



**FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA**



**SCHOOL OF ENVIRONMENTAL TECHNOLOGY
INTERNATIONAL CONFERENCE (SETIC 2016)**

SETIC 2016 *Conference Proceedings*

EDITORS:

**Yekeen A. SANUSI
Olatunde F. ADEDAYO
Richard A. JIMOH
Luqman O. OYEWObI**

THEME:

**SUSTAINABLE BUILT ENVIRONMENT
AND CLIMATE CHANGE:
THE CHALLENGE OF POST 2015
DEVELOPMENT AGENDA**

DATE:
**TUE. 10TH - THUR. 12TH
MAY, 2016**

VENUE:
**SCHOOL OF ENVIRONMENTAL
TECHNOLOGY COMPLEX**

TIME:
**9:00AM - 5:00PM
DAILY**

CHIEF HOST:
PROF M. A. AKANJI
VICE CHANCELLOR, FEDERAL UNIVERSITY
OF TECHNOLOGY, MINNA

HOST:
PROF Y. A. SANUSI
DEAN, SCHOOL OF ENVIRONMENTAL TECHNOLOGY,
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

SUPPORTED BY



**School of Environmental Technology
International Conference
(SETIC) 2016**

10-12 May 2016

**Federal University of Technology Minna,
Niger State, Nigeria**

Conference Proceedings

Editors

**Yekeen A. SANUSI,
Olatunde F. ADEDAYO,
Richard A. JIMOH,
Luqman O. OYEWOLI,**

Conference Proceedings of the School of Environmental Technology International
Conference (SETIC) 2016

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10th – 12th May 2016
School of Environmental Technology,
Federal University of Technology, Minna, Niger State, Nigeria.

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FOREWORD

The organising committee of the 1st School of Environmental Technology International Conference is pleased to welcome you to Federal University of Technology Minna, Niger State Nigeria.

The conference provides an international forum for researchers and professionals in the built and allied professions to address fundamental problems, challenges and prospects that affect the Built Environment as it relates to Climate Change and Sustainable Development. The conference is a platform where recognised best practices, theories and concepts are shared and discussed amongst academics, practitioners and researchers. The papers and scope are quite broad but have been organised around the sub-themes listed below:

- Infrastructure Development and Financing
- Sustainable Practice Theories
- Urban Resilience and Energy Conservation
- Waste Management and Sanitation
- Health and Safety Issues
- Climate Change and Threat to Sustainability of the Built Environment
- Climate Change Induced Disaster
- Designing the Human Settlement for Climate Change
- Conceptual Issues on Climate Change and Sustainable Development
- Sustainable Materials
- Cross Cutting Issues

The peer review process saw us making use of 48 senior academics and specialist as reviewers drawn from institutions in Nigeria and England. There were some papers were outside the theme of the conference but we had to create a cross cutting issues to accommodate such papers this is in spirit that every knowledge is important.

We hope you enjoy your time at our conference, and that you have the opportunities to exchange ideas and share knowledge, as well as participate in productive discussions with the like-minded researchers and practitioners in the built environment and academia.

Professor Yekeen Adeeyo Sanusi
Conference Chair
School of Environmental Technology International (SETIC) 2016
Federal University of Technology Minna, Niger State Nigeria.
May 2016

ACKNOWLEDGEMENTS

The success of the 1st School of Environmental Technology International Conference holding at the Main Campus of the Federal University of Technology Minna, Nigeria is predicated on the support and goodwill from Vice-Chancellor of Federal University of Technology and many other highly motivated people.

I sincerely wish to appreciate you for attending this maiden event and to warmly welcome you to the city of Minna the capital of the *POWER STATE*. It is a great honour to have you in the beautiful campus of Federal University of Technology Minna, Nigeria, **THE MOST PEACEFUL UNIVERSITY IN NIGERIA**. I am aware of the great sacrifices made by many of you to be present in this occasion and I will definitely not overlook the long distances some of you have had to cover to get to this conference venue. We genuinely appreciate all your efforts. It is our singular hope and desire that the conference meets your expectations and gives you unquantifiable experience and tremendous developmental networking opportunities for a life fulfilling career.

We are grateful for the presence of the Vice Chancellor of the Federal University of Technology Minna – Professor Musbau Adewumi Akanji whose leadership and distinguished academic career has served as inspiration and encouragement to many young academics. His desire to see the University compete at International level has led to the upsurge in the organisation of International conferences, Public lectures and Seminars on regular basis within and outside the university. We are happy to have you as the Chief host to declare the conference open and deliver the welcome address.

We are grateful to the Dean of School of Environmental Technology, Federal University of Technology Professor Yekeen Adeeyo Sanusi for providing the robust platform, academic support and leadership for the organisation of the conference. You threw the challenge and provided the required resources and strategies for achieving its success, it is a great honour of having the opportunity to learn at your feet. We are happy to have you as the host and keynote speaker at the conference. I wish to thank also all the special guests particularly leaders of the Industry, Built Environment and Academia.

SETIC is beginning at the foundation this year and for this I wish to thank all those who have supported us through various forms of participation. Specifically I wish to thank the delegates and the partners for contributing significantly to the conferences. I wish to thank Prof. Oluwole O. Morenikeji (DVC Academic), Prof. Stella N. Zubairu and Prof. A. M. Jinadu who genuinely and consistently monitored the progress of the conference preparations. It is my desire that SETIC becomes a constant feature in the calendar of the university and global conference listings.

Delegates to SETIC 2016 are from 39 different academic and research institutions that are spread across six different countries. This offers participants a wonderful opportunity for exchange of cultural, social and academic ideas during the conference periods. It is also an opportunity to create awareness about programmes and events at the participants' individual institutions. I encourage you all to make good use of the networking opportunities that are available.

We received a total of 226 abstract, based on a quick review we were able to accept 175 of them and the authors were communicated on what they needed to focus on while developing the full papers. A total of (129) full papers were received and reviewed, the reviewers report for the authors to make corrections and submit revised papers. It was after the process that we were able to accept 112 papers for presentation at the conference, I therefore congratulate all the authors whose papers made it to the conference. We acknowledge the amount of hard work you had all put in producing these papers. It is my sincere believe that the presentation of the different ideas in your paper would go a long way in improving the knowledge of the participants and also generate meaningful discussions at the tea beaks, lunch and beyond.

I wish to express my utmost gratitude to each reviewer for a wonderful job done and for tolerating our deadlines and Oliver Twist syndrome. It is your dedication and expertise that has ensured that the conference is a success.

Special thanks to all our keynote speakers, Prof. Oluwole O. Morenikeji (Deputy Vice-Chancellor Academics, Federal University of Technology Minna), Prof. Hussein Makun (Director, Directorate of Research Innovation and Development, Federal University of Technology Minna), Prof. Musa Aibinu (Director, Centre for Distance Learning), Prof. Mustapha Zubairu (Director, Centre for Human Settlement and Urban Development), Dr. Appolonia A. Okhimamhe (Director, WASCAL) and Prof. Yekeen Sanusi, (Dean School of Environmental Technology, Federal University of Technology Minna).

It is important to appreciate the roles and efforts of the following people for their selfless and very significant contributions made towards the successful organization of the conference: Adedokun John, Idowu Oqua, Akhabue Oriwoh and Ailoyafen Dorcas (for being available to run around at very short notice), Arc. Oyetola Stephen and Tpl Samuel Medayese (for typesetting the papers for the conference proceedings).

I have come to realise that it is not easy to organize conference without dedicated individuals offering to serve. My heartfelt gratitude goes to Dr. R.A. Jimoh, Dr. L.O. Oyewobi, Dr. Taibat Lawanson, Dr. P. Ayuba, Dr. J.J. Dukiya, Dr. A.I. Anunobi, Dr. N.I. Popoola and Dr. O.A. Kemiki for their unflinching support all through the process.

It is our sincere hope that this conference will serve as a forum for the advancement of research in the urban sphere towards achieving a sustainable environment. It is our sincere believe that academics and professionals in practices will continually participate in this forum.

Once again I wish to thank you all for creating time out of your busy schedule to attend this conference. Please do enjoy your stay at Federal University of Technology Minna, and the city as a whole. Ensure that you make use of the different fora created throughout the conference to build new relationships for the future and strengthen existing relationships. I look forward to seeing you all in future.

Olatunde Folaranmi ADEDAYO
Chairman SETIC 2016 Organising Committee
May 2016

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DECLARATION

PEER REVIEW AND SCIENTIFIC PUBLISHING POLICY STATEMENT

10th May 2016

TO WHOM IT MAY CONCERN

I wish to state that all the papers published in SETIC 2016 Conference Proceedings have passed through the peer review process which involved an initial review of abstracts, blind review of full papers by minimum of two referees, forwarding of reviewers' comments to authors, submission of revised papers by authors and subsequent evaluation of submitted papers by the Scientific Committee to determine content quality.

It is the policy of the School of Environmental Technology International Conference (SETIC) that for papers to be accepted for inclusion in the conference proceedings it must have undergone the blind review process and passed the academic integrity test. All papers are only published based on the recommendation of the reviewers and the Scientific Committee of SETIC

Names and individual affiliation of members of Review and Scientific Committee for SETIC Conference 2016 are published in the SETIC 2016 Conference Proceedings and made available on www.futminna.edu.ng

Olatunde Folaranmi ADEDAYO
Chairman SETIC 2016
Federal University of Technology, Minna, Nigeria

Papers in the SETIC 2016 Conference Proceedings are published on www.futminna.edu.ng.

REVIEW PANEL

We wish to express our deepest and sincere gratitude to the following people in no particular order who provided comprehensive scientific reviews and made commendable suggestions towards improving the over 200 abstracts and 100 full papers submitted to SETIC 2016. They provided constructive comments to authors regarding their papers, it is necessary to state that there was no reported case of conflict of interest by any of the reviewers or the authors.

Dr. J.J. Dukiya, Department of Transport Technology, Federal University of Technology, Minna

Dr. Naomi I. Popoola, Department of Estate Management, Federal University of Technology, Minna

Dr. Anthony I. Anunobi, Department of Architecture, Federal University of Technology, Minna

Dr. Philip Ayuba, Department of Architecture, Federal University of Technology, Minna

Dr. Taibat Lawanson, Urban and Regional Planning, University of Lagos, Lagos

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Dr. Yakubu Mohammed, Department of Quantity Surveying, Federal University of Technology, Minna

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Dr. Rotimi University of West England, UK

Dr. Babatunde J. Olawuyi, Department of Building, Federal University of Technology, Minna

Dr. Bashir Nuhu, Department of Estate Management, Federal University of Technology, Minna

Dr. Olatunde F. Adedayo, Department of Architecture, Federal University of Technology, Minna

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Dr. Rotimi University of West England, UK

Dr. Olatunde F. Adedayo, Department of Architecture, Federal University of Technology, Minna

PROFILE OF KEYNOTE SPEAKERS

SETIC 2016 organisers wishes to thank our keynote speakers for accepting to create time to share from their rich wealth of knowledge and interact with delegates and participants on varied issues being examined at this year's conference. A brief profile of each keynote speaker is provided here, this would allow for future interaction and networking with them.

Prof. Hussaini Anthony MAKUN

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Hussaini Anthony Makun is currently working as Professor of Biochemistry in the Department of Biochemistry, Federal University of Technology, Minna where he has been since 1992. He completed his PhD in 2007 in Biochemistry (Toxicology) from same University. The researcher was a National Research Foundation Postdoctoral Fellow (PDF) with Food Environment and Health Research Group of the University of Johannesburg (UJ) between 2008 and 2010. He is teaching basic and advanced courses in biochemistry, and toxicology related courses at both undergraduate and postgraduate levels.



He has supervised and graduated over seventy B-Tech and ten M-Tech students and two PhDs. He is currently the Lead Researcher of the Food and Toxicology Research Group (FTRG) of the University which has 2 Senior Researchers, 3 M.Tech and 4 PhD students. FTRG conducts researches on environmental health monitoring and mycotoxins at national and international levels. The researches focus on detection and health impacts of mycotoxins and establishing novel integrated intervention strategies approach against mycotoxins. The intervention strategies include exploration of natural preservatives from African traditional medicinal plants with fungicidal effects for production of fungicides for storage of crops. Other approaches at animal farms include formulation of nanoparticle based multi-mycotoxin feed binder against exposure to common, toxic mycotoxins. The research group is also involved in studies to produce simple medicinal supplements encapsulated in

nanoparticles with protective effects against diseases induced by mycotoxins from African traditional medicinal plants; such supplements will alleviate the adverse health impact of mycotoxins in animals and human beings. The research group is also interested in toxicological studies of medicinal plants used in the folkloric treatment and drug toxicology. Following the trend of drugs abuse in Nigeria, the research group is embarking on research titled “Elucidation of the chemical composition and biomonitoring of substances of abuse in the Northern region of Nigeria”. The focus of this research is to establish the current state of art of drugs of abuse in the Northern region of Nigeria; to elucidate the chemical composition and active ingredient of new psychoactive substances (NPS); to modify validated analytical methods for the detection of new psychoactive substances in blood, urine and hair.

In last 5 years, 6 research projects were granted with funding from NRF, South Africa and TETFUND, Nigeria. He is a member of Mycotoxicology Society of Nigeria (Vice President (North), Experts on Mycotoxins in Food, Food Hygiene, Food Import/Export Inspections and Certification System of the National Agency for Food and Drug Administration and Control (NAFDAC) 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) (2012-2016). 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 (CAC/RCP 51-2003)”.

Prof Makun has 57 publications, mostly on mycotoxins in peer review journals, technical papers and books and is currently the Director of Research, Innovation and Development, Federal University of Technology, Minna.

Dr. Appollonia A. OKHIMAMHE

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Dr A. A. Okhimamhe is the Director of the Masters Research Programme on Climate Change and Adapted Land Use (MRP CC & ALU) of the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), a German sponsored graduate research programme with its Headquarters in Accra, Ghana.



In collaboration with colleagues, 20 West African students from Nigeria, Ghana, Benin, Togo, The Gambia, Cote D'Ivoire, Mali, Niger and Burkina Faso graduated with Master of Technology (M.Tech) in Climate Change and Adapted Land Use from the University. Another Batch of 10 students are expected to commence their programme in mid 2016. Aside from her academic qualifications, her participation in various training activities organized by the United Nations in Regional Centre for Mapping of Resources for Development in Nairobi, Kenya (1992); University of Stockholm, Sweden (1994); Harare, Zimbabwe (1995); and European Space Research Institute in Frascati, Italy (1997, 1998) had prepared her professionally for her career. Additionally, in 2000, she secured a 6 months fellowship-traineeship for a colleague in the Department and herself at the European Space Research Institute in Frascati, Italy. Dr Okhimamhe is an alumni of the International Visitor Leadership Programme (IVLP), U.S. Department of State's Bureau of Educational and Cultural Affairs' (ECA) premier professional exchange program. Currently, she is an Associate Professor of Geography with a research focus on application of remote sensing and GIS in geographical sciences including climate change.

Dr Okhimamhe has served her country as a Technical Delegate at the UNFCCC COP in Cancun, Mexico (2010), Durban, South Africa (2011), Doha, Qatar (2012) and Warsaw, Poland (2013). She has supervised more than 30 postgraduate students and has several publications and is still publishing. In collaboration with her students in the last 3 years, she has focused on urban climate change studies using geospatial techniques.

Prof. Abiodun Musa AIBINU
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Abiodun Musa AIBINU (PhD), is a highly motivated career driven achiever with over Eighteen (18) years working experience in the field of: Mechatronics Engineering; Telecommunication Engineering; Spectrum Management; Industrial Automation; Teaching; Research and Project Development.



He received: National Diploma award from The Polytechnic, Ibadan, Nigeria; B.Sc degree from Obafemi Awolowo University (OAU), Ile-Ife, Nigeria; M.sc degree from Blekinge Institute of Technology (BTH), Sweden and Doctoral degree award from International Islamic University Malaysia, (IIUM), Malaysia. He has been actively involved in teaching and research activities at various universities since the completion of his post-graduate studies. However, prior to that he has worked with: MTN Communication (Nigeria) Limited; GS Telecom (Nigeria) Limited; DCC Satellite and Networks Limited; Oganla Consulting and Investment (OCI) limited; Communications Associates (COMSAC) (Nigeria) Limited just to mention but a few.

Engr. Aibinu has participated and won several awards at various international and national exhibitions and was nominated for 2012 promising researcher award and best teacher award at IIUM Malaysia. He has also won several research grant awards in and outside Nigeria and has authored/co-authored several publications in both local and international journals and conferences.

He is presently, the Head of Department, Mechatronics Engineering Department, Federal University of Technology, Minna and the Director, Center for Open Distance and e-Learning (CODEL), Federal University of Technology, Minna.

Prof. MORENIKEJI, Olakanmi Oluwole

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Morenikeji, Olakanmi Oluwole joined the services of the Federal University of Technology, Minna in 1990 as an Assistant Lecturer and rose to become a Professor of Urban and Regional Planning in 2006. He obtained his B. Sc in Geography and Regional Planning from the University of Calabar in 1983 and M. Sc Urban and Regional Planning from the University of Benin in 1998. He enrolled for his Ph.D in Transport Planning in 1992 at FUT Minna and won a Nigerian-Italian Ph.D scholarship which enabled him to do part of his Ph.D work at the University of Trieste, Italy. He bagged his Ph.D in 1998 and utilized his post-doctoral Commonwealth Fellowship at the Instrumented City, Institute for Transport Studies, University of Leeds, UK (2004/2005).



Morenikeji served as the Head of Department of Urban and Regional Planning from 1995 – 2002 and later, Director of the Centre for Human Settlements and Urban Development established in collaboration with the UN-Habitat in FUT, Minna. He was also the Dean of the School of Environmental Technology from 2008-2012. He has also participated in a number of internationally funded research projects and published several papers in learned journals. His areas of interest include transportation planning, human development studies, spatial analysis and Research Methods.

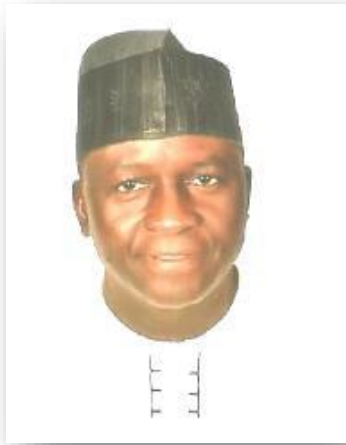
He is currently participating in a collaborative research between The Construction and Property Research Centre, University of the West of England (CPRC-UWE), Bristol, UK and the Federal University of Technology (FUT), Minna being funded by DFID. He has been appointed by the West African Science Centre on Climate Change and Adapted Land Use (WASCAL) as a visiting Lecturer at the Joint Facility for Language and Common Courses (JFLCC) 2016 which is a collaborative programmes for Masters (MRP) and Doctoral Research Programme (GRP) students from 10 participating Universities.

He is currently the Deputy Vice-Chancellor (Academics) Federal University of Technology, Minna, Niger State, Nigeria.

Prof. Mustapha ZUBAIRU
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Mustapha Zubairu is currently a Professor in the department of Urban and Regional Planning and the Director Centre for Human settlement and urban development (CHSUD) in the Federal University of Technology, Minna. He received his B.Sc. and M.Sc. degrees in architecture from the Ahmadu Bello University Zaria, Nigeria, in 1975 and 1977 respectively. He also holds M.Sc. and Ph.D. degrees in urban and regional planning from the University of Strathclyde, Glasgow, Scotland 1983 and 1990. He is a Member of the Royal Planning Institute, Member, Nigerian Institute of Architects, Fellow, Nigerian Institute of Town Planners and a Member, Nigerian Institute of Management.



Prof. M. Zubairu was amongst others, a principal architect in the Ministry of Works and Housing, Minna, Niger State from 1979-1981, a Chief Architect/Planner in the Niger state housing corporation between 1983 – 1984 after which he became the general manager Niger State Housing Corporation, Minna between 1984 and 1992. He eventually became the General Manager, Urban Development Bank of Nigeria PLC, in charge of the Lagos Regional Office from 1992 to 1999 where he was trained by World Bank on Project development and appraisal.

In 1999 he was appointed the position of Managing Director/Chief Executive, Federal Housing Authority, Abuja where he stayed until 2001. Through a large portion of his tenure (1995 till date) to be exact, he established and was also involved in private practice as principal partner in an architecture and urban planning consultancy firm. In 2003, he was appointed as director, Centre for Human Settlements and Urban Development in the Federal University of Technology, Minna and has retained this position till date. Since his appointment he has been servicing the department of urban and regional planning and architecture as mentor, supervisor and all round resource person.

His area of specialization includes; Housing, Urban design, Urban Management and Slum upgrading.

Professor Yekeen A. SANUSI
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Yekeen A. Sanusi is a Professor of Urban and Regional Planning at the Federal University of Technology, Minna. His lecturing experiences span over 20 years and has lectured at both undergraduate and postgraduate classes. His academic works cover issues on urban environmental quality, urban dynamics, urban governance and green economy (poverty, service delivery and deprivations, water and sanitation, energy and climate change).



He also has studies and reports sponsored by international bodies and Research Board of the Federal University of Technology, Minna. His teaching areas cover planning theory, development control and settlement of disputes, urban governance, project planning and evaluation, energy planning, environmental impact assessment and tourism planning. He has successfully supervised many postgraduate theses (PhD, Master and Postgraduate Diploma). On administrative front,

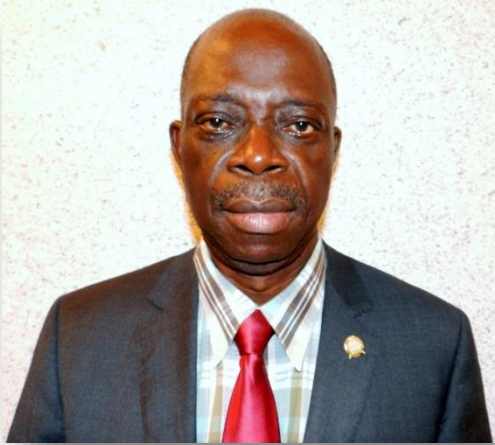
He was Deputy Dean, School of Environmental Technology of the Federal University of Technology, Minna between 2006 and 2008 and the Head of Department, Urban and Regional Planning between 2008 and 2012. Since 2012, he has been the Dean of the School of Environmental Technology. He is a Registered Town Planner (RTP) and a member of Nigerian Institute of Town Planners (NITP).

He is a member of many international research networks. Among these are Environment, Health and Development Network and Renewable Energy Policy Network for the 21st Century.

PROF Johnson Bade FALADE

Executive Director of the Foundation for Development and Environmental Initiatives (FDI)

He is currently the Managing Director/Chief Executive Officer of Gotosearch.Com Ltd and Executive Director of the Foundation for Development and Environmental Initiatives (FDI) from July 20012-date. He is currently a Senior Programme Advisor for the Urbanisation Research Nigeria Project.



Prior to this appointment, Prof Falade was the first Country Director of UN-HABITAT Programme Support office for Nigeria (2003-2012); UNDP (Programme Analyst in the Governance Team (2000-3), UNDP Zonal Officer for the North-West Zone of Nigeria (1998-2000); Programme Officer for Economic Management Team (1994-98); Programme Officer for Water and Sanitation (1992-94).

He was appointed Pupil Town Planner, County Planning Department, County Durham, Durham, UK (1977-78) and Air Mapping Assistant with the Photogrammetry Department, Ministry of Lands and Housing, Ibadan, Nigeria (1968-1970).

Professor Falade has a vast teaching and research experience. He was appointed Assistant lecturer (1982-83), Lecturer 1 (1985-87), Senior Lecturer (1987-91) with the Faculty of Environmental Design and Management for the Obafemi Awolow University Ile-Ife. He was a Visiting Professor, Department of Geography and Regional Planning, Adekunle Ajasin University, Akungba, Akoko, Ondo State (2005-7); He was Visiting Associate Professor, Department of Urban and Regional Planning University of Lagos, Lagos (1998-90); Visiting Lecturer Department of Geography and Regional Planning Lagos State University, Ojoo (1998).

Professor Falade is member of several Professional Bodies: namely Nigerian Institute of Town Planners (1984-till now), Fellow of the Institute (1999-till date); Town Planners Registration Council (1986-till date); Nigerian Construction Industry Academy (1986-to-date); Nigerian Institute of Management (NIM) and International Union on Parks and Recreational (2004-to-date).

Professor Falade has been awarded many national and international awards. He has several publications to his credit in the areas of urban planning, landscape design and conservation and urbanization and urban governance.

STRATOSPHERIC OZONE VARIABILITY: AN IMPLICATION FOR CLIMATE CHANGE OVER SOME SELECTED STATIONS IN NORTHERN NIGERIA

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The sun is the major source of energy that drives the entire atmospheric processes. The insolation from the sun is responsible for the wind pattern experienced on earth. The harmful part of the radiation from the sun is shielded from the earth by two layers namely; the stratospheric ozone and the tropospheric ozone. In this paper, a study of the statistical analysis of total ozone concentration as released by Earth Probe Total Ozone Mapping Spectrometer (EPTOMS Satellite) was used to get the total ozone variability in some selected stations in northern Nigeria. The annual coefficient of relative variability (ACRV) of ozone at these stations over a period of 72 months from January 2009 to December 2014 was carried out. The climate variables of average annual temperature and rainfall for these stations were obtained from the Nigerian Meteorological Agency (NIMET) office in Oshodi, Lagos. The climatological stations used for the study include; Yelwa, Sokoto, Zamfara, Katsina, Kano, Dutse, Damaturu and Maiduguri. The results of the findings showed that there was a variation in the average value of stratospheric ozone between 4.2% and 6.8%. A strong positive correlation of 0.92 was observed between the ACRV of ozone and average annual temperature, which increased from 12°C at Kebbi to 25°C at the hot arid north of Maiduguri. Also a negative correlation of -0.32 was observed between the ACRV of ozone and the average annual precipitation over the region which varied from an average of 718.4mm to 1053.7mm. Maximum ozone inter-annual variability of between 6% and 10% occurred between December and March, coinciding with the dry Harmattan season, while the minimum of between 2% and 4% occurred between June and September coinciding with the raining season. The findings of this study reveal that the higher temperature characteristic of the study area could be accounted for by the ACRV. This variability of ozone if properly monitored will assist in the prediction of rainfall and temperature variability as the thermal processes observed in the atmosphere are responsible for the convective activities. It will also serve as a good tool for the monitoring of climate variability in the zone.

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1.0 Introduction.

Air in the troposphere has relatively low ozone concentrations, except in highly polluted urban environments. Even polluted regions are relatively low when compared to stratospheric levels. As this "ozone clean" air moves slowly upward in the tropical stratosphere, ozone is being created by the slow photochemical production caused by the interaction of solar UV radiation and molecular oxygen.

Ozone is created in this region because it is here that the Sun, positioned high overhead during the day all year long, is most intense. There is enough of the necessary sufficiently energetic UV light to split apart molecular oxygen, O₂, and form ozone. It typically takes more than 6 months for air at 16 km (near the tropical tropopause) to rise up to about 27 km.

Even though ozone production is small and slow in the lower tropical stratosphere, the slow lifting circulation allows enough time for ozone to build-up. This ozone has a higher density up to about 27 km. It is this that is commonly referred to as the "ozone layer". (Bojkov and Fioletov, 1995; Orsolini *et al.*, 1998).

Ozone advection shows the effect of weather systems. Transport and wind motion in the stratosphere are interconnected with that of the troposphere. This is important in order to balance both the chemical processes and radiative flux in both regions. This overall way of moving ozone around in the atmosphere is referred to as transport process. It is different from photochemical processes that actually create and destroy ozone. Transport merely redistributes ozone from place to place (Holton, 1992; Cordero and Forster 2006). There is a linkage between ozone depletion and climate change but ozone depletion is not known to be the major cause of climate change. Ozone in its formation performs two basic functions by absorbing the ultraviolet radiation which heats the earth surface from above and also absorbs the longwave infrared radiation that is emitted by the earth surface. Therefore, the changes in the earth ozone concentration will depend on the altitude. The major losses observed in ozone concentration is largely due to human activities which have a cooling effect on the earth's surface. (Sivasakthivel and Siva, 2011)

In the semi-arid mid-north, annual rainfall averages about 480 mm. The far northern portion of Nigeria is hot and arid and stretches into the Chad area with rainfall averaging about 400 mm and less than 250 mm in the Maiduguri and Damaturu areas. All this changes to the rainfall regime in this zone is attributable to the convective activities that takes place in the zone. This is a major reason why the study of the insolation at this zone is important. The duration of the dry season get prolonged as one moves farther north. The average temperature South of Latitude 10° is 38°C, and in the north of latitude 12° is 44°C, which has been attributed to the depletion of the ozone layer (Ojoye, 2012). The climate system encompasses complex interactions between the different subsystems such as the oceans, the land surface, the ice coverage of land and oceans, thus incorporates many feedbacks. It has also been proven by Forster *et al.*, (1997) and Hansen *et al.*, (1997) that the stratosphere is a sensitive component of the climate system, which can affect the troposphere through coupling mechanisms and thereby triggers the climate of a place. According to the study of Sivasakthivel and Siva (2011), they observed that the redistribution of ozone in the atmosphere has some link with the weather pattern variation. It is pertinent to note that areas of high ozone depletion are characterized by high temperature. This study thereby assesses the total concentration of ozone in the stratosphere as a cause of the observed climate change in some

selected parts of Northern Nigeria and in order to achieve this aim, the study examines the linear trend in temperature and rainfall over the study area and examined the relationship between ozone variability and climatic variability over the time under study.

The study area:

The Northern Nigerian lies between 7°N and 12°N, which is known to be vulnerable to climatic and ecological anomalies such as flood, cyclones, drought and desertification. The anomaly had enormous socio-economic impacts in the region where pressure on available resources is on the increase amidst fluctuations of rainfall (Ojoye, 2012). Rainfall in the region is highly seasonal and variable in time and space, with 2 seasons, the wet and dry. The dry season is from October to April/May, while the highly variable seasonal rainfall is concentrated in a short wet season and runs from May to September.(Odjugo, 2010). Annual rainfall in the region is marked by clear seasonal variation and by virtue of the geographical location; rainfall is the most critical element of climate. The effect of the higher and cumulative rainfall variability over this zone is presently not well understood but Ojoye, (2012) explained the fundamentals in terms of the atmospheric systems controlling the whole region. The temperature of the region is generally sufficient throughout the year to allow plant growth but the insufficient rainfall, its variability and the single short rainy season imposed serious limitations on the growth of viable vegetal cover. The region is rich in agricultural production, but the large inter annual variability of rainfall produces dry spells which lead to severe and widespread drought which imposes serious socio-economic constraints.

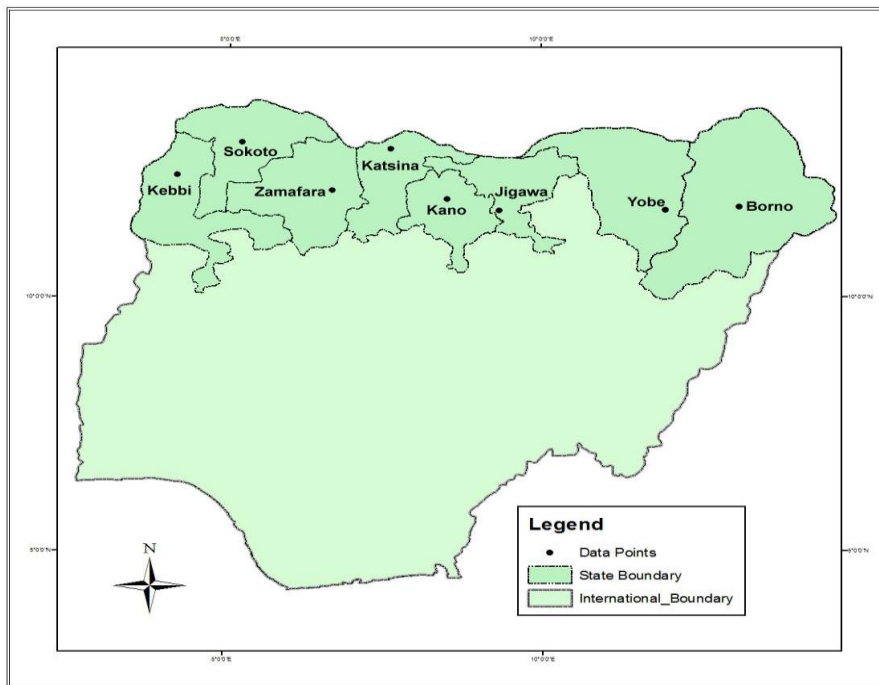


Figure 1: The study area showing the data collection points

The climate of the zone is dominated by the influence of three major meteorological features, namely; the Tropical Maritime (mT) air-mass, the Tropical Continental (cT) air-mass, and the equatorial easterlies. The first two air-masses (mT and cT) meet along a slanting surface called the inter-tropical discontinuity (ITD); the equatorial easterlies are rather erratic and relatively cool air masses from the east in the upper troposphere along the ITD. The movement of the ITD Northwards across the country between January and August, and its retreat from the Southern fringe of the Sahara desert, after August, causes much of Nigeria to experience seasonal rainfall (Ojoye, 2012) Within the mT air mass is enclosed a number of rainfall producing system such as the disturbance lines (especially the easterly waves), squall lines and the two tropospheric jet streams. The magnitude of these systems was reported to be the contributing factor that influences the amount and seasonal distribution of rainfall over the region.

2.0 Materials and Methods.

Total ozone data were collected from the NASA TOMS website for a period of six years (2009 to 2014). The average annual meteorological data of rainfall amount and temperature over eight stations in northern Nigeria were collected from Nigeria Meteorological Agency, Oshodi, Lagos State Nigeria. In order to study the long term trends in the three variables (Ozone, Rainfall and temperature) a linear regression analysis was used on the daily means.

The long term trend is given as

$$Y = a + bX + e \text{ ----- } 1.0$$

Y = Rainfall variation or Temperature variation

X= ozone variation

a and b are constants of regression.

In order to compute the annual coefficient of relative variation for the ozone values ,the standard deviation (SD) was deduced and the annual coefficient of relative variation (ACRV) was calculated thus:

$$ACRV = \frac{A(t) X \sigma}{A(mean)} X 100 \text{ ----- } 3.0$$

Where:

ACRV = Annual Coefficient of Relative variation.

A(t) = Annual total

A(mean) = Annual mean

σ = Standard Deviation.

The standardized anomaly index and the coefficient of relative variation were used to compare the relative variability of rainfall and temperature with the ozone value received at the time of study.

The linear multiple regression analysis was used to investigate the relationship between the climate variable and total ozone variability over the study area. The linear multiple regression equation is given as

$$Y = a + b_1X_1 + b_2 \text{ -----} -4.0$$

Where:

Y = ozone variability

X₁ and X₂ are climate variables.

3.0 Results and Discussion

3.1 Spatial Variability of Climatic variables.

The trend analysis carried out on the temperature values reveals that the mean temperature during the dry season is on the decrease over the years under study while the rainfall keep increasing, an indication that for the six years under study, the northern part of Nigeria is getting wetter. This results corroborate the earlier findings of Odekunle, *et.al.*, (2008) , Dami, (2008) and Ojoye, (2012) when they found out that the rainfall received in the northern part of Nigeria after the drought episode of 1998 has been on the increase.

In order to investigate the relationship between climate and total ozone variability over Northern Nigeria, a linear multiple regression analysis carried out indicates that the observed variability in the temperature and rainfall over the area could be explained by the annual variability in the stratospheric ozone. The coefficient of multiple determination R² reported a 79% variation due to ozone variability in temperature and rainfall combined, a 54% variation on temperature alone and 1% variation on rainfall alone. This inferred that the rainfall received at the station is not connected to the ozone variation at the zone and an indication that the increasing trend in temperature of the area could be attributed to stratospheric ozone variability.

Table 1.0 shows the ACRV at the various stations used for the study. In the six years studied, minimum average ACRV value of 4.2% was observed at Kebbi, 6.0 % in Zamfara, 5.2% in Dutse, 6.7% in Kano, 6.1% in Katsina, 6.5% in Sokoto and 6.8 % at Maiduguri and Damaturu an indication that Maiduguri and Damaturu having the highest variation and Kebbi the lowest. This explains the reason why temperature is higher at this two locations above other locations used for the study. This may not be unconnected with the Sun's inclination and the aridity of the area.

The ACRV of ozone when correlated with average zonal temperature and rainfall revealed significant positive and negative trends respectively in the eight stations. The correlation coefficient of ACRV with temperature was 0.70 in Kebbi, 0.97 in Sokoto, 0.96 in Zamfara, 0.95 in Katsina, 0.92 in Kano, 0.90 in Jigawa and 0.98 in both Damaturu and Maiduguri. This yielded an average positive correlation of 0.92 (Table 2.0). The average zonal temperature increased from 38.4°C at Kebbi to about 45.2°C at Yobe (Table 1). This

corroborate the findings of Azeem *et al.*, (2001) and Akinyemi, (2010) when they observed that variations observed in total ozone concentration are among other things, directly linked with photochemical coupling between ozone and temperature. The correlation coefficient of ACVR with rainfall as revealed by Table 2.0 was -0.34 for Kebbi, -0.26 for Sokoto, -0.37 for Zamfara, -0.42 for Katsina, -0.23 for Kano, -0.36 for Jigawa, -0.30 for Yobe and -0.33 for Maiduguri. This yielded a notable inverse relation between rainfall and the ozone average ACVR.

Table 1.: The average ACVR, Temperature and Rainfall in the selected stations in some parts of Northern Nigeria

Stations	Average. ACVR	Average AnnualTemp(0C)	Average Rainfall(mm)	Annual
Kebbi	4.2	38.4	839.3	
Sokoto	6.5	41.3	953.9	
Zamfara	6.0	41.8	934.9	
Katsina	6.1	41.7	718.4	
Kano	6.7	45.6	905.1	
Jigawa	5.2	39.3	1053.7	
Yobe	6.8	45.2	720.4	
Borno	6.8	44.9	739.1	

Table 2.: Correlation of ACVR and average annual rainfall and temperature

Stations	ACVR Vs. Average AnnualTemp(0C)	ACVR Vs. Average Annual Rainfall(mm)
Kebbi	0.70	-0.34
Sokoto	0.97	-0.26
Zamfara	0.96	-0.37
Katsina	0.95	-0.42
Kano	0.92	-0.23
Jigawa	0.90	-0.36
Yobe	0.98	-0.30
Borno	0.98	-0.33

3.2 Inter-annual variability of total column ozone

For further investigation of the relationship between total ozone distribution and the climatic variation over Northern Nigeria, seasonal percentage variability of monthly ozone concentration over the period of seventy-two months (January, 2009 to December, 2014) was computed for the eight stations. Figure 2. make the changes in the magnitudes of variability in ozone trend distinct and easy to identify. The figure shows there was an increase in the average ozone variability from December to March coinciding with the peak of harmattan

period in the northern hemisphere when the planetary wave causes strong coupling of the stratosphere and the troposphere resulting in large year-to-year or inter-annual ozone variability.

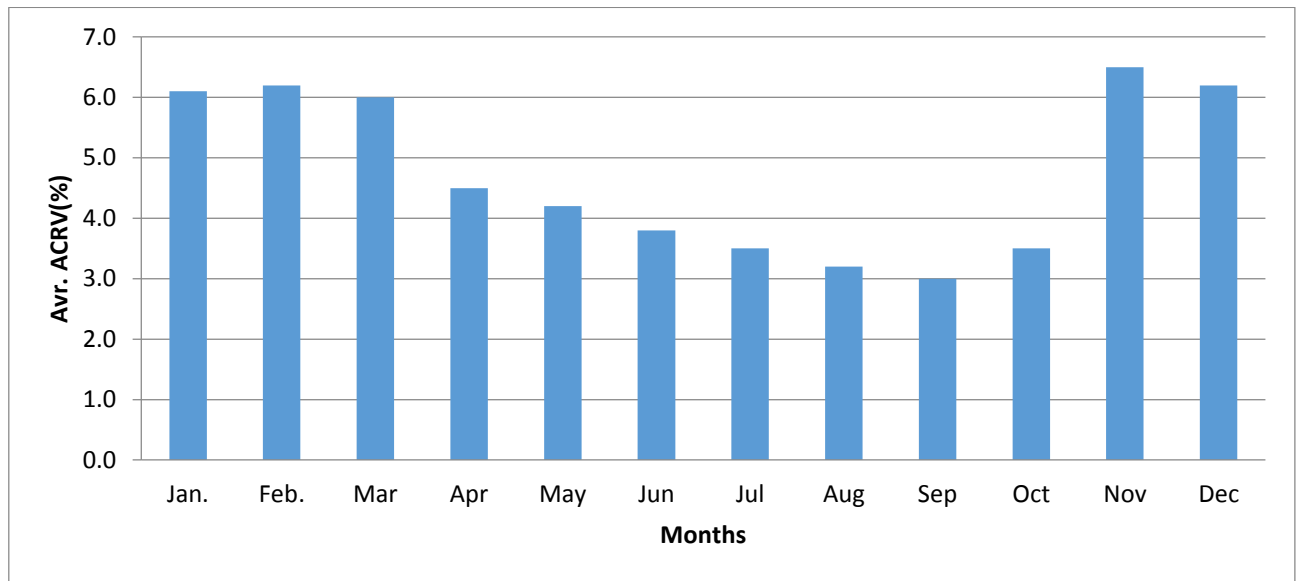


Figure 2: Inter-annual variability of ozone (2009-2014)

This results corroborated the findings of Fusco and Salby, (1999) and Akinyemi (2010) when inter-annual variability was compared for different stations over Africa. The observed maximum inter-annual fluctuations in ozone column from December to March may be associated with the variation in the strength of the local harmattan wind, a prevailing atmospheric dynamics over Northern Nigeria during that period. The year-to-year variability in intensity of the planetary scale atmospheric dynamics is responsible for driving the harmattan wind and could be suggested to be responsible for the high inter-annual fluctuation in total ozone column observed between December and March. The period of maximum ozone concentration coincided with the period of minimum ozone variation which happened to be the peak of tropical over Northern Nigeria between June and September.

This observation could possibly be attributed to reduction in the strength of the extra tropical suction pump (ETSP) action responsible for the transportation of ozone from the tropical stratosphere into the mid and high latitudinal region. The ETSP is a phenomenon, whereby the extra-tropical stratosphere and mesosphere through relevant eddy effects act globally on the tropical stratosphere as a fluid-dynamical suction pump. Thus it may be inferred that there is interconnectivity between reduction in the strength of the ETSP and ozone distribution during the tropical rainfall season.

Conclusion

The average coefficient of relative variability (ACRV) in ozone was ACRV computed for eight stations in northern Nigeria between it and climate variability. The mean annual rainfall and temperature was used as an index of climate variability between 2009 and 2014.

The results revealed an average correlation of 0.92 between ACRV and average annual temperature, a result of which manifested in a high temperature received at the stations. The coefficient of determination R^2 computed for ACRV and temperature revealed that the ACRV explained 79% variation in temperature and a 1% variation in rainfall, an indication that the rainfall variability observed at the station cannot be attributed to the ACRV observed over the years under study in the zone. These observations suggest significant association between the radiative activities and total ozone redistribution over the region and the possibility of total ozone trend over Northern Nigeria being used as an indicator of climate variability over the zone.

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