yield

Table 5.2.3: Pearson Correlation

		Consecutive Wet Days	Consecutive Dry Days	Ginger Yield
Consecutive Wet Days	Pearson Correlation	1	-.074	-.224
	Sig. (2-tailed)		.698	.233
	N	30	30	30
Consecutive Dry Days	Pearson Correlation	-.074	1	-.059
	Sig. (2-tailed)	.698		.756
	N	30	30	30
Ginger Yield	Pearson Correlation	-.224	-.059	1
	Sig. (2-tailed)	.233	.756	
	N	30	30	30

Source: Author's Analysis, 2025

Table 5.2.3. Reveals that The Pearson correlation coefficient of -0.224 between consecutive wet days and ginger production in Jema'a, with a p-value of 0.233, suggests a weak, negative, and statistically insignificant relationship between the two variables. The value of -0.224 indicates a weak negative correlation, meaning that as consecutive wet days increase, ginger yield or some other related metric tends to decrease slightly, but not strongly. The p-value of 0.233 is greater than the typical significance level of 0.05, meaning the observed correlation is not statistically

significant (Fig. 5.2.3a). This suggests that the observed relationship could be due to random chance rather than a true association between the two variables. A correlation coefficient of -0.224 is considered a weak correlation, meaning that there is little to no linear relationship between the two variables.

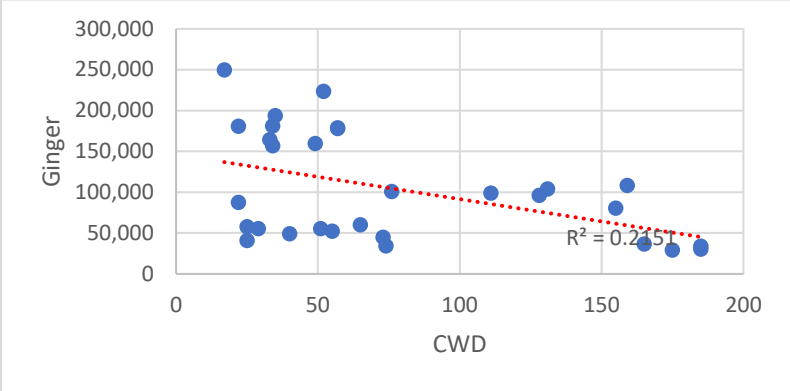

Fig. 5.2.3a: correlation between CWD and Crop Yields in Jema'a

Source: Author's Analysis, 2025

Also, the provided result, -0.059, indicates a **very weak, negative correlation** between Consecutive Dry Days (CDD) and Crop Yield in Jema'a LGA. This means that as the number of consecutive dry days increases, crop yield tends to decrease very slightly, but the relationship is so weak that it is likely due to random chance rather than a significant association.

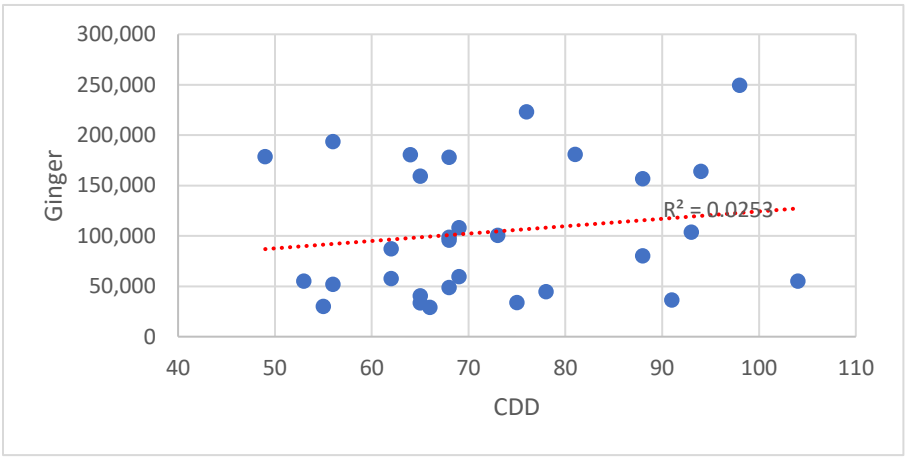

Fig. 5.2.3b: correlation between CDD and Crop Yields in Jema'a

Source: Author's Analysis, 2025

These is in line with a study carried out in Thailand by Pharm *et al* (2024), also in Southern Africa by Wajiru (2021), in Semi-Arid Region of Nigeria by Sawa *et al* (2018) and in Kaduna by Pius *et al* (2020). Based on these results, it is not possible to conclude that consecutive wet days have a significant impact on ginger in Jemaa. Further research with a larger sample size and potentially different statistical methods may be needed to explore this relationship more thoroughly.

6.0 CONCLUSION AND RECOMMENDATIONS

SPI analyses show that in Chikun, October 1999 is considered as a very dry month with rainfall value of -1.693, while August 1995 is classified as extremely wet month with rainfall value of 2.626. September, 1999 is described as a very dry month in Ikara with value of -1.647 while June 1997 is considered as an extreme wet month with rainfall value of 2.086 as compare with the SPI table and in Jemaa May 2005 is considered as a very dry month with value -1.851 while June 2022 is considered as an extremely wet month with rainfall value of 3.231. Jema'a has the maxinun value of rainfall among the three locations, as you can see it on the graph. The Relationship Between Wet and Dry Spells on Crop Yield shows that the Pearson correlation coefficient of -0.224 between consecutive wet days and ginger production in Jemaa, with a p-value of 0.233, suggests a weak, negative, and statistically insignificant relationship between the two variables. Consecutive Wet and Dry Days: The Consecutive Wet days have a correlation coefficient of 1, that is a positive correlation and the p-value is not relevant in this case, while the Consecutive Dry Days has a correlation coefficient of 0.079 (a very weak positive correlation), and the p-value is 0.680 (not statistically significant). And the correlation coefficient with Maize Yield is -0.065 (a very weak negative correlation), and the p-value is 0.732 (not statistically significant). The correlation coefficients (0.079 and -0.065) are extremely small, suggesting very weak or no linear relationship between the variables. The p-values (0.680 and 0.732) are both greater than the typical significance level of 0.05, meaning the observed correlations are likely due to random chance and not a real relationship. Based on these results, we cannot conclude that consecutive wet days, consecutive dry days, or their combination, have a statistically significant impact on maize yield.

The correlation between consecutive wet days and cowpea yield is weakly positive (0.108), suggesting a slight tendency for more wet days to be associated with slightly higher yields, but the relationship is not strong. The correlation between consecutive dry days and cowpea yield is weakly positive (0.003), suggesting a negligible relationship. This also suggests a strong negative correlation between consecutive wet days and cowpea yield, with increased wet days leading to significantly lower yields. the provided data shows that with 1 consecutive wet day, the cowpea yield is 0.003, while with 29 consecutive wet days, the yield is 0.989. This indicates that as the number of consecutive wet days increases, the cowpea yield decreases significantly. The Pearson correlation coefficient of -0.224 between consecutive wet days and ginger production in Jemaa, with a p-value of 0.233, suggests a weak, negative, and statistically insignificant relationship between the two variables. Excessive rainfall or wet spells can lead to waterlogging, which can damage roots and hinder plant growth. Also, wet conditions can promote the spread of diseases, impacting cowpea and other crops. Consequent upon the findings of this study, it is concluded that, it is important farmers to start planting drought-tolerant varieties of cowpea, maize, ginger and other crops to mitigate the impact of dry spells. It is therefore recommended that, government approval agencies, professionals and other stakeholders should sensitised farmers on the onset and cessation of rain, impact of climate change and other factors which can affect crop yield such as pest and diseases that affect food insecurity.

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