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31. Musa. K.O, Lawal. A (2021) Analysis of Drought and Flood Occurrence Using Markov Chain. A paper presented at 3rd School of Physical Science Biennial International Conference held at Federal University of Technology, Minna from 25th - 28th October, 2021.



SPCBBIC 2021

25th – 28th October, Minna Nigeria

**3RD SCHOOL OF PHYSICAL SCIENCES BIENNIAL
INTERNATIONAL CONFERENCE
(SPSBBIC 2021)**

PROCEEDINGS

**THE THEME:
THE ROLE OF SCIENCE AND TECHNOLOGY IN THE
REALIZATION OF RESEARCH AND DEVELOPMENT IN THE
ERA OF GLOBAL PANDEMIC**

**FEDERAL UNIVERSITY OF TECHNOLOGY MINNA,
NIGER STATE, NIGERIA**

PREFACE

It is a great privilege for us to present the proceedings of 3rd School of Physical Sciences Biennial International Conference (SPSBIC) 2021 devoted to the role of science and technology in the realization of research and development in the era of pandemic. We hope that authors, delegates, agencies other individuals will find this compilation very useful and inspiring.

The school of Physical Sciences 3rd Biennial International Conference is an interdisciplinary forum for the presentation of new ideas, recent developments and research findings in the field of Science and Technology. The Conference provides a platform to scholars, researchers in the academics and other establishments to meet, share and discuss on the role of science and technology in the realization of research and development in the era of pandemic. Submissions were received both nationally and internationally and severally reviewed by our international program committee. All contributions received were neither published elsewhere nor submitted for publication as asserted by contributors.

This conference brought together experts from varying fields, visions, knowledge and experience with potentials; pre-conference workshop and four keynote speakers with world class experience in varying fields of specialization in addition to over 150 scientific participants who unveiled the latest scientific evidence to boost contemporary scientific and technological research development in the era of pandemic.

The success of the conference was a function of the collective efforts of numerous individuals. Our profound gratitude goes to the Dean School of Physical Sciences Prof. Jonathan Yisa for putting the trust in us to serves as the Local Organizing Committee (LOC). The Vice Chancellor Prof. Abdullahi Bala and the entire management team for their unflinching support that led to the success story. We are most grateful to our workshop facilitator and his team as well as our keynote speakers for accepting our invitations and travelled long distances to be with us at no cost to the University. We also acknowledge the participants themselves, without whose expert input there would have been no conference. Thank you all for your contributions.

Prof. A. Abdulkadir
Chairperson Local Organizing Committee

THEME OF THE CONFERENCE

The Role of Science and Technology in the Realization of Research and Development in the Era of Global Pandemic

SUB-THEMES OF THE CONFERENCE

- Sustainable Management of Pandemic
- Global Change, Responses and Strategies for Limiting Pandemic
- Modelling and Monitoring of Pandemic
- Science, Technology, Engineering and Mathematics as Leveraging tools for Management of Pandemic

PRE-CONFERENCE WORKSHOP TITLE

Isolation, Purification and Structural Elucidation of Compounds and Drug Testing on Animals

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Dr. A. N. Amadi

KEYNOTE SPEAKERS



Dr. H. A. Shaba

Dr. Halilu Ahmad Shaba was a Director, Strategic Space Applications Department (SSA), National Space Research and Development Agency (NASRDA) as well as HOD, Department of Geo-informatics & GIS Applications, Institute of Space Science and Engineering (ISSE) affiliate of Africa University of Science and Technology (AUST), Abuja.

Dr. Shaba has successfully overseen and implemented over 20 projects among which are:

- Mapping the Drivers of Deforestation and Forest Degradation in Cross River State, Nigeria (Sponsored by FAO)
- Erosion Mapping and Monitoring with Space Technology in South-East and South-South Nigeria (Sponsor by World Bank via NEWMAP).
- Monitoring deforestation and forest degradation in cross river state, Nigeria (Part of the implementation of the UN-NEDD program in Nigeria)
- National Personnel Audit Geospatial Database Development: Sponsor by UBEC
- Geo-referenced Infrastructure and Demographic Data for Development (Grid3) Project in Nigeria (NASRDA, eHealth Africa, Centre for International Earth Science Information Network (CIESIN) USA and Novel T)
- Engagement for harmonization of health facilities database (Phase 1: Geospatial Tracking System (GIS): (Ministry of health, National Primary Health Care Development Agency collaborating with National Space Research & Development Agency, eHealth Africa Foundation and Novel T).
- Space Based Digital Farm Monitoring from space for 2020 dry season farming (CHN Anchor Borrower)

Dr. Shaba has also provided services to several National and International Committees/Panels throughout his tenure as director SSA, amongst are:

- Member, Nigerian Delegation to United Nations Committee on Peaceful Use of Outer Space (UN-COPUOS) from 2005 to date
- Member, Joint Expert Group & (JEG) on the implementation of an integrated AU-EU Joint Strategy under the 8th Partnership on Science, Information Society and Space, 2010 to date.
- Member, Extended Coordinating Team of Global Monitoring of the Environment & Africa (GME&A Africa), 2010 to date
- Executive Committee Member & GEO Principal for Nigeria, Group on Earth Observation (GEO), Geneva, Switzerland (2013-date)

Finally, Dr. Shaba is a member of several organizations and has been conferred with the award of honorary fellow by the following prestigious bodies;

- Geo-information Society of Nigeria (GEOSON)
- Society of Professional Disaster Risk Managers of Nigeria (SOPDRIMN)
- Nigerian Cartographic Association (NCA)



Dr. M. Alkali

Dr. Muhammad Alkali is a versatile scientist, instructor, and administrator with numerous published articles in academic and scholarly journals. Before he was appointed the Group Head, SIC, Dr Alkali bagged his Ph.D. in Integrated Systems Engineering with a research bias in Spacecraft Power Systems from Kyushu Institute of Technology (KYUTECH/KIT), a prestigious University of Technology in Japan. While in Japan, he participated in the design and development of the Electrical Power System of the Arc Event Generator and Investigator Satellite (AEGIS), a scientific spacecraft also known as Horyu-IV which was successfully launched into orbit on-board the H-2A rocket in February 2016.

He received his Masters degree in Personal, Mobile & Satellite Communications from the University of Bradford, England. His tertiary education commenced with a Bachelor degree (second class- upper division) in Physics/Electronics from the Federal University of Technology Minna, Niger State. Dr. Alkali has had a colourful, impactful career spanning from Advanced Microcomputer Systems to Central Bank of Nigeria (NYSC) to SAGEM SA to the Abuja area office of the United Bank for Africa (UBA) to the National Space Research and Development Agency (NASRDA) and finally to the Nigerian Communications Satellite Limited (NIGCOMSAT) where he has served in various capacities over the years in Satellite Network Control and Applications. He was also a pivotal member of the AFRICARE-NIGERIA's project (Independent Policy Group), a think-tank for the President of Nigeria (2002-2003).

Dr. Alkali has always aimed to have an expansive international and local repertoire of knowledge while keeping abreast with industry trends. This has led to his participation in the study visit on European Union Global Navigation Satellite System in Spain, his attendance at the Indian Institute for Public Administration (IIPA) New Delhi, where he trained in Global Strategic Leadership for Growth and Sustainable Development. He attended the Advanced Visioning and Leadership Programme on Managing Human Capital and Shaping Culture organized by TL First Group/Institute of Leadership and Management of UK. He also attended a practical project management course at CCLL, Cardiff University-United Kingdom. He was among the 50 Scientists/Engineers trained at the China Academy of Space Technology/ Beijing Institute of Tracking & Telecommunications Technology for Know-how Technology Transfer training on NigComSat-1 from 2005. In 2008, he attended a Satellite networking course at PT Telkom learning Centre in Bandung, Indonesia.

Dr. Alkali is a fellow of the African Scientific Institute (FASI), a Fellow of the Institute of Corporate Administration (FCIAI), a senior member of the American Institute of Aeronautics and Astronautics, Member Nigerian Institute of Physics, and a Member of the Computer Professionals Registration Council of Nigeria (MCPN). Dr. Alkali has vast interests ranging from Design thinking; energy; CT; science, technology, and innovations (STI) to spacecraft design and systems integrations (payload and bus systems).



Professor Abdul Kabir Mohammed

Professor Abdul Kabir Mohammed is currently serving as Professor and Chair of the Department of Chemistry & Biochemistry at North Carolina Central University, Durham, NC. Previously, he served as the Chair of the Department of Chemistry at Winston Salem State University, Winston-Salem, NC and prior to that appointment he was an Associate Professor at North Carolina A&T State University, Greensboro, NC.

Prof. Mohammed graduated from the University of Benin, Benin-City in 1983 with a B.Sc. (first class honors) degree in chemistry. He worked briefly in 1987 as a Graduate Assistant at Federal University of Technology, Yola (now Modibbo Adama University of Technology), before proceeding to Louisiana State University for his postgraduate education.

He received his Ph.D. in inorganic chemistry in 1982 and did postdoctoral research at Florida State University from 1982 to 1983. He was a Fulbright Scholar at Sultan Qaboos University in Oman from 2003 to 2004; and he served as a Carnegie African Diaspora Fellow at the Federal University of Technology, Minna, Nigeria in the summers of 2017 and 2019. His research interests include photochemistry and photochemistry of transition metal complexes and chemical education. He teaches general, inorganic and environmental chemistry courses.

University from 1983 to 1983. He was a Fulbright Scholar at Sultan Qaboos University in Oman.



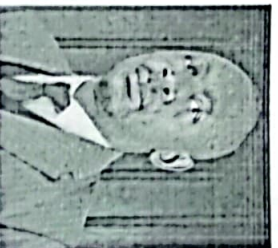
Prof. Makun Hussaini Anthony

Prof. Makun Hussaini has 29 years of experience as a university academic staff and a researcher in areas relating to food safety, environmental health monitoring, mycotoxicology and mycology. He possess a Doctorate degree in Biochemistry (Toxicology) after successful completion of a thesis entitled “Studies on mycoflora and mycotoxins contaminating guinea corn and rice in Niger State, Nigeria” This was preceded by an MSc degree in Biochemistry (thesis titled “Analysis of blood levels of trace metals, total lipids and cholesterol in Ajaokuta Steel Industry workers”). The novelty of finding *Fusarium verticillioides* in Nigerian rice during his PhD work, which is the fungi associated with oesophageal cancer (EC) in South Africa, earned him a National Research Foundation Postdoctoral Fellowship (PDF) with Food Environment and Health Research Group of the University of Johannesburg (UJ).

Being a university teaching staff for over almost three decades, Prof. Makun has taught many biochemistry and environmental toxicology related courses at both undergraduate and postgraduate levels. He has supervised and graduated over 85 B-Tech, 18 M-Tech students and 9 PhDs. The graduate students all worked on mycotoxins.

Prof. Makun has won national and international research grants to the cumulative sum of \$8, 647,787. 47. He is a Fellow of Mycotoxicology Society of Nigeria (FMSN), a member of the National Agency for Food and Drug Administration and Control (NAFDAC), National Food Safety Advisory Committee of Nigeria, National Codex Committee of Nigeria, African Union Expert Committee on Contaminants in Food (2011 to date) and Joint FAO/WHO Expert Committee on Contaminants in Food (JECFA) (2012-2020). He coordinated the writing of the “discussion paper on fungi and mycotoxins in Sorghum” which was adopted as a document of the Joint FAO/WHO Experts Committee on Food Additives (JECFA) in 2012 and participated in the writing of “Proposed draft annex for “prevention and reduction of aflatoxins and ochratoxin A in sorghum” in the existing code of practice for the prevention and reduction of mycotoxin contamination in cereals (CACRCP 51-2003)”. He wrote on the prevention and control of sterigmatocystin and diacetoxyscirpenol for the 83rd meeting of JECFA held in November, 2017 in Rome.

Prof. Makun has 72 publications, mostly on mycotoxins in peer review journals, technical papers and books. He was the immediate past Director of Research, Innovation and Development of the Federal University of Technology Minna, Nigeria. He is currently the Lead Researcher of the Food and Toxicology Research Group and Centre Leader of the Africa Centre of Excellence for Mycotoxin and Food Safety of the Federal University of Technology Minna. Project Coordinator of the West African Food Safety Network (WAFOSAN) and Member of the African Food Safety Network. He has served as election monitor, election collation and returning officers at state and national assembly elections from 1999 to 2015). He has passion for jogging and reading. He is married to Barrister Evelyn Pumbelo Hussaini and blessed with four children.



Dr. Eustace Manayi Dogo

Dr Eustace M. Dogo has over ten years of industry experience working in Russia, Europe and Nigeria. He holds a BSc and MEng degrees in Electrical Engineering from Peter the Great Saint Petersburg Polytechnic University, Saint Petersburg, Russia and PhD degree from the University of Johannesburg, South Africa. His PhD research focused on investigating imbalanced learning using Artificial Intelligence algorithms in real-world drinking-water quality detection problems, where he proposed three new dynamic selection algorithms combined with data pre-processing methods.

Among his notable contributions while at the University of Johannesburg during his postgraduate studies, Dr Eustace Dogo served as a volunteer to the 6th International Conference on Soft Computing and Machine Intelligence (ISCMI 2019) held in Johannesburg, South Africa, on November 19-20. In 2019, he served as a tutor in the first Short Learning Programme (SLP) in Computational Intelligence for Industry, organized by the Institute for Intelligence Systems in collaboration with the Department of Information Systems at the University of Johannesburg, and successfully graduated two batches of students drawn across diverse works of life (over 50 students).

Dr Eustace Dogo was recently among a panel of discussants in the University of Johannesburg's *Cloudshare* on the Fourth Industrial Revolution and Technology for People with Disabilities. Between 2018 and 2019, he co-supervised to completion 16 undergraduate students in the Department of Electrical and Electronic Engineering Science, University of Johannesburg, South Africa. He also presented a technical talk at the *POWER-GEN & Distrib TECH - GEN-A* conference and exhibition which took place in Sandton, Johannesburg in 2017.

Dr Eustace Dogo has extensive knowledge in industry, research, training and teaching. He is an active undergraduate and postgraduate degree supervisor and has authored and co-authored in reputable journals, conferences and several scholarly research books in his areas of interest. He joined the academia in 2012 and currently lectures at the Department of Computer Engineering, Federal University of Technology Minna, Nigeria. His broad research interest includes, theoretical and applied Machine Learning, Intelligent Systems, Cloud Computing and Emerging Technologies. He is married to Barrister Fatima Eustace-Dogo and blessed with three children.

CONFERENCE WORKSHOP FACILITATOR



Prof. Derek Tantoh Ndinteh

Prof. Derek Tantoh Ndinteh is an expert in areas of Natural Products Chemistry; drug discovery and drug delivery platforms. He is currently working on Natural Products Chemistry that deals with extraction, purification, isolation and characterization of chemical substances and evaluation of biological and pharmacological activities of African plants for pharmaceutical industries.

He is interested in collaborating with Federal University of Technology, Minna on the evaluation of the antidiabetic, antimicrobial, antioxidant, anticancer and anti-ulcerogenic potentials of secondary metabolites from Nigerian Medicinal Plants.

Our interaction so far with Prof. Derek Tantoh Ndinteh has been very mutual and beneficial to both Universities involved because it has potential to increase our visibility at global level based on academic activities and mainstreaming and replication of the research and teaching outcomes of this collaboration by the staff and students can be integrated into overall development of Nigeria and South Africa.

PRO IS INTERESTED IN COLLABORATING WITH FEDERAL UNIVERSITY OF TECHNOLOGY MINNA ON THE EVALUATION



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Analysis of Drought and Flood Occurrence Using Markov Chain

¹Musa, Oziolu Khadijat; ¹Lawal, Adamu

¹Department of Mathematics Federal University of Technology, Minna.

Abstract

Flood and drought are among the most common natural disasters affecting the world. In this paper, Markov model has been used to analyse and predict flood and drought occurrences in Birnin Kebbi Nigeria. The Standardized Precipitation index (SPI) was used to classify the annual rainfall of Birnin Kebbi into three states (flood, normal and drought). After some successful iterations of the model, the model stabilized to equilibrium probabilities, revealing that in the long-run 20% of the years in Birnin Kebbi will experience flood, 60% will experience normal rainfall and 20% will experience drought. It was also observed that, a drought year cannot be followed by a flood year and the probability of a drought year to be followed by a normal year is high while the probability of a normal year to be followed by a drought year and a drought year to be followed by another drought year is extremely small. Results from this research is an important information to the government and people of Kebbi state for better understanding of rainfall dynamics in their locality.

Keyword: Markov model, Annual Rainfall, Standardized Precipitation Index, Transition Probability, Equilibrium Probabilities.

Introduction

Floods and droughts are among the most disastrous natural hazards in the world (Bates, *et al.*, 2008; IPCC, 2007b, 2012). Drought occurs when there is significant rainfall deficit that causes hydrological imbalances and affects the land productive systems. Drought practically occurs in all climate regions with both high and low mean rainfalls (Um *et al.*, 2017). It can result in damaging agricultural production and the natural environment (Gidye *et al.*, 2018). Drought is often seen as a “creeping” phenomenon with slow onset and cessation. As a result, an effective drought monitoring system is the most important tool for developing and implementing efficient mitigation strategies. However, not only can the onset of drought conditions be rapid, an indication of how long drought conditions may continue will enable improved planning and resource allocation. For this reason, a capability to accurately forecast the onset, persistence and cessation of drought conditions will enable more effective drought mitigation strategies to be developed (Singleton, 2012). Guba-sapir *et al.* (2012) defines flood as significant rise of water level in a stream, lake, reservoir or coastal region. Also, (Nelson, 2007) defined flood as excessive water run-off or the rise in water level in a particular area which is more than what the particular environment can absorb. Flood and drought are one of the most devastating natural disasters in the world.

In Nigeria, the story is not different as these has caused serious havoc to our environment and the economy. However, little or nothing can be done to avoid its occurrence but prior information such as prediction of flood and drought can assist the farmers, stakeholders and the general public to take adequate proactive measure in order to mitigate their effects. Hence, the result from this model will provide adequate information about flood and drought in some upcoming years for the studied areas. According to NEEMA, in 2012 alone, floods caused more than N2.6 trillion in economic damage, much of which could be attributed to large-scale trans boundary floods (from rivers Niger and Benue). In 2019, about 126 deaths were recorded, over 48,000 people were displaced and property worth millions of Naira destroyed across the country. (Nigeria Hydrological Services Agency, 2020). The Standard Precipitation Index (SPI) was introduced by McKee *et al.* (1993) as measure of the precipitation deficit that is uniquely related to probability. It can be calculated for any accumulation timescale, usually from monthly precipitation observations, and is typically expressed

as SPI-n, where n is the number of months of accumulation. The time series is analogous to a moving average in the sense that a new value is calculated each month and is auto-correlated to previous months depending on the accumulation timescale (Singleton, 2012).^T

Materials and Method

Birnin Kebbi is the capital city of Kebbi state, is located in north-western Nigeria on (12° 27' N and 4° 11' E). The data used for this research work were obtained from the National Oceanic and Atmospheric Administration (NOAA) for the period of thirty years (1991 to 2020). After which the SPI was used to classify the rainfall into states

Model Formulation

Suppose that the SPI rainfall classification for a year is considered as a random variable x , the collection of these random variables over the years constitute a stochastic process $X_n, n=0,1,2,3,\dots$, we assume that this stochastic process satisfies Markov property.

Let the annual rainfall be modelled by a three-state Markov model based on the SPI classification

State 1: Flood (SPI Value ≥ 1)

State 2: Normal ($-0.99 \leq \text{SPI Value} \leq 0.99$)

State 3: Drought (SPI Value ≤ -1)

The transition probability matrix is represented by

$$P = \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix} \quad (1)$$

Following (Lawal, 2017), let $P^{(n)}$ be the probability state vectors of the Markov chain, where $n=0,1,2,3,\dots$ and let $P_i^{(n)}$ be the probability that the annual rainfall is in the i^{th} state at the n^{th} year.

$P^{(0)}$ is the initial state vector of the Markov chain and $p^{(n)}$ is the state vector at the n^{th} year. Then, by induction we have that

$$P^{(n)} = P^{(n-1+1)} = P^{(n-1)} P = P^n \quad (2)$$

On iteration we have,

$$P^{(n)} = P^{(0)} P^n \quad (3)$$

That is, the initial state vector $P^{(0)}$ and the transition matrix P determine the state vector $P^{(n)}$ at the n^{th} year. If we now let

$$P^{(n)} = [P_1^n \ P_2^n \ P_3^n] \quad (4)$$

Denote the probabilities of finding the annual rainfall in any of the three states at the n^{th} year and also let

$$P^{(0)} = [P_1^0 \ P_2^0 \ P_3^0] \quad (5)$$

Denote the initial state vector and its elements, the Markov chain model for annual rainfall based on SPI classification in the study area can be represented by

$$[P_1^n \ P_2^n \ P_3^n] = [P_1^0 \ P_2^0 \ P_3^0] \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix} \quad (6)$$

Limiting State Probability

The limiting state probability is represented by equation (7) below and is obtained when $n \rightarrow \infty$ in equation (3).

$$\pi = \pi P \quad (7)$$

where $\pi = [\pi_1 \ \pi_2 \ \pi_3]$

$$\pi = \sum_{i=1}^3 \pi_i = 1 \quad (8)$$

These equations will be used to find the limiting state probabilities for our model.

Results and Discussion

Table 1: A Summary of SPI Annual Rainfall Classification of Berinin Kebbi.

SPI classification	frequency	State
SPI value ≥ 1	6	Flood
$-0.99 \leq$ SPI value ≤ 0.99	18	Near normal
SPI value ≤ -1	6	Drought

From Table 1, we obtained the transition count presented in equation (9)

$$C = \begin{bmatrix} 2 & 2 & 2 \\ 4 & 10 & 3 \\ 0 & 5 & 1 \end{bmatrix} \quad (9)$$

The probability transition matrix obtained from equation (9) is presented below

$$P = \begin{bmatrix} 0.333 & 0.333 & 0.333 \\ 0.235 & 0.588 & 0.176 \\ 0 & 0.833 & 0.167 \end{bmatrix} \quad (10)$$

Calculating P^n , on iteration we have

$$P^2 = \begin{bmatrix} 0.189 & 0.584 & 0.225 \\ 0.216 & 0.571 & 0.211 \\ 0.196 & 0.629 & 0.174 \end{bmatrix} \quad (11)$$

$$P^4 = \begin{bmatrix} 0.206 & 0.585 & 0.205 \\ 0.205 & 0.584 & 0.206 \\ 0.207 & 0.582 & 0.207 \end{bmatrix} \quad (12)$$

$$P^8 = \begin{bmatrix} 0.206 & 0.583 & 0.205 \\ 0.205 & 0.583 & 0.205 \\ 0.206 & 0.583 & 0.206 \end{bmatrix} \quad (13)$$

$$P^{20} = \begin{bmatrix} 0.204 & 0.577 & 0.204 \\ 0.204 & 0.577 & 0.203 \\ 0.203 & 0.578 & 0.203 \end{bmatrix} \quad (14)$$

$$P^{30} = \begin{bmatrix} 0.202 & 0.573 & 0.202 \\ 0.202 & 0.572 & 0.202 \\ 0.202 & 0.573 & 0.202 \end{bmatrix} \quad (15)$$

$$P^{50} = \begin{bmatrix} 0.199 & 0.563 & 0.199 \\ 0.199 & 0.563 & 0.199 \\ 0.199 & 0.563 & 0.199 \end{bmatrix} \quad (16)$$

Limiting State Probabilities

As n increases, P^n gets closer to equation (16) that is, $n \geq 50$ the transition probabilities stabilise to equation (16); and from equation (3) with the initial state probability vector

$$P^0 = [1 \quad 0 \quad 0]$$

$$P^{(n)} = P^0 P^n = [1 \quad 0 \quad 0] \begin{bmatrix} 0.199 & 0.563 & 0.199 \\ 0.199 & 0.563 & 0.199 \\ 0.199 & 0.563 & 0.199 \end{bmatrix}$$

$$P^{(n)} = [0.199 \quad 0.563 \quad 0.199] \quad (16)$$

Correcting to one decimal place, we have:

$$P^{(n)} = [0.2 \quad 0.6 \quad 0.2]$$

This is the probability of finding the annual rainfall based on SPI classification fall in any of three states for large n (i.e. $n \geq 50$)

From equation (3), we obtained the limiting state probability vector that is equation (7).

$$\text{Thus: } \pi = \pi P \quad (0.2 \quad 0.6 \quad 0.2)$$

The interpretation of this result is that, in the long-run 20% of the years during rainy season in Birnin Kebbi will experience flood, 60% will experience normal rainfall while 20% will experience drought. As it can be seen from equation (10) (transition probability matrix) a drought year cannot be followed by a flood year and the probability of a drought to be followed by a normal year is high while the probability of a normal year to be followed by a drought and a drought year to be followed by another drought year is extremely small.

