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# ASSESSMENT OF FARMERS' COPING STRATEGIES AND PERCEPTION IN MANAGING RAINFALL VARIABILITY AND CROP YIELD IN KADUNA STATE

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## *ABSTRACT*

***Purpose:*** *To understand how Kaduna State farmers perceive and cope with unpredictable rainfall and its impact on crop yields by assessing current strategies and applying the Markov Chain Model. This paper aims to analyse the development of effective adaptation plans to improve food security and livelihoods in the face of wet and dry spells.*

***Design/methodology/approach:*** *To achieve this aim, the study used both primary and secondary data. Primary data included surveys, oral interviews, and 384 questionnaires, which were administered based on the population of each LGA. The secondary data include daily rainfall from (NIMET), and crop yield data (Cowpea, Maize and Ginger) from (KADA) for a period of 30 years (1994 – 2023). Purposive sampling was deployed to select the three local government in the study area thus; Ikara, Chikun and Jema'a, percentage, graphs and charts were used for data analysis and Markov chain Model was used to analysed P(W), P(W/W), (P/D), P(D/D). from the total population of the study area, 384 questionnaires were drawn out, administered and filled, while qualitative and quantitative analytical designs were utilized in the analysis and discussion of findings.*

***Findings:*** *The result reveals that most of the farmers believed that Changes in agricultural practices implemented by the farmers to adapt to wet and dry spells could help to mitigate the negative effects of wet and dry spells on crop yield and food security, while the Markov Chain model reveals that in Chikun the P(D|D) is 82%: indicates 81.9% for dry days to persist and P(W|W), is71.2% and in ikara the P(D|D) is 36.9% while the P(W|W) is 63.1% and in Jema'a, P(D|D) is 79% compared to P(W|W) is 73% suggests that dry spells are more persistent than wet spells in Jema'a.*

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***Research limitations/Implications**: Rainfall variability, with its unpredictable dry and wet spells, significantly impacts rain-fed agriculture, leading to decreased crop yields, food insecurity, increased pest infestations, and economic hardship for farmers.*

***Originality/value:** The study revealed the contributions and responses of farmers towards rainfall variability and effects of wet and dry spells towards mitigating against food insecurity in Kaduna State by Stake Holders.*

**Keywords:** Perception, Wet and dry spells, Agriculture, Adaptation & rainfall Markov Chain

## 1.0 INTRODUCTION

The success or failure of the crops, particularly under rainy conditions, is highly related to the distribution of dry spells. For achieving maximum benefits from dry land agriculture, the knowledge of the distribution of dry spells within a year is useful (Leona Maurer 2018 and Korbinian *et al*, 2020). Dry spells, apart from limiting soil moisture for plant use, pose serious threat to the uptake of nutrients, thereby affecting crop yield. The occurrence of dry spells during the growing season which cause deficiency of soil moisture therefore, poses the greatest threat to food security in this region. Dry spell occurrence has not only reduced the yield of crops in this region but have in many cases lead to complete loss during extended period of occurrence, leading to drought (Sawa and Adebayo, 2018). 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). Rising temperatures caused by climate change are making already dry regions drier and wet regions wetter. In dry regions, this means that when temperatures rise, water evaporates more quickly, and thus increases the risk of drought or prolongs periods of drought. 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, 023).

One of the impacts of climate change on rain-fed agriculture in the arid and semi-arid region of Northern Nigeria is the increasing frequency and magnitude of occurrence of dry spells. Dry spells, apart from limiting soil moisture for plant use, pose serious threat to uptake of nutrients thereby affecting crop yield. Occurrence of dry spells during the growing season which cause deficiency of soil moisture therefore, poses the greatest threat to food security in this region. Dry spell occurrence has not only reduced the yield of crops in this region but have in many case lead to complete loss during extended period of occurrence, leading to drought. 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). Farmers generally perceive wet and dry spells as indicators of climate change, with increasing temperatures, decreased rainfall, and changes in rainfall patterns leading to more frequent dry spells and droughts. These perceived changes significantly impact agricultural practices, with farmers adapting by adopting drought-tolerant crops, water-saving technologies, and adjusting their planting schedules. 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 ((U.S. Department of Agriculture USDA, Economic Research Service,2024, Sawa and Adebayo, 2018). According to Aremu (2020), a dry spell is a period of drought with less than 1mm of rainfall for a period of 15 consecutive days. They can have negative implications for societies including water security and agriculture. For example, changes in their durations and within-year timing can pose a threat to food production and wildfire risk. Conversely, he also defines wet spells as sequences of days with precipitation above 1mm for 15 days. Changes in their duration also withinyear timing can impact agriculture, flooding or the prevalence of water-related vector-borne diseases (Korbinian, Giuliano, Maurizio, David and Giulia 2020).

Crops are not only sensitive to water deficit and hence the duration of dry spells, but also to their timing with respect to sowing and developmental stages, provided the crop establishes, the highest sensitivity to excessive rain and water logging occurs during the vegetative phases and to drought during the reproductive stages. Also, excessive rain can enhance the risk of lodging or pathogen development. Further, in croplands, near soil saturation during sowing and harvesting make field operations impossible. Similar, forests are most sensitive to drought when it occurs early in the growing season, when radial growth peaks (Sawa and Adebayo, 2018). The objectives of the paper include; To; (I) examine the Socio-demographic characteristics of the respondents in the study area; (II) examine farmers' perception to wet and dry spells (III) analysed the occurrences of the initial probability P(W), P(D) and the conditional probability P(W/W), P(D/D) of wet and dry spells.

## 2. LITERATURE REVIEW

In a study by Pervez, Velpuri, and Costabile (2022), interviewed 554 households and conducted focus group discussions in western Nepal to understand farmers' perceptions of climate change and its impacts on agriculture. The findings revealed that while farmers generally perceive rising annual and summer temperatures, their perceptions contradict observed trends in winter temperatures and precipitation. They also reported an increase in extreme weather events like floods, landslides, and droughts, which significantly impact agricultural production and household income. The study emphasizes the importance of integrating farmers' perceptions with hydrometeorological observations to better assess the impacts of climate change and design effective mitigation and adaptation strategies. Studies have investigated climate and rainfall patterns to assess impacts on agriculture, using tools like Markov Chain models to analyze weather data and predict trends. Research in Sri Lanka identified a bi-modal rainfall pattern, while a global study found that co-occurring hot and dry weather negatively impacts crop yields. In the Himalayas, farmers perceive rising temperatures but also face increased extreme events, which affect their livelihoods. Additionally, a study in Ethiopia used Markov models to analyze dry and wet spells, revealing a high probability of wet decades from late June to early October (Wimalasiri, and Ampitiyawatta, 2022, Heino, Kinnunen, Anderson, Ray, Puma, Varis, Siebert and Kummu 2023).

Other studies such as Tettey (2017), Jules *et al* (2020), Israel (2022) and Hillary *et al* (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, ranging from 7-12 years and the method of data analysis covers; Markov chain First Order, Mann-kendal test, Multiple regression and application of remote sensing technology. A more serious analysis incorporating short-term variations and recent climatic changes could enhance understanding of how crop yields respond to evolving weather patterns in Kaduna. Moreover, the impact of climate change on wet and dry spells and its cascading effects on agriculture were briefly mentioned. The literature lacks a comprehensive discussion on community involvement in the planning and implementing of adaptation strategies. Finally, scholarly literature like Yussuf et al (2017), Abaje et al (2018), Kawu (2019), Abaje et al (2019), Pius, et al (2020), Doruwaju, Ologunorisa and Akimbola (2022), Pius, Yelwa and Sada (2023) and Sada, Yusuf and Aremu (2023) provide valuable insights into rainfall variability and their impact on crop production, mainly guinea corn and maize production, in Kaduna State, Nigeria. However, specific gaps and opportunities for further research are that the literature predominantly centers mainly on guinea corn and maize.

## 3.0 AREA STUDY

Kaduna state was created on May 27, 1967 by General Yakubu Gowon. It is located in the NorthWest region of Nigeria, and there are 23 local governments with the state capital being Kaduna with an estimated population of over nine (9) million. 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. This choice is based on rainfall variation across the state kaduna State lies at (lat *10° 36' 33.5484'' N and 7° 25' 46.2144 E*). It is made up of 23 local government area and three senatorial zones thus: Northern, Southern and Central Senatorial Zone respectively and covers an area of 46,052 square kilometers (Policy MSION, 2015, Bununu, Ludin, and Hosna, 2015).

## 4.0 METHODOLOGY

**Data Sources and Type:** The paper used two types of data; primary and secondary. The Primary data. include questionnaire, oral interviews and surveys. These types of data include sourcing information on socio-economic challenges attributed to variation in crop production in the study area and adaptation strategies put in place to reduce the impact of weather on Cowpea, Maize and Ginger yields. While secondary data include Daily and monthly rainfall data from 1994-2023 (30 years), were obtained from the Nigeria Meteorological Agency (NIMET), FCT Abuja. Crop yield (Cowpea, Maize and Ginger) were obtained from Kaduna State Agricultural Development Agency (KADA) for a period of 30 years (1994 – 2023). Data on precipitation (daily/ rainfall) were sourced from (NIMET), for the three (3) locations; Ikara, Chikun and Jema'a respectively. Records on crop yield were also sourced from Kaduna State Agriculture Development Authority (KADA). These crops spread over the 3 selected Local Government Areas of the 3 senatorial zones. Thus; Ikara LGA represents the Northern Senatorial Zone where data on beans production were got, Chikun LGA represents the North Central, records on maize production were collected and Jema'a LGA represents the Southern Senatorial Zone with record on Ginger production collected. For questionnaire, 384 copies were administered to farmers. the data was analysed by simple percentage and the application of Markov chain model First order

**Sampling Frame:** purposive sampling was used to select the three (3) locations in the study area (Chikun, Ikara and Jema'a LGA, based on rainfall variation across the stud area. Also 384 questionnaires were administered in the study area based on the population of each local government.

## 5.0 PRESENTATIONAND DISCUSSION OF RESULTS 5.1 Socio-Demographic Characteristics of the Respondents

Table 1 Gender of the Farmers

| Gender | Chikun Frequency | % | Ikara Frequency | % | Jemaa Frequency | % | Total Frequency | % |
|---|---|---|---|---|---|---|---|---|
| Male | 130 | 76.0 | 82 | 100.0 | 90 | 78.3 | 302 | 82.1 |
| Female | 41 | 24.0 | 0 | 0.0 | 25 | 21.7 | 66 | 17.9 |
| **Total** | **171** | **100.0** | **82** | **100.0** | **115** | **100.0** | **368** | **100.0** |

**Source:** Author's Analysis, 2025

In table 1, 384 questionnaires were administered and returned successfully thus; 171 respondents are from Chikun, 76% are males and 24% are female, 82 are from Ikara, here all the respondents are male (100%) and in Jema'a from the 115 respondents 78.3% are male and 21.7% are female. The questionnaires were allocated based on population of each location in the study area

**Table 2: Age of the Respondents**

| Age | Chikun | | Ikara | | Jemaa | | Total | % |
|---|---|---|---|---|---|---|---|---|
| <18 | 5 | 2.9 | 2 | 2.4 | 6 | 5.2 | 13 | 3.5 |
| 19-40 | 29 | 17.0 | 18 | 22.0 | 34 | 29.6 | 81 | 22.0 |
| 40-60 | 77 | 45.0 | 36 | 43.9 | 46 | 40.0 | 159 | 43.2 |
| >60 | 60 | 35.1 | 26 | 31.7 | 29 | 25.2 | 115 | 31.3 |
| **Total** | **171** | **100** | **82** | **100.0** | **115** | **100** | **368** | **100.0** |

**Source:** Author's Analysis, 2025

Table 2 reveals that in Chikun the highest number of farmers (45%) lies between the age of 40-60 while below18 years has the least (2.9%), while above 60 is 35.1% and 17% for 19-40 years.In Ikara 43.9% of the farmers are between the age of 40-60 and below 18 has the lowest number of farmers 2.4% while above 60 and ages 19-40 have 31.7 % and 22.0% . In Jema'a, the maximum number of farmers lies in between age 40-60 (40.0%) and the minimum are in age 18 (3.5%), while 19-40 has 29.6 and 25.2% lies in age above 60.

### 3: Educational Background

| Education | Chikun | | Ikara | | Jemaa | | Total | % |
|---|---|---|---|---|---|---|---|---|
| Adult Edu. | 38 | 22.2 | 32 | 39.0 | 30 | 26.1 | 100 | 27.2 |
| Vocation Edu. | 27 | 15.8 | 17 | 20.7 | 12 | 10.4 | 56 | 15.2 |
| Pri Sch. | 31 | 18.1 | 14 | 17.1 | 17 | 14.8 | 62 | 16.8 |
| Sec. Edu. | 59 | 34.5 | 12 | 14.6 | 35 | 30.4 | 106 | 28.8 |
| Tertiary Edu. | 16 | 9.4 | 7 | 8.5 | 21 | 18.3 | 44 | 12.0 |
| **Total** | **171** | **100.0** | **82** | **100.0** | **115** | **100.0** | **368** | **100.0** |

**Source: Author's Analysis, 2025**

In Chikun, table 3 shows that about 34.5% of the respondents acquired Secondary Education, while 9.4% have tertiary education, 22.2% attended Adult Education, vocational education has 15.8% and primary education has 18.1%. In Ikara, Adult Education has the maximum respondents 39,0% while Tertiary Education has the lowest (8.5%), vocation, primary school and secondary school have 20.7%, 17.1%, and 14.6 respectively

In Jema'a 30.4% have Secondary Education, and vocational education has the lowest 10.4% while Adult Education, Primary Education and Tertiary Education have 26.1%, 14.8%. and 18.3% respectively

### 5.2 Farmers' perception and their adaptation strategies adapted to the impact of wet and dry sp1ells.

| 4: Impact of Wet and Dry Spells | Chikun | | Ikara | | Jema'a | | Total | % |
|---|---|---|---|---|---|---|---|---|
| A a v/serious prob | 141 | 82.5 | 39 | 47.6 | 56 | 48.7 | 236 | 64.1 |
| B a serious prob | 18 | 10.5 | 20 | 24.4 | 48 | 41.7 | 86 | 23.4 |
| C a normal prob | 12 | 7.0 | 23 | 28.0 | 11 | 9.6 | 46 | 12.5 |
| **Total** | **171** | **100.0** | **82** | **100.0** | **115** | **100.0** | **368** | **100.0** |

**Source:** Author's Analysis, 2025

Table 4 reveals that in Chikun 82.5% of the farmers sees impact of wet and dry spells as a very serious problem, 7.0% viewed it as a normal issue while 10.5% responded that it is a serious problem. In Ikara, 47.6% see it as a very serious problem, while 24.4% and 28.0% opine it to be a serious problem and a normal problem, while in Jema’a, about 48.7 see it as a very serious problem, 9.6% and 41.7% attributed it to a normal and a serious problem.

| 5 Farmer’s Adaptation strategies | Chikun | | Ikara | | Jema’a | | Total | % |
|---|---|---|---|---|---|---|---|---|
| A Change in agricultural practices | 79 | 46.2 | 48 | 58.5 | 48 | 41.7 | 175 | 47.6 |
| B Planting hybrid crops that can mature earlier | 43 | 25.1 | 5 | 6.1 | 32 | 27.8 | 80 | 21.7 |
| C Promotion of local water management practices | 19 | 11.1 | 22 | 26.8 | 24 | 20.9 | 65 | 17.7 |
| D introduction of early warning systems for natural disaster response mechanisms | 18 | 10.5 | 7 | 8.5 | 8 | 7.0 | 33 | 9.0 |
| E implementing policies to support and empower farmers with modern | | | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 12 | 7.0 | 0 3 15 | 0.0 | 2.6 | 4.1 |
| **Total** | **171** | **100.0** | **82 115 368** | **100.0** | **100.0** | **100.0** |

agro-farm input

**Source: Author's Analysis, 2025**

Table 5 reveals that in Chikun, 46.2% of the respondents believed that Changes in agricultural practices implemented by the farmers could mitigate against negative effects of wet and dry spells on crop yield, 25.1% of the respondents opine that Planting hybrid crops that can mature earlier before the rain seized, 11.1% are of the view that Promotion of local water management practices by harvesting water for irrigation in case of cessation of rainfall, while 10.5% of the respondents believed in the introduction of early warning systems for natural disaster response mechanisms and 7.0% of the respondents are of the view that implementing policies to support and empower farmers with modern agro-farm input could help to mitigate the negative effects on crop yield. Likewise, in Ikara, 58.5% of the farmers' responded the same. 6.1% opine that Planting hybrid crops that can mature earlier before the rain seized, could help to mitigate the negative effects of wet and dry spells on crop yield and food security in the study area, while 26.8% of the respondents are of the view that Promotion of local water management practices by harvesting water for irrigation in case of cessation of rainfall and 8.5% of the respondents believed in the introduction of early warning systems for natural disaster response mechanisms.

In Jema'a, 41.7% of the respondents have the same believed that Changes in agricultural practices implemented by the farmers to could mitigate it negative effects, 27.8 of the respondents opine that Planting hybrid crops that can mature earlier before the rain seized, 20.9 are of the view that Promotion of local water management practices by harvesting water for irrigation in case of cessation of rainfall, while 7.0 of the respondents believed in the introduction of early warning systems for natural disaster response mechanisms and 2.6% of the respondents are of the view that implementing policies to support and empower farmers with modern agro-farm input could help to mitigate the negative effects, This is in line with Pervez et *al* (2022), Heino *et al* (2023), Wimalasiri *et al* (202) and Sifer *et al* (2016)

### 5. 3 Initial and Conditional Probabilities

In order to examine the P(W), P(D) and P(D/D) in the study area within the study period- Markov chain first order Model was deployed

Where,

P(W) = Probability of a Wet Day

P(W/W) = Probability of a Wet Day following a Wet Day

P(D) = Probability of a Dry Day

P(D/D) = Probability of a Dry Day following a Dry Day

**(a)** in **Chikun**

P(W) is 0.385 and P(W|W) = 0.712. Using first-order Markov chain model, the initial probability of state "W" (P(W)) is 0.385, and the conditional probability of transitionin g to state "W" given that the previous state was "W" (P(W|W)) is 0.712, indicating a moderate te ndency for the system to remain in state "W.

Initial Probability P(W): This means that at the beginning of the process, there's a 38.5% chance the system is in state "W".

Conditional Probability P(W|W): This indicates that if the system is currently in state "W", there's a 71.2% chance it will remain in state "W" in the next step.

Initial Probability P(D): 0.615 and Conditional Probability P(D|D): 0.819

(P(D|D)) suggest a high likelihood of dry days continuing, but not a guarantee.

(P(D) = 0.615): This means that, initially, there's a 61.5% chance of a dry day occurring in Chikun.

(P(D|D) = 0.819): This indicates that if the previous day was dry, there's an 81.9% chance the next day will also be dry. The high conditional probability suggests a tendency for dry days to persist, but it doesn't mean that a wet day is impossible. This is in line with some studies such as a study in Sri Lanka by Wamalasari et al (2020), Sifer *et al* (2016) in Eastern Ethiopia, jules *et al* (2021) in South America and Southern Africa, Jorge *et al* (2023) in South Africa and in the Middle Belt Region of Nigeria by Tyubee *et al* (2019).

**(b) in Ikara**

P(W): 0.317 and P(W|W): 0.631, P (D): 0.683 and P (D|D): 0.829

In a first-order Markov chain, the probabilities of all possible states must sum to 1 To calculate the remaining conditional probabilities. There for:

Since the probabilities from a state must sum to 1

P (W/D = 1- P(D/D)

P (W/D) = 1- 0.829

P (W/D) = 0,171

Transition probabilities shows that

P(W|W) = 0.631

P (D/W) = 0.369

P (D/D) = 0.829

P (W/D) = 0.171

State D is more likely initially (P/D) = 0.683

The state W (P/W) = 0.317

State D is more likely to remain in state D P(D/D) = 0.829

The state W P(W/W) = 0.631

If the current state is W, there is 36.9% chance the next state will be D

If the current state is D, there is a 17.1% chance the state will be W

The Markov chain shows that state D is more probable initially and more stable than state W.

**(c) In Jemaa**

P(W): 0.439 and P(W|W): 0.726; P(D): 0.561 and P(D|D): 0.786

(P(D)) is 0.561. A wet spell is more likely to continue (P(W|W) = 0.726), and a dry spell is even more likely to continue (P(D|D) = 0.786). Initial Probabilities:

Conditional Probabilities:

P(W|W) = 0.726

P(D|D) = 0.786

There is higher value of P(D|D) (0.786) compared to P(W|W) (0.726) suggests that dry spells are more persistent than wet spells in Ikara. This is in line with some studies such as the one that was carried out in Sri Lanka by Wamalasari et al (2020), Sifer *et al* (2016), in Eastern Ethiopia, jules *et al* (2021) in South America and Southern Africa and Jorge *et al* (2023).

## 6.0 CONCLUSION AND RECOMMENDATIONS

A survey on farmer's perception and adaptation strategies reveals that in Chikun, 46.2% of the farmers believed that Changes in agricultural practices implemented by the farmers to adapt to wet and dry spells could help to mitigate the negative effects of wet and dry spells on crop yield and food security, in Ikara, about 58.5% of farmers responded the same, likewise in Jema'a, 41.7%. Also, farmer's perception of wet and dry spells on crop yield shows that in Chikun 47.4% of the farmers Strongly Agree that Dry Spells is the major cause of drought which affects crop yields in the study area, 1.8% are Neutral while 38.0%, 7.6% and 5.3% of the farmers; agree, disagree and strongly disagree that Dry Spells is the major cause of drought which affects crop yields. In Ikara, 42.7% of the farmers strongly agree that Dry Spells is the major cause of drought which affects crop yields in the study area, while 25.6%, 17.1 and 14.6 of the farmers; Agree, Disagree and Strongly Disagree that Dry Spells is the major cause of drought which affects crop yields in the study area, and in Jema'a, 49.6% of the respondents Strongly Agree that Dry Spells is the major cause of drought which affects crop yields in the study area, while 45.2%, 0.9% and 4.3% of the farmers; Agree, Disagree and Strongly Disagree that Dry Spells is the major cause of drought which affects crop yields in the study area.

Also, in Chikun the Markov Chain Model analysis of the initial and conditional probability result reveals that P(W) is 0.385 and P(W|W) = 0.712. and P(D): 0.615 and Conditional Probability P(D|D): 0.819. This indicates that if the previous day was dry, there's an 81.9% chance the next day will also be dry. The high conditional probability suggests a tendency for dry days to persist, but it doesn't mean that a wet day is impossible. In Ikara the paper reveals the P(W): 0.317 and P(W|W); P (D): 0.683 and P(D|D): 0.829. If the current state is W, there is 36.9% chance the next state will be D. If the current state is D, there is 17.1% chance the state will be W. Markov chain shows that state D is more probable initially and more stable than state W and in Jema'a, the P(W): 0.439 and P(W|W): 0.726, P(D): 0.561 and P(D|D): 0.786 (P(W)) is 0.439, while (P(D)) is 0.561. A wet spell is more likely to continue (P(W|W) = 0.726), and a dry spell is even more likely to continue (P(D|D) = 0.786

Rainfall variability negatively impacts crop yield by disrupting water availability, affecting crop growth and survival. 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. Prolonged dry spells can cause significant yield losses for all three crops. Early-season dry spells affect germination and establishment, while mid-season dry spells impact late-maturing varieties. For example, maize, a major grain-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.

Consequent upon the findings of this study, it is concluded that, during wet spells, farmers should choose crops suitable for periods of high rainfall, implement drainage to prevent waterlogging, and time their planting to coincide with the onset of the wet season to optimize rainwater use. Also, farmers should be understanding local weather patterns and employing crop models as well as rainwater harvesting, and soil and water conservation techniques

## REFERENCES


Aremu, J.K. (2020). The *Language of Meteorology.* Third Edition, Cee Kay Bee, Kaduna

Bununu, P., Ludin, A., Hosna A. (2015): City profile: Kaduna. *Science Direct Article*. 5365

Chimimba, E.G., Ngondo, C., Li, C., Minoungou, B., Monjerezi, M. and Eneva, L. (2023) Carry out a study on Characterisation of dry spells for agcterisricultural applications in Malawi. *Applied Science Article*, (5) 199-215

Daniel, S., Mengistu, M.G., Olivier, C., and Clulow, A.D. (2023). Analysis of Dry-Spells in the Western Maize-Growing Areas of South Africa. *Water and Environmen Article,* 1506 1521

Durowoju S.O.; Ologunorisa T.E.; Akinbobola A (2022). Impact of drought on cereal crop yields in the Savanna Region of Nigeria. *Journal of Africa Geographical Review*. 273-293.

Gobin, A. and de vyver, H.V. (2021). Spatio-temporal variability of dry and wet spells and their influence on crop yields. *Article of Agricultural and Forest Meteorology.* 108565

Hansel, S., Hoy, A., Brendel, C., and Maugeri, M. (2022) Carry out a study titled "Record summers in Europe: Variations in drought and heavy precipitation during 1901–2018 *International Journal of Climatology*. https://doi.org

Heino, M., Kinnunen, P., Anderson, W., Ray, D. K., Puma, M. J., Varis, O., Siebert, S., and Kummu, M. (2023). Increased probability of hot and dry weather extremes during the growing season threatens global crop yields. *Scientific reports,* 13(1) 3583. https://doi.org

Jorge, A. B., Camilla, D., Roberto F., Nicolo, B. and Anna, D. M. (2023). Modelling climate Change impacts on crop production in food security region, the case of Niger, *Article of European Journal of Agronomy* 142(4) 126667

Kawu, M.U. (2019). Impact of Weather on Guinea Corn Production in Igabi Local Government Area of Kaduna State, Nigeria. M.Sc Thesis, Department of Geography Federal University of Technology, Minna

Korbinian, B., Giuliano D. B., Maurizio M., David L., and Giulia V. (2020). Extreme Dry and Wet Spells Face Changes in Their Duration and Timing, *Environmental Research Letters*, 15:(2) 67-73

Jean, M.J, Mathias, B., Elliott, D.Y and Kazuki, S. (2023). Farmers perception and management of water scarcity in irrigated rice-based systems in dry climatic zones of West Africa, A*article of Agronomy for Sustainable Development* (2) 42-45

Jules, B., Moctar, C., Ibrahima, D., and Aarona, D. (2021) Probability of dry and wet spells over West Africa during the summer monsoon season. *Scientific and Research Essays Journal*. 16 (3) 20-35

Makinde, A.A., Eruola, A.O., Ufoegbune, G.C.and Ojekunle, Z.O. (2019). Sensitivity Assessment of Maize (Zea Mays L.) Cultivars Growth Parameters to Agrometeorological Indices in Abeokuta, Southwest Nigeria *Journal of Tropical Agriculture, Food, Environment and Extension*. (8) 39-44

Oduwale, K. (2020). A Markov Chain Model for Wet and Dry Spell Probabilities at Yola, Adamawa State. *Agricultural Engineering Article.* 5-7

Pervez, M.S., Velpuri, N.M., and Costabile, P. (2022) Farmers' Perception of Climate Change and Its Impacts on Agriculture. *Journal of hydrology*. **https//doi.org/hydrology**

Pius M.N., S.A Yelwa and A.B Sanda (2020). Assessment of Drought across Kaduna State Nigeria using MODIS Dataset. *Journal of Geography, Environmental Science International.* 24 (6) 45-61

Pius M.R., Yelwa S.A., Jibrillah A., and Umar U. (2023) Time Series Analysis of Climate Change, Drought and Foot Security, Nexus in Kaduna State Nigeria. *Environmental Science International journal.* 20 (3) 47-62

Redane, H.R., Beketie., K.T., Fantahun, E.E., Feyisa, G.L., and Anose, F.A (2022) The Impact of Rainfall Variability and Crop Production on Vertisols in The Central Highlands of Ethiopia, *Environmental System Research Journal*. (11) 26-44

Reshmita N., Debesi N., and Wen C (2017), Impact of Drought on Agriculture in the Indo-Gangetic Plain, India, *Journal of Advances in Atmospheric Sciences* 34(3) 34(3)

Sada, A.B., Yusuf, F., and Aremu, J.K (2023) Assessment of the Effect of Rainfall Variability on Maize Productivity in Kaduna State, Nigeria, Dutse *Journal of Pure and Applied Sciences* 9 (3b): 240-246

Sanchi, I. D., Alhassan, Y., Sabo, Y., Hamid, B. J. (2021). Critical Review of the Causes and Effects of Dry Spell in 2021 Rainy Season in Danko Wasagu Local Government, Kebbi State, Nigeria. *Cross Current International Journal of Agriculture and Veterinary Sciences*, 2454-2663

Sawa, B.A and Adebayo, A.A. (2018). Effects of Pentad Dry Spells On the Yield of Some Crops in The Semi-Arid Eco-Climatic Region of Northern Nigeria. *Article on Agricultural Engineering,* 19 (1) 49-60

Sifer, K., Yemenu, F., AsfawKebede, A. and Quarshi, S. (2016). Wet and dry spell analysis for decision making in agricultural water management in the eastern part of Ethiopia, West Haraghe. *International Journal of Water Resources and Environmental Engineering*, 7-8.

Tettey, M, Adedia, D, Oduro, F.T., and Abaye, D.A. (2017). Markov Chain Analysis of The Rainfall Patterns of Five Geographical Locations in The South Eastern Coast of Ghana. *Earth Perspectives* (4) 6. https://doi.org

Tyubee, B. T. and Iwan, M.T. (2019). A markov chain analysis of wet and dry spells for agricultural crop planning in the Middle Belt Region of Nigeria. *Journal of Agriculture Sand Environmental Sciences* 8 (2), 132-147.

Walsh, J E., Ballinger, T. J., Euskirchen, E.S., Hanna, E., Overland, J. M., Tangen, H., and Vihma, T. (2020) carry out a study titled "Extreme Weather and Climate Events in Northern Areas: A review" Earth-Science *Reviews Journal* **(**209**)** 103324

Wimalasiri, E.M, and Ampitiyawatta, A (2022) Markov Chain Probability Models to Describe Bi modal Rainfall Pattern in Sri Lanksa. *Journal of Agricultural Science* 17 (2) 319-333 WHO (2023) **https://www.who.int/**health-topics/drought