RIVERS STATE UNIVERSITY,
PORT HARCOURT

RAINFALL, CLIMATE CHANGE AND FLOODING A BLESSING OR A CURSE

AN INAUGURAL LECTURE

By

PROFESSOR AKURO EPHRAIM GOBO (KSC)

B.Sc. (Maths./Edu.) Uniport, M.Sc. (Applied Meteorology) UI,
Ph.D (Environmental Mgt.) RSU

Professor of Applied Meteorology and Environmental Management,
(MNMetS; MNES; FRMetS, London)

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2008 invested Knight of St Christopher (KSC) Anglican Communion Diocese of Okrika. Chairman; Diocese of Okrika Land Development Committee, that successfully completed 8 blocks of Flats in three years. 2016 – 2018; Chairman, Project and Maintenance Committee St. John's Anglican Church, Abuloma (2016 to Date); Chairman, Accommodation – Sub-Committee LOC and member Accommodation Central Planning Committee 2018 Synod, Diocese of Okrika; 2016-2018, Member, Synod Central Planning Committee, Diocese of Okrika; and 2018 to Date Chairman, Diocese of Okrika synod, Central Planning Committee.

He was a former Chairman CDC Abuloma and during his tenure brought B+B to Abuloma and opened up Owuda (Bitter Leaf Estate) Road and other feeder roads. He was among those instrumental to the establishment of CSS Abuloma, Port Harcourt. Chairman PTA Federal Girls College, Abuloma. Also Chairman PTA Nig. Navy Sec. School, Borikiri, Port Harcourt 2005 – 2010. Member, Nigerian Meteorological Society, Member Nigerian Environmental Society and Fellow Royal Meteorological Society London. He is happily married to Lady Sotonye Gobo and blessed with what Africans will call a blessed family with Engineers, Lawyer, Doctor, Accountant in making and grand daughter. To God I return All Glory.

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(UAAC), February 2016 to date; and Elected Member, Senate Representative in Governing Council, River State University (April 2018 to date).

His research interest include, flood management and predictions, climate change phenomenon and waste management techniques. Consultant to RSG/UNDP on Climate Change Vulnerability /Impact Assessment in Rivers State (2011). Delegate to Delta State/UNDP SCCD (State Climate Change Dialogue (State delegate) sponsored by Delta State/UNDP 2011. Consultant RSG/UNDP on Mainstreaming Climate Change Adaptation and Mitigation Issues into Development Planning for Legislators and Directors in Rivers State (2012). A member Rivers State Delegation on Climate Change and Coastal States Dialogue; a workshop organized by UNDP in collaboration with Lagos State Government September, 2012.

In July 2013 RSG/UNDP Consultant/Organized a 3-day Training Workshop for Rivers State Legislators/Policy Makers on Integrated Water Resources Management and Funding of Flood Related Disasters. Also in 2013 REG/UNDP Consultant/Study on Post Impact Assessment of some Flood Impacted Communities in 2012 in Rivers State. In 2017 Consultant, Rivers SEEFOR Project, Desiliting of Okochiri Road Drainage, Okrika Local Government, Rivers State.

From 1985 - 1995 (10 years), Chairman Adult Harvest Committee St. Johns Anglican Church Abuloma. Chairman of the New St. John's Anglican Church Abuloma Building and Chairman Foundation Stone Laying Committee. In 2007, Chairman Diocese of Okrika Synod Planning Committee (LOC) for 2009 Synod. Member, Diocese of Okrika Cental Synod Planning Committee (2007 – 2010) and also Chairman, Planning and Inauguration Committee Abuloma Archdeaconry and Launching of Archdeaconry support fund. A Diocesan Board Member and in post graduate students. He co-edited the book on the Proceedings Minimizing Greenhouse Gas Emissions in Rivers State.

As at his Professorial Promotion, he has published in many National and International Journals with over 60 publications to his credit. At present he has supervised/co-supervised over 59 M.Sc/M.Phil students and supervised and co-supervised 16 Ph.D students. Member, Rivers State and Agip Technical Committee on Urban Solid Waste Management; Member, Rivers State Environmental Guidelines and Standards Committee (2002). Also in 2010; Member Review Committee on Guidelines, Standards and Policies on Environmental Pollution Control and Management in Rivers State. In 2004, Resource person, Technical Committee on Review of National Erosion and Flood Control Policy, organized by Federal Ministry of Environment, Abuja.

In 1989 was a Federal and State Government Delegation to Holland and London on the Master Plan for the Development of the Niger Delta (sponsored by European Economic Community EEC). In 2001, was on State Government/Nigerian Agip Oil Company Delegation to Milano, Italy for Urban Solid Waste Management for Port Harcourt. September 2003 to March 2004, Supervising Councillor, Port Harcourt City Council Caretaker Committee. September 2003 to December 2004 Special Assistant to the Executive Governor Rivers State, (Local Govt. Liaison) under Sir Dr. Peter Odili. In 2016, he was appointed member Rivers State Primary Health Care Management Board. He served and occupied various positions in the University among which are: Member, IGST Senate Library Committee, 1988 to 2005. Member IGST Representative Faculty Board, Faculty of Environmental Sciences 1988 to 2007. Member, IGST Representative, Faculty of Science 2005 to 2007 and 2012 to date. Member, IGST Representative Senate Research and Publication Committee, 2013 to date; Chairman, University Accommodation Advisory Committee

FIGURES

10.0 CITATION

PROF. AKURO EPHRAIM GOBO (KSC)

Professor Akuro Gobo was Born on 6th January 1958 to a humble and God fearing family of Isreal and Ruth of Abuloma Town in Port Harcourt LGA Rivers State. Attended Abuloma/Amadi Central State School and passed with Distinction in his Primary Six Examination (1970). Attended Stella Marris College Port Harcourt where he obtained his School Certificate.

Prof. Akuro E. Gobo holds a B.Sc (Hons) Maths/Education Degree University of Port Harcourt (1981), M.Sc. Applied Meteorology/ Atmospheric Physics / Pollutions (1984) at University of Ibadan and Ph.D Degree in Environmental Management, Rivers State University of Science and Technology, Port Harcourt. He enjoyed various scholarships throughout his academic career including aviation sponsorship.

He worked with the Federal Ministry of Aviation in Meteorological Services Department, Oshodi, Lagos. There, he was involved in the day to day analyses of Meteorological Data for Pilots and Industries. Resigned the Aviation work because of my excitement to join the University (Academics) and even refunded the expenses incurred on me during my M.Sc. programme.

He is currently a Professor of Applied Meteorology and Environmental Management at the Institute of Geosciences and Space Technology (IGST), Rivers State University, Port Harcourt. Professor Gobo has carried out a lot of Environmental Consultancy projects for oil, gas and other related companies within the Niger Delta region and outside.

He is the author of the book "Meteorology and Man's Environment". He co-authored the book "Fundamentals of Environmental Chemistry and Meteorology" for undergraduate and

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Protocol

The Ag. Vice Chancellor,

Deputy Vice Chancellor,

Registrar and other Principal Officers:

Provost College of Medicine,

Dean PG School,

Deans of Faculties,

Directors of Institutes;

Professors and HODs, Staff and Students of RSU;

Distinguished Ladies and Gentlemen.

1. INTRODUCTION

When the Lord turned again the captivity of Zion, we were like them that dream and our mouth was filled with laughter, and our tongue with singing. And it came to pass (Psalm 126:1, Psalm 37-5). My sincere thanks go to the Ag. Vice Chancellor Professor Opuenebo Binya Owei and the Chairman, Senate Lectures Committee Prof. IKE Ekweozor for the opportunity, for me to present the inaugural lecturer. My adventure into Academics started when Federal Ministry of Aviation Meteorological Services Department employed me after my NYSC and sent me for in-service Masters Degree Programme (M.Sc Applied Meteorology at University of Ibadan). After the programme I developed interest in Academics, refunded the school fees (expenses) Aviation spent on me just to join the University. I thank Emeratus Professor, D.M.J Fubara, Prof. (Mrs.) O. Salau and Prof. Wiston Bell Gam who stressed me through rigorous interviews; facilitated my employment into this prestigious University.

The words Rainfall, Climate Change and Flooding phenomenon have been in existence from creation. Nevertheless, certain issues related to it remain mystery and cause for continuous research. This bring to bear some fundamental questions as regards some mysterious issues regarding rainfall; why does fish/crabs and snakes fall from the sky when there is heavy rainfall? Why does it rain in a particular place continuously in Togo? Why should it be raining within Rivers State University Campus and as you get to the gate it is sun shine. Why does it start raining and in the next few seconds it stops suddenly. Why does it rain suddenly without any sign? Why should God allow certain disasters to befall the human race, after the pains of creation.

How does someone God spend His precious time and energy to create the land and sea and saw that it was good (Gen. 1:10) and some one will build and block natural water ways? Lets look at some issues related to these.

CLOUDS

A visible mass of water droplets suspended in the air. A cloud is an aerosol consisting of a visible mass of minute liquid droplets, frozen crystals or other particles suspended in the atmosphere of a planetary body. Water or various other chemicals may compose the droplets and crystals.

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8. 2011 RSG/UNDP Consultant (Study on Climate Change Vulnerability/Impact Assessment in Rivers State.
9. 2012 RSG/UNDP Consultant/Organized - A 3day Residential Training Workshop for Rivers State Legislators/Policy makers on Mainstreaming Climate Change Adaptation and Mitigation Issues into Development Planning in Rivers State.
10. 2013 - RSG/UNDP Consultant/Organized a 3-day Residential Training Workshop organized for Rivers Legislators/Policy Makers on Integrated Water Resources Management and funding of Flood related disasters. Wednesday 10th - Friday 12th July 2-013).
11. 2013 - RSG/UNDP: Consultant Study on Post Impact Assessment (PIA) of some Flood Impacted Communities in 2012 in Rivers State.
12. 2014 - Consultant to PTDF Petroleum Technology Development fund for 2014/2015 Ph.D Central Selection Committee (CSC) Interview for Overseas Scholarship Scheme.
13. 2017 - Consultant, Rivers SEEFOR Project, Desilting of Okochirie Road Drains Okrika Local Government, Rivers State.

8.0 SOME IMPORTANT RESEARCH PUBLICATIONS AND OTHER PRODUCTIVE WORKS/ CONSULTANCY SERVICES

1. Gobo, A. E. (1988). Meteorology and Man's Environment. Africa-Link Books, Ibadan.
2. Ubonbg, I.U & Gobo, A.E. (2001). Fundamentals of Environmental Chemistry and Meteorology. Tom and Harry, Ltd., Port Harcourt, 264pgs.
3. Konya, R.S, Gobo, A. E. & Imabo, C. (2005) Editors. Minimizing Greenhouse Gas Emission in Rivers State. Rivers State Ministry of Environment and Safe Earth Consults Ltd., Port Harcourt, Konitz Repronics Co., Port Harcourt.
4. Gobo, A.E. and Ubong, I.U (1997). Climate and Air Quality of the Niger Delta in Chapter 5 of the Niger Delta Environmental Survey (NDES) Phase I Report Vol. 1. Environmental and Socioeconomics Characteristics. Environmental Resource Manager Ltd., Lagos.
5. Gobo, A. E. (2005). The Greenhouse Gases. Causes, Effects and its Implications for Climate Change Minimizing Green House Gas Emission in Rivers State. Chapter 7: Edited by Konya, R.S., Gobo, A. E & Imabo, C.
6. Gobo, A.E. (1991). Coordinator Nigerian LNG Dev. Project. Shell Gas Nigeri BV Annual Meteorological Report (1989 - 1990) and Coordinator, Nigeria LNG Project Report on Historical Weather Data Analysis for Port Harcourt International Airport Weather Station (1980 - 1989), Volumes I - IV.
7. 2010 - 2011 UNEP - Participated as Expert (Air / Public Health Team), Environmental Assessment of Ogoni Land.

Types of clouds

- The highest clouds in the atmosphere are cirrocumulus, cirrus, and cirrostratus. Cumulonimbus clouds can also grow to be very high.
- Mid-level clouds include altocumulus and altostratus.
- The lowest clouds in the atmosphere are stratus, cumulus, and stratocumulus.

Altostratus (A)

Cumulus (B)

Mammatus (C)

Altocumulus Castellanus (D)

Cumulonimbus Incus (E)

Cumulus congestus (F)

Cumulus Humilis (G)

All clouds are made up of water droplets or crystals that float in the sky. According to World Meteorological Organisation (WMO) Cloud Atlas, more than 100 types of clouds exist.

Major Cloud Groups include:

Cloud Groups		Cloud Types
High Clouds that form above	1	Cirrus
20,000ft (6,096m)	2	Cirrostratus
	3	Cirrocumulus
Middle Clouds	4	Altostratus
	5	Altocumulus
Low Clouds	6	Stratus
	7	Stratocumulus
	8	Nimbastratus
Clouds with vertical development	9	Cumulus
	10	Cumulonimbus

Clouds represent the basic building blocks to our weather.

On earth there are four main types of clouds, namely:

1. Cumulus
2. Stratus
3. Cirrus
4. Nimbastratus

Rain / Rainfall

Rain is a liquid water in the form of droplets that have condensed from atmospheric water vapour and then become heavy enough to fall under gravity. The major cause of rain production is moisture contracts known as weather fronts. Clouds and rain are related. Clouds are air that has cooled and become saturated, so the excess forms very small droplets. Rain therefore occurs when further cooling caused droplets to

To my Royal Kings: HRM Brig. Gen Bright Fibonumama (Rtd), King Abuloma Kingdom; HRM, Nicholas Nimenibo Amayabo of Ogu and HRM Frank Micah Ache Senimie JP Amayanabo of Bolo, Chief (Senator) George Thompson Sekibo. My Chiefs T.B. Gobo; Chief Orumo Giali; Chief Jene R. Jene; Chief A. Igbile and Chief P. B. Otopo, Chief (Barr.) S. G. Iwori, Chief T. Gudi. Chief (Dr.) A. E. Pina, Chief (Sir) Austin Opara, Chief A. Nmerikini, Hon. Ken Chikere, Hon. E. Bipi, Chief Loveday Adda, Hon. Victor Ihunwo, Hon. Smart Adoki.

To my lovely wife Lady Stonye Gobo and my God given Children, whom by African Tradition include Engineers, Lawyer, Doctor and Accountant who said she will be counting their money: Kelvis, Tamunoimama, Obubelebara, Iyowuna, Ibikaribo and my grand daughter Tokoni Ariella; in them I am well pleased and return all glory to God.

AND IT CAME TO PASS (Psalm 37:5)

My spiritual Father Rt. Rev. Tubokosemie R. Abere JP, Bishop Diocese of Okrika, Ven. G. Eche, Ven. E. Atuboyedia, Ven. G.T. Orabere, Ven. A. Neheminah, Ven. P.P. Nyanaboibi, Ven. Dr. M. Aprioku, Ven. S. Iniworikabo, Ven. I.I. Lawrence, Dr. C.I. Abam, E. Amakiri, Rev. Can. C. Ekene, Ven. E. Opuda (Rtd.). My brethren in the Lord's vineyard: B. David; R. Geofrey Gudi; Jobby Job; Sir G. Abibo (SAN); Sir R. I. Mathew; Sir A.T. Alabo, Sir. C.F. Iberiyenari, Sir. P.K Fiabema, Chief Koko M. Koko, Bob Sydney, Elder Tekena Douglas, Moses Benjamin, Rev. Can. Orango Sunday.

To my relations/Friends whose prayers has always kept me going; Elder Abel T. Abraham, Elder Ibukuro J. Gobo, Pastor/Mrs. Flora Adanamaka, Gboreneamie, Sis. Charity Gobo, Chief Abukwa David, Justice T. Gobo, Dr. Nengi Alazigha, E.T. Oloye, Ibiye Hezekieh, Mauren Hezekiah, Happiness Kelvis Gobo, Ibiye Orupabo, Godswill Fiabema. Others include: H.O. Ifiesimama, H. Asifamake Uyi Hanson, Sunny Nleremchi and my technical group Uche Anireh, B. Siminialayi and McCauley Opuwari.

Special gratitude to the RSU 12th Governing Council, lead by Hon. Justice I.N. Ndu (Rtd.), a blessing to our University and to me. Chief Dr. S Ajie, Barr. Dr. N. Akani, Barr, A. Amadi, Rev. Dr. J.C. Omaegbu, Prof. Ezekiel-Hart, Prof. A. Ojule, Barr. I. Aguma, Prof. N. Okogbule, Prof (Mrs.) B. Ahiazu, Prof. E. C. Chukwu, Prof. N.G. Nwokah, Mrs. I. Harry, T. Owuma and D. A. Hart, J.P. Brown, K. Echomgbe, S. Toby, T. Amachree. Also from the Rivers State Primary Healthcare Management Board, Dr. G.I Kinikanwo, Dr. Barthimeus S. E; Chief Noble Diri, Dr. G. Okeafor, R. Dublin-Green, Dr. Agiriye Harry, Mrs I Awani, G.M. Ovuah, Mrs. C. Wali, Mrs. A.E Teetito, Mrs U.C Uriri, Sir, G.A Jumbo and Mrs M. Fiberesima, Dr. George Opuda.

merge and become too heavy to stay suspended in the cloud so they fall as rain. This can range from tinny drops that are almost mist up to high ones. This is the cause of very big drops. If the drops are blown into colder air they can breeze and fall as hail.

Therefore, rain is liquid water in form of droplets that have condensed from atmosphere. They fall under gravity. Rainfall is a form of precipitation. The word rainfall is used to describe precipitation in the form of water drops sizes larger than 0.5mm.

Rainfall is described in terms of the amount of precipitation falling over a given area in a given period of time. It is stated in terms of the depth of water that has fallen into a rainguage. Also considered as the amount of rain that falls in a place during particular periods.

Main types of rainfall include:

- Relief Rainfall
- Convectional Rainfall
- Frontal Rainfall

Rainfall is affected or influenced mostly by temperature, pressure pattern and wind speed and direction.

Even in hot dry areas, some waters remain suspended in the sky. Before it rains, water droplets in the air condense and cool in tinny particulates (such as dust) in the atmosphere forming clouds. Once the clouds grow large and heavy enough they fall, melting along the way.

FORMATION/CAUSES OF RAINFALL

This is considered as the amount of rain that fall in a place during a particular period. Rainfall is the amount of precipitation in a specified place or time. The amount of precipitation falling over a given area in a given period of time is stated in terms of the depth of the water that has fallen into a gauge.

The vapor rise cools changes into tiny water droplets, which form cloud. The water droplets in the clouds join together to form bigger drops; when the water droplets get too large and heavy, they fall as rain (www.weatherquestions.com).

Also when water on the earth surface is hated by the sun, it evaporates and turns into water vapour which rises into the air. When the air cools it condenses around some dust or other particles in the air condensation nuclei. These small droplets then become visible as clouds.

The phenomenon of rainmakers and rainmaking:

Rain is formed through the formation of clouds in the atmosphere and when held capacity is reached it falls back as rain. The rainmakers therefore work on the assumption of trying to accumulate clouds by incarnation/invocations. They try to cause rain to fall by rituals or scientific techniques such as seeding clouds with crystal.

On the other hand when they want to control or stop rain they try to introduce heat into the earth's atmosphere by setting fire (warm) in order to disperse the clouds. China spent Millions on shady projects to control the weather ahead of the Beijing Olympics, dozens of other countries are also doing it too.

In July 2016 China set aside $30 million for a controversial project that involved shooting salt and mineral filled bullets into the sky. Their mission is to make it rain or for rain to fall. The aim of the project is part of a larger campaign of so-called

Amos, Dr. N.M. Nafo, Dr. N. Nwiabu, Dr. B. Okonni, Prof. G.T. Sokari, Dr. I. K Nafo, Dr. E.H. Amadi, Dr. A. Nwaoburu. Senior and other colleagues and friends Prof. C.O. Ahiakwo, Prof. G. Akani, Prof. J. Vipene, Prof. I. R. Jack, Dr. S. Orike, Prof. Wachuku C. Obunwo, Dr. N. Boisa, Dr. C. Agi, Dr. B. Nkoi, Engr. Wokoma, Prof. J. Sodiki, Prof. S. Orupabo, Prof. O.B. Owei, Prof. I. Kakulu, Dr. F.U. Igwe, Surv. T. Opuaji and Dr. Ekenta, Prof. J. Onwuteaka, Prof. E. Jaja, Prof. E. Wami, Prof. D.I. Hamilton, Prof. L.C. Obara, Prof. B.D. Kiobel, Prof. Zeb-Obipi, Prof. S.N. Amadi, Dr. Agwor, Prof. M. Koko, Prof. J. A. Alamina, Prof. N.S. Okoromah, Prof. M.J. Ahiakwo, Prof. G. Ken. Akaniwor, Prof. Eric Amadi, Prof. Fred Amadi, Emeritus Prof. S. Achinewhu, Prof. S.Y. Giami, Prof. J. Alawa, Prof. D.I. Ekine, Prof. A.O. Amakiri, Prof. S.N Deekae, Prof. B.A. Ekeke, Prof. N.H. Ukoima, Dr. S.A. Abere, Emeretus Prof. A.O. Amakiri, Prof. Onome Davis, Rev. Dr. C.N. Ogbujah, Prof. R. Oruamabo, Prof. I.G. Sokari, Prof. H. Hart, Prof. K. Nyeke, Prof. Fubara Manuel, Prof. M. Ogburia.

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To my post graduate students Ph.D graduates without whom this success story would have remain an illusion include: Dr. T.T. Amangabara, Dr. H.O. Nwankwoala. Also the following Ph.D holders whom I supervised/co-supervised include: Dr(s). E.E. Kalu; Dr. A.N. Diafori-Orji; Dr. U.R. Obot; Dr. A.E. Abaje; Dr. E.L. Elenwa; Dr. C.B. Osai; Dr. A.O. Asimea; Dr. P.A. Bariweni; Dr. J.A. Ebibakefie; Dr. A. Chukwu; Dr. J.E. Umunnakwe; Dr. A. Ayotamuno; Dr. C.O. Irehie; Dr. A.F. Ebakpa, Dr. I.B. Jack and Dr. H.I Ogan. I am also grateful to my M.Sc/M.Phil graduates whom I supervised/co-supervised that stood at more than 60 as at 2015.

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weather modification techniques that the country has been using since at least 2008, when they claimed to have cleared the skies for the Beijing Olympics by forcing the rain to come earlier than expected.

China is far from the only nation trying to bring (or stop) the rain. At least 52 countries including United States have weather modification programmes, 10 more countries than five years ago according to WMO.

Between 1967 and 1972, during the Vietnam War, a whopping sum of $3 million each year was spent on weather (modification campaigns designed to draw out the monsoon) season and create muddy, difficult conditions for enemy fighters. The aim was to flood the main routes of the enemy fighters so that they could not deliver their supplies and cut off the enemies. That is to increase rainfall sufficiently to stop the enemies from the use of roads, wash out river crossing etc.

Whether the program worked or not is still a matter of debate, scientists agree that one of the biggest problem of cloud-seeding programme is that it is difficult to determine if it had any effect at all. Even with improved technique, it is difficult to differentiate the weather that might have already occurred from that generated by cloud seeding.

China's Ministry of Finance tried to create more than 60 million cubic meters of additional rain every year by 2020. Indian State of Marahasthra spent $4.5 million on cloud seeding. The attempts at creating rains are not limited to preparing for natural disasters, fighting wars or climate change effect. This year, in May, 2019 the Russian Government allocated $1.3 million to a project designed to stop rain from falling on International day.

The question is if the rain makers or cloud seedings were not carried out, would it have rained or not. What is the percentage of rain formed or dispersed? This is the big question. Therefore the Research continues whether the local rain makers or at the global level the issue of cloud seedings or formation or stoppage of rain is possible? ***The search continues.***

Weather, Climate and Climate Change

Weather is considered as the instantaneous state or condition of the Atmosphere. The changing atmospheric condition, more especially as they affect man (Gobo and Akpan, 2009). Weather elements are measured on hourly basis and averaged twenty four (24) hours of the day. This could be for the day, month and year. The hours of the day are considered in terms of 0100 to 2400 hours or from 0000 hour to 2300 hours based on the researcher decision. Weather elements include Rainfall(mm), Temperature (^oC), Relative Humidity (%), Barometric pressure (mb), Wind Speed (m/s), Wind direction (0 – 360^o), Cloud Cover (Oktas) and Sunshine (hours). Weather is therefore used in a more limited sense to denote the state of the sky and occurrence of precipitation or mist fog (instantaneous condition/state).

While climate is considered as the average weather condition/data of an Atmosphere taken over a long period of time or averaged over a time period. That is weather in synthesis constitute the climate of a place. Climatologists all over the world adopted a thirty to fifty, hundred year period for climate change estimates, (Gobo, 2000; Miller, 1961). Therefore, we could say the weather now or the weather today is dull, bright, cloudy, sunshine. Nevertheless we cannot say the climate today. Also we could say that an area Port Harcourt, Rivers State and the Niger Delta displays climatic

Education (Rumuolumeni, Ndele Campus); and selected Secondary Schools e.g. at Stella Maris Colleges, Port Harcourt; County Grammar School, Ikwerre Etche; and also at Ahoada, Omoku, Degema, Okrika Grammar School Air Force Base, etc. which records hourly/daily basic meteorological data.

4. Network of Hydrological Stations

Also in existence then were Network of guage stations for measurements of hydrological data at coastal locations and towns in Rivers State; such as Bonny, Oyigbo, Andoni, Okrika, Ndoni, Onne and in Neighbouring Bayelsa State at Nembe, Brass etc. which records daily water level.

What has happened to these innovative, scientific ideas that by today we would have had a lot of data base for researches, planning and development?

5. Need for the establishment or creation of state commissions on climate change.

6. For our monthly sanitation to succeed, there must be synergy among neighbours, landlords, tenants who reside in the same area, especially during the monthly sanitations. As you clean your portion of the gutter, your neighbour must clean his/her part also. Therefore, if one party refuses to do his/her, there is no work done because water will not flow effectively and so will not discharge into the terminal point or the creeks.

6.0 RECOMMENDATIONS

1. Legislation

There should be legislation that for any design works for construction of Drainage, gutters, roads etc.

a. There must be inputs on meteorological, hydrological, soils, geotechnical data

b. Professionals in the areas of surveyors (slope stability), quantity surveyors, urban and regional planners, soil scientists, meteorologist/hydrologist, Civil/Town Planners and structural Engineers must be involved.

c. There must be synergy among parastatal, in both State and Federal ministries of environment, Urban and Regional Planning, Works, Land and Survey and also among the various legislative bodies such as State Assembles, House of Representatives and Senate.

2. That any design for construction of roads must have drainages component attached to it and most importantly feasibility studies must be carried out to identify surrounding rivers, creeks, water ways and that the drainage must discharge into the rivers/creeks.

In order words, the drainage must be wide deep and slope into appropriate channels as in Cross River (Calabar) metropolises.

3. Need for Network of Monitoring Stations (Meteorological)

Up to the early Eighties, we had network of meteorological or weather stations established in Secondary Schools, Colleges, Universities e.g. Rivers State University; University of

characteristics that could be classified as semi-hot equatorial type with heavy rainfall most times of the year (Gobo, 1988; Gobo, 1990). The wet season lasts from March to October (about eight months) while the dry season lasts from November to February (Approximately four months). Nevertheless, the months considered as dry months are not even free from occasional rainfall, Fig. 1.1 (Gobo, 1988, 1991). The mean annual rainfall ranges from 2,500mm upland locations to up to 4,500 mm in the extreme coastal locations. Typical mean monthly rainfall amounts of some selected stations for high rainfall months could be as high as Port Harcourt, July (361.2mm) September (367.0mm); Brass, July (447.9mm) September (570.1mm); Bonny, July (492.3mm) September (665.8mm) and Warri, July (464.6mm), September (464.4mm).

Periods of Onset and Cessation of the Rains

The areas are governed by the general circulation patterns in the equatorial tropics associated with the apparent movement of the sun and the relative position of the Inter-Tropical Discontinuity (ITD). Two air masses also influence the climate of the area. The first is the southwest monsoon (moisture laden) which originates from the region of the tropical high-pressure belt over the southern Atlantic ocean.

The peak rains occur in July and September with sometimes a break in August commonly known as August break. The periods of the onset of the rains February/March and the cessation period of the rains October/November, experience sudden, heavy, severe and in most cases very brief rainfall. The rainfall at this period is also very destructive, that is high intensity rainfall with Thundering activities; heavy but of short duration.

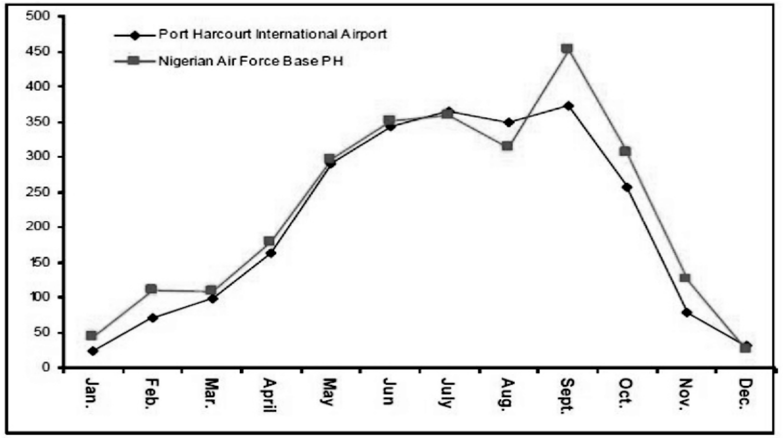


Fig. 1.1: Comparative Analysis of Mean Monthly Rainfall for Port Harcourt International Airport and Nigerian Airforce Base Port Harcourt (2006 - 2010 [5 year inclusive]

Fig. 1.1 shows periods of the onset, maximum, and period of the cessations of the rains.

The wind speeds are very high and associated with thundering and lightening activities. There is the need to be very cautious at this period; that is, during the onset/cessation periods. We are advised to avoid parking of cars under trees especially dry trees, under NEPA (PHCN) or electric poles.

Climate Change

A change in the statistical condition of weather pattern, when that change lasts for an extended period of time. A change in global or regional climate patterns, particularly a change apparently from the mid to late 20th century onwards and attributed lately to the increased levels of carbon dioxide produced by use of fossil fuels (Fig. 1.2 and 1.3).

5.0 CONCLUSION:

Rainfall characteristic, climate change phenomenon and flooding issues were well articulated. These environmental challenges, for us to succeed and overcome, individuals, corporate bodies and government at all levels must contribute their little quota to mitigate, minimize the occurrence and effect where ever we find ourselves.

Countries, nations suffer from sudden natural disasters such as Tsunami, Volcanic Eruptions, Earthquakes, Earth Tremors etc. So why is our case so different? I always argue that we are so blessed that is why we are having these problems.

When we compare some of these experiences we could comfortably say we are blessed. Why so much mismanagement of funds in our governments or our system. For example:

a. We have a well defined rainy and dry season which could facilitate planning and pro-activeness

b. We are surrounding by creeks/Rivers that could serve as discharge routes or channels to manage excess water in our environment

This could also be considered in some cases as global warming. The main cause of climate change the burning of fossil fuels, such as oil and coal which emits green house gases into the Atmosphere; primarily carbon dioxide. Other human activities that contribute include Agriculture and deforestation.

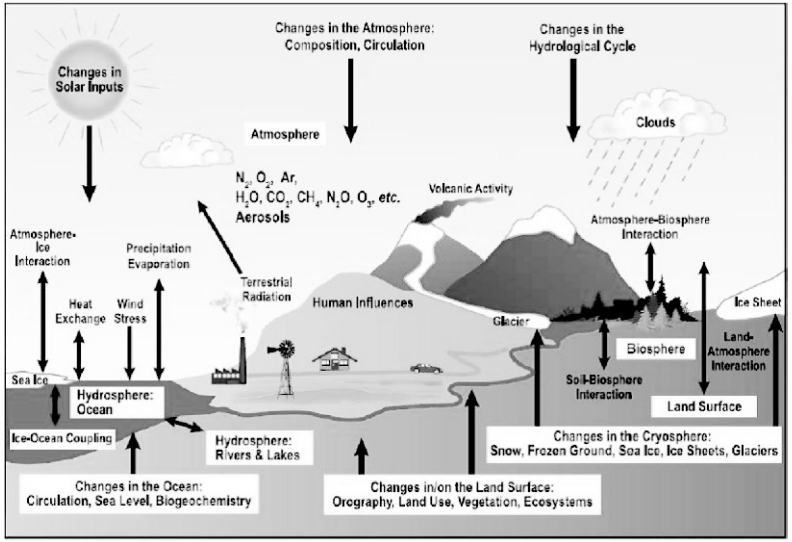
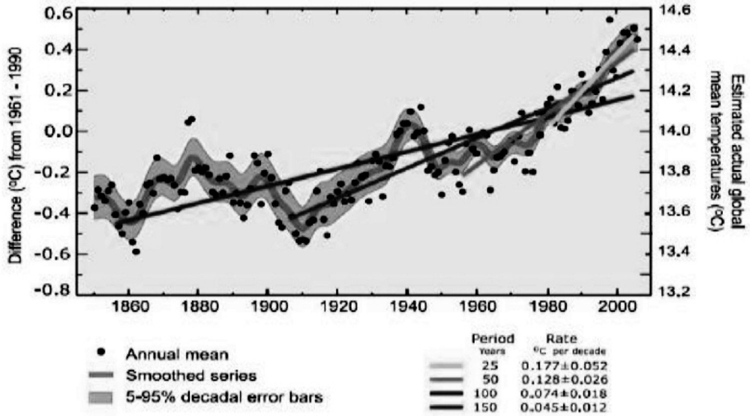


Fig. 1.2: Relationship between Weather and Climate Change



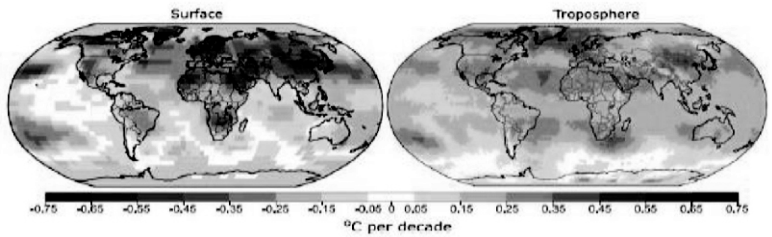


Fig. 1.3: Global Mean Temperature

Evidence of climate change, showing continuous rise of Temperature (°C) over years on global level.

Climate Change and its attendant adverse effects has become global phenomenon in time past and recent decades. A study which considered Mean Annual Temperature Departures, moving averages for temperature data (1970 – 2010), (40 years inclusive) showed climatic changes in urban development in a coastal area of Rivers State, Nigeria (Figs 1.4 & 1.5).

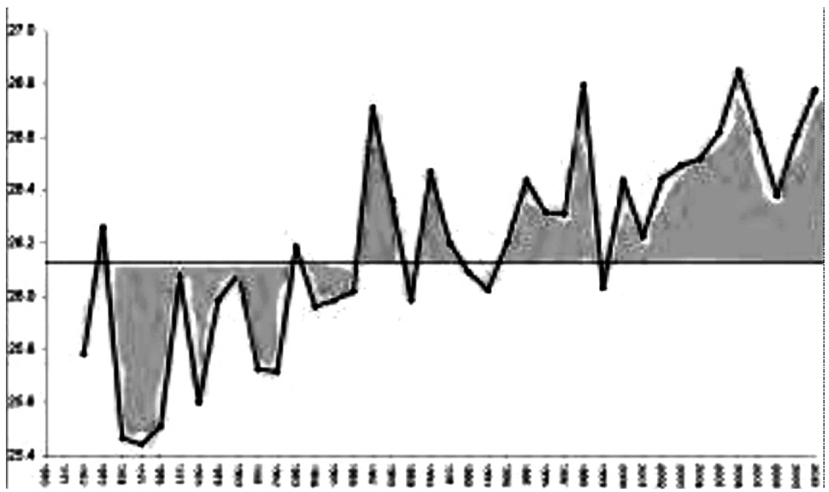


Fig. 1.4: Mean Annual Temperature (°C) over the years in Port Harcourt (1970 – 2010) (40 years inclusive)

RAINFALL, CLIMATE CHANGE AND FLOODING: A BLESSING OR A CURSE

Plate 4.18: Ford 9n Wiring Harness

How do the Dutch overcome this Perennial Problem?

There is network of meteorological/hydrological/guage stations monitoring the least drop of rainfall, water droplets that come into the system. For instance, immediately it rains, the quantity of water that is introduced into the environment is known and drained off into the ocean.

The Dutch draw a thirty (30) year physical or master plan. As head of parastatal, Commissioner, Minister as the case may be once you are appointed, you must follow the existing plans. You do not just introduce your programme or change the existing plans that you meet on ground. There are Technocrats (Civil Servants) say Directors, Permanent Secretaries etc that are there daily studying, working and making any necessary adjustment and amendments. Today in Holland through use of reclaimed Lands for Agric activities, food is so cheap

Plate 4.16: Exploring Holland's Charming Polder County

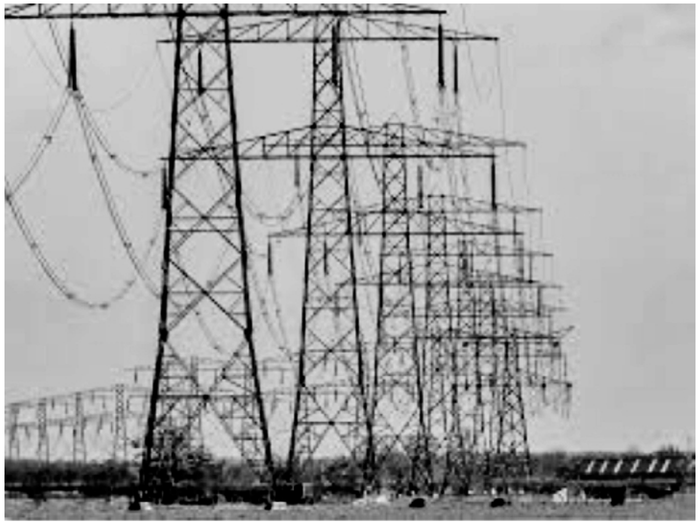


Plate 4.17: High Voltage Transmission Towers

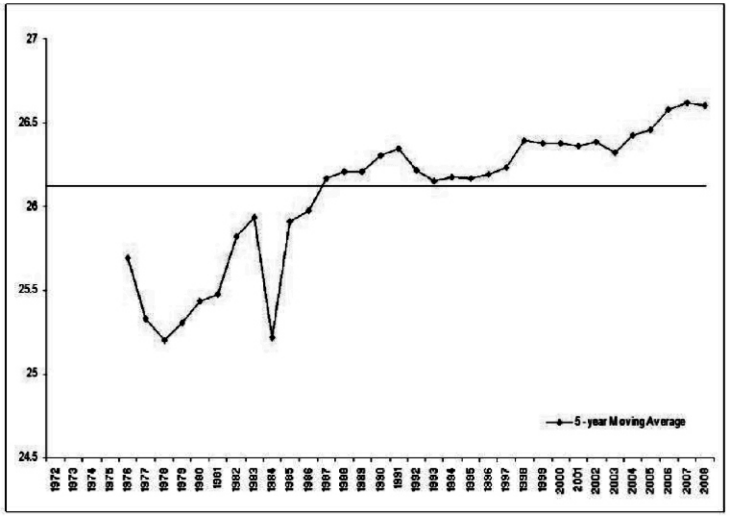


Fig. 1.5: Five year moving Average for Temperature Distribution Port Harcourt (1972 – 2010)

Evidence indicates continuous rise in temperature characteristic from 1987 to present years for a five year moving average and consequent flooding of the coastal communities of the state after heavy rainfall accompanied by thundering activities. Climate and its variability and climate change effect, include many aspect of socio-economic development and can take the form of meteorological hazards (Ogun toyinbo, *et al*., 1991). Changes in global climate will be best characterized by surface global mean temperature which is estimated to rise between 1.5°C – 4.5°C by the year 2030.

Weather, Health and a Clean Carbon Environment

Empirical Evidence abounds to show that economic growth, human well being and a clean environment go together. Increased wealth is associated with improvement in nearly all aspect of human well-being and environmental quality (Goklany, 1999). Wealthier people live longer, are better nourished, have lower mortality rates, have better access to clean water, education sanitation and cleaner carbon free environment, reduce use of firewood and stoves. Countries with significant declines in air and water pollution have significant improvement in environmental quality. Existing and new technologies allow people to use their resources more efficiently, to be healthier and to live more benign existence. Such technologies allow people to earn a living, to control their environment, invest in the future of their children, their community, their states and their country as well as their environment. With increased wealth, children can attend good schools, improved technology, eradication of water borne diseases, improved infrastructures, children can eat good food, good health that will enable them to grow up and live healthy, happier and longer lives. Accepting this three in one relationship between prosperity (wealth), health and clean environment will be the best policy for reducing the vulnerability of people. Potentially, a negative aspect of climate change is one that enables people to become rich and thereby avail themselves of all the adaptive measures wealthy people can afford.

a. The Natural Process (N)

- ❖ Rainstorm
- ❖ Extreme / Excessive Rainfall / Flood

Causes of Climate Change

These are considered in terms of climate model. The inputs involve:

- ❖ Cyclonic Activities
- ❖ Sudden Natural Disasters
- ❖ Earth Quakes Tsunami

Plate 4.14: Waterweg Deltawerken - The Netherlands Exports Flood-Control (Close)

Plate 4.15: Holland's Polder

Plate 4.12: Flood Control in the Netherlands

Plate 4.13: Waterweg Deltawerken - The Netherlands Exports Flood-Control (Open)

RAINFALL, CLIMATE CHANGE AND FLOODING: A BLESSING OR A CURSE

b. Anthropogenic Activities (A)

Also considered as man made and human induced activities which include:

- ❖ Industrial Activities (such as gas flaring)
- ❖ Forest fires

Increasing amounts of invisible greenhouse gases which include methane, carbon dioxide, nitrous oxide and chlorofluoro carbons are slowly raising the temperatures of the atmosphere.

As the earth warms, sea levels rise, Arctic Sea-Ice retreats, rainfall increases and droughts are more sever. Communities everywhere will be affected. Some changes will be positive but many others will have a negative impact.

Our attitude towards the environment such as poor waste disposal practices; dumping of waste in drainages, poorly designed, and uncoordinated drainage designs that are not channeled into natural waterways. Designs that do not take into consideration inputs such as runoff, return periods and extreme value analysis, slope analysis, soils and topography.

When the Natural (N) and Anthropogenic (A) factors combined, then the effect becomes unbearable. Aftermaths of such disasters, as a result of climate change are flooding, houses are destroyed, fallen trees, broken down vehicles, overflow of debris which is indicated in the climate model (Fig. 1.6).

MAINSTREAMING CLIMATE CHANGE INTO DEVELOPMENT PLANNING

Mainstreaming simply imply, bringing into focus. In terms of development planning, this indicates the extent to which climate change mitigation (reduction of unpleasant situations) opportunities are integrated into development projects or programmes (Fig. 1.6).

In Nigeria, development programmes are made on annual basis. Our national development plans are now Millennium Development Goals each year with the ritual of annual budgets. The developed countries e.g. Holland operate development plans that span thirty years. Therefore a minister or commissioner coming in only continues where his predecessor stopped. Here in Nigeria and Rivers State each government or any administration that comes in introduces his programmes according to his dictates.

There is urgent need to integrate climate change phenomenon into development projects such as:

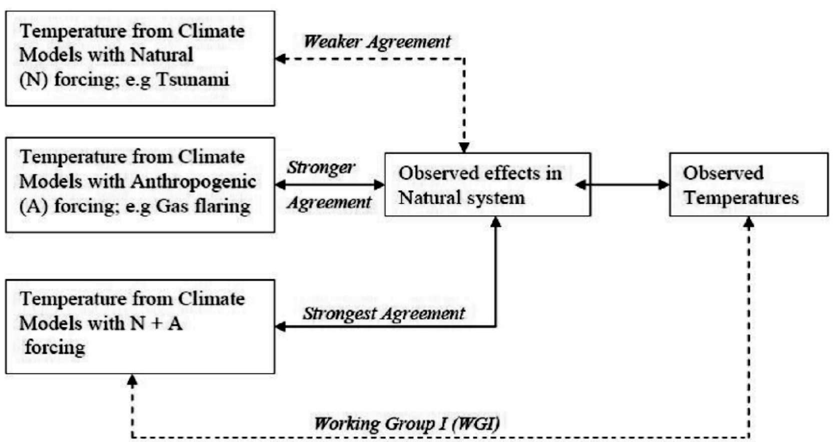


Fig. 1.6: Climate Model (Source: Parry *et al.*, 2007 in Gobo, 2012)

Plate 4.10: Dutch Dykes - Massive Dyke Creation

Plate 4.11: River Training Initiative

Plate 4.8: Holland cycling.com

Holland also boasts of a long coastline with beautiful beaches. There is so much water that makes the Netherlands always at the risk of flooding(s). This age long battle against the water, the Dutch constructed a water system consisting of Dykes, Polders, and Weirs. They make great use of Dykes, Polders and Wires their construction and engineering designs (Plates 4.9 – 4.18).

Plate 4.9: Land Reclamation at Penang Netherlands

Integration of planning programmes in project preparation processes to identify climate change mitigation measures. Identifying specific entry points project development objectives, sector / microeconomic objectives and macroeconomic linkages for mainstreaming climate change processes with development plans e.g. in Rivers State, waste to wealth projects).

Undertake analytical work to create climate change related performance indicator for monitoring of climate change measures over time e.g. risk reduction strategies, reducing vulnerability, improving livelihood, in case of quality of life (QOL), industrial safety and security.

Develop a benefits frame work that links climate change phenomenon / interventions to local benefits and priorities e.g. projects that reduce vulnerability.

Climate Change Impacts are considered in terms of

Physical Impacts – dislocation due to flooding, epidemic diseases

Economic Impacts – Loss of livelihood, loss of production, loss of income

Social Impacts – Increased risk of isolation due to vulnerability, hunger, social maladjustments

The Creation of the State Commission on Climate Change

Urgently there is the need to set up a commission on climate change in Rivers state. The body should be charged with the responsibilities of providing the strategies for handling the impact. The level of preparedness of the society is what determines the response. Even in the most advanced countries like USA and others people are still vulnerable. This was seen clearly with the Katrina disaster in New Orleans, USA.

The commission when created must work together with the State Ministries of Environment and Urban Development. This is because if the commission is domiciled in a particular ministry, networking will be difficult. However, there are funds and expertise made from the United Nations and World Bank for climate change related issues. Climate change adaptation strategies are not always capital intensive and expensive or technologically advanced.

Some of the things required to check the impact on climate change are simple and cheap e.g. maintaining open spaces, setbacks and natural landscaping of our environment. In this direction, we appreciate the present government of the state for the green schools.

In another vein, we must be prepared to teach aspect of climate change in the primary and post primary schools. This is necessary because this segment of the society is even more vulnerable especially health related. Waste sorting for instance is best handled in a household when children are involved. Ultimately, neighbourhoods and communities must be active participants in any strategy to minimize climate change impacts.

Physical Planning and Development Control

Port Harcourt as a fast growing city has no development plan. The city is allowed to develop eating up all available open spaces within and at the periphery. Thus the need for development control activities in addition to comprehensive physical planning base is here by emphasised. This is necessary because the city Port Harcourt has lost its form and

Plate 4.3: Child Friendly Holidays in Holland

Plate 4.4: The Beach House

Plate 4.5: Holland – Travel Fashion & Lifestyle

Plate 4.6: Dutch Caribbean a Piece of Holland

Plate 4.7: Holland cycling.com

As a result of the flat nature of the country, the landscape is perfect for cycling and walking tours. The countries countless nature parks, each with its own character offer wonderful landscape (Plates 4.1 - 4.8).

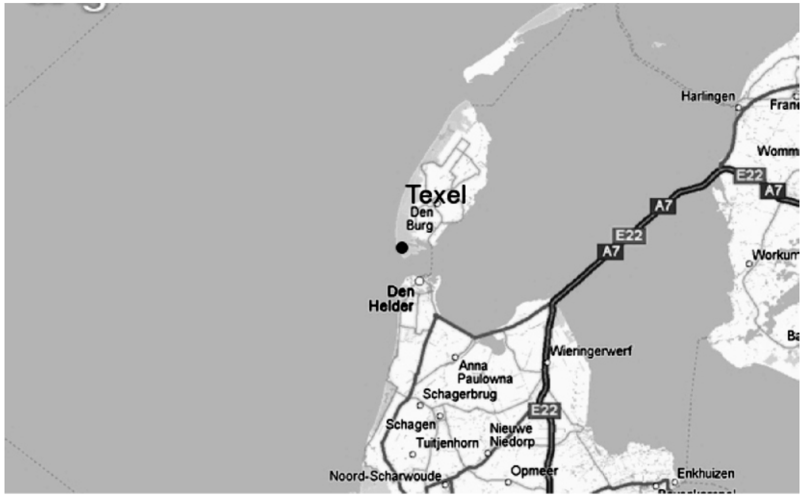


Fig. 4.1: Arial View of Holland Dutch

Plate 4.1: Xel - North End of the Island with the Eierland

Plate 4.2: Holiday Apartment in South-Holland

grown beyond the capacity of town planner to manage and provide services.

The strength to sustainably secure our urban and rural areas in the state from the impacts of climate change depends on political will. Countries in the world at one time or the other that have experienced bitter taste of the impact of climate change have resolved to channel their policies and resources to prevent further occurrences. As it stands, the signals of climate change are obviously around our cities and villages and the resources to deal with them are available but the political will to consistently pursue the required strategies are crucial.

The Continuous Rise in Temperature

This could lead to global warming which will cause desertification proceeding at increasing pace, claiming Arable lands and human lives, changing rainfall patterns leading to destruction of food distribution systems.

Melting of Polar Ice leading to a rise in sea level, claiming acres of coastal and low land areas, dwellers of these areas risking their lives, port facilities losing their utility in the face of more frequent storm surges and hurricanes.

Sea water intruding into estuaries aquifers, making the estuaries *in hospitable* breading grounds to fishes and aquifer water unfit for human consumption. Destruction of the habitat of countless animals and species imposing significant but unknown effect on food chains.

Nevertheless, you can not also think of total eradication of climate change but rather to reduce the impact by increase in taxation on fossil fuel, gradual reduction on coal combustion to drastically reduce the production of CO_2. Aforestation and Reforestation should be encouraged. Encourage the phenomenon cut one *tree and plant one.* World population growth rate should be checked as this is related to the use of Aerosol and CFCs. Climate change converts energy consumption pattern and sensitization and enlightenment programmes.

SPECIFIC EFFECTS OF CLIMATE CHANGE

Health

Warmer periods mean fewer deaths, particularly among vulnerable groups like the aged or elderly.

It is generally believed that warmer climate encourage migration of disease bearing insects like mosquitoes and malarial.

Agriculture

While CO_2 is essential for plant growth, all Agricultural activities depends also on steady water supplies. Climate change disrupts and distorts water availability through floods and droughts. Agriculture could also be disrupted by wildfires and changes in seasonal periodicity which takes place and causes changes periodicity to grasslands and water supplies would impact on grazing welfare of domestic livestock.

Sea Level Rise

Many part of the world are low-lying and will be severely affected by sea rises. Rice paddies are being inundated with salt water, which destroys the crops Seawater is contaminating rivers as it mixes with fresh water further upstream, and aquifers are becoming polluted.

Environmental

positive effects of climate change may include greener rainforests and enhanced plant growth in some continents. Negatively it may include further, poor ocean zones, contamination or exhaustation of

4.0 THE HOLLAND DUTCH EXPERIENCE

As a young researcher in the Eighties precisely 1988; I was privileged to travel to Holland on a research project with some senior professors in the likes of:

1. Emeritus Prof. DMJ Fubara (then with the Inst. of Flood Erosion, Reclamation and Transportation (IFERT)
2. Prof. Felix Ideriah (Engineering)
3. Prof. T. M. Oguara (Engineering)
4. Doctor Now Prof. S.C. Teme (IFERT)
5. Prof. K. Zuofa (Agriculture)
6. Engr. Boma Princewill
7. Mr. Ceese Beets
8. Akuro Gobo

On a Federal Government sponsored programme to Holland, to study flooding and development issues, the Dutch Experiences. The Netherlands is a country in North Western Europe, is known for flat lands, by canals, tulip fields, windmills and cycling routes. The capital city of Netherlands is AMSTERDAM.

When landing at the Amsterdam Airport, it is like the flight (Aeroplane) is landing or diving into the deep ocean, Twenty six percent (26%) of the Netherlands is undersea level. That is nearly one-third ($^1/_3$) of the Netherlands lies below sea level (Fig. 4.1). Three big European rivers (Rhirre, Meuse and Scheldt) reach the ocean via the Netherlands and create an important Delta.

Fig. 3.10: Satellite Map of Rivers State Showing Kereigani Axis, Vulnerable Area in the 2012 Flood

fresh water, increased incidence of natural fires, forest fires, extensive vegetation death due to drought, disruption to food chains and species loss.

Economics

Disruption of global trade, transportation, energy supplies and labour markets, banking and finance, investment and insurance. Developing countries involved in military conflicts are worst hit because of protracted disputes or worsened water supply, energy supplies, food supplies.

Other areas affected include Polar Melting, Ocean Acidification, Melting Ice/Glaciers etc.

Floods

God said to Noah (Genesis Chapters 6:17) “I shall send rain and there would be great flood the whole world would be destroyed but you and your family, your birds and animals will be saved”. Noah listened to the voice of God, built an Ark and he was saved with his entire family.

Sheehan and Hewit (1969) studied the major natural hazards (excluding droughts) and concluded that flooding ranked first out of sixteen disaster types responsible for either million dollars damages or for hundreds of person injured or lost.

Various authors adopt different techniques or approaches to the variations of flow and their impact. Ojo (1991) applied the time series, of the normalized diurnal rainfall departures to examine flooding phenomenon in Lagos metropolitan and also applied socio-economic variables through news paper reports. He found that flood hazards have persisted in recent years with the adverse consequences on the city's environment in general and the socio-economic activities of the inhabitants in particular. He also found variations in the spatial distribution of these floods. In general, no much work has been carried out in the Niger Delta areas as regards statistical data analyses for flood prediction. This lack of data and related works on flows, water levels and discharge measurements was also highlighted by Ekpete (1990) in his study on simulation of flow in the Bonny and New Calabar River System of the Niger Delta.

Rainfall Anomalies and Flooding Over the World in Recent Times:

In England and Wales in 2001, above average rainfall continued during the first three months of the year, making the 24 month period ending in March 2001 the wettest in 236 years in England and Wales (precipitation times series) and causing heavy flooding (WMO, 2002). In Britain and France, between October, 2000 and March, 2001, Rainfall totals were exceptionally high. The normal annual rainfall was exceeded by 20 to 40 per cent above normal in parts of that region during the six-month period and winter (October – March) rainfall extremes were received in many locations including Rannes (721mm) and Brest (1,260mm) (WMO, 2002).

Also in March 2001 a third consecutive year of severe flooding occurred in parts of Eastern Europe. In March the rain-swollen Tisza River rose to 7.6m in Zohony, Hungary reaching its highest level since 1888. In July, the worst flooding to affect Poland since 1997 occurred as two weeks of heavy rains caused flooding along the Vistula River, displacing 1,400,000 people from towns and villages in southern and south-Western Poland. Flood waters killed at least 52 people in Poland and 39 in the Czech Republic. Areas of Northern Iran also experienced devastating flooding from a single August storm that resulted in at least 183 deaths in the provinces of Golestan and Khoressan (WMO,2002).

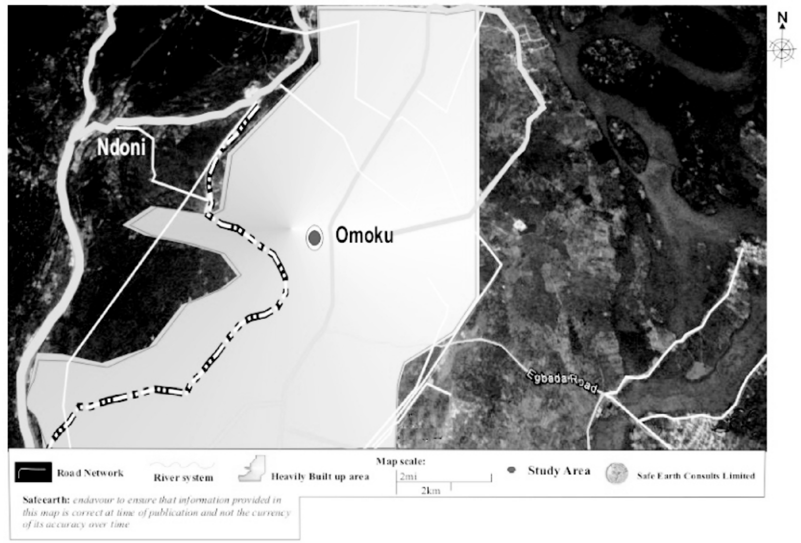


Fig. 3.8: Satellite Map of Rivers State Showing Omoku Axis, Vulnerable Area in the 2012 Flood

Fig. 3.9: Satellite Map of Rivers State Showing Kereigani Axis, Vulnerable Area in the 2012 Flood

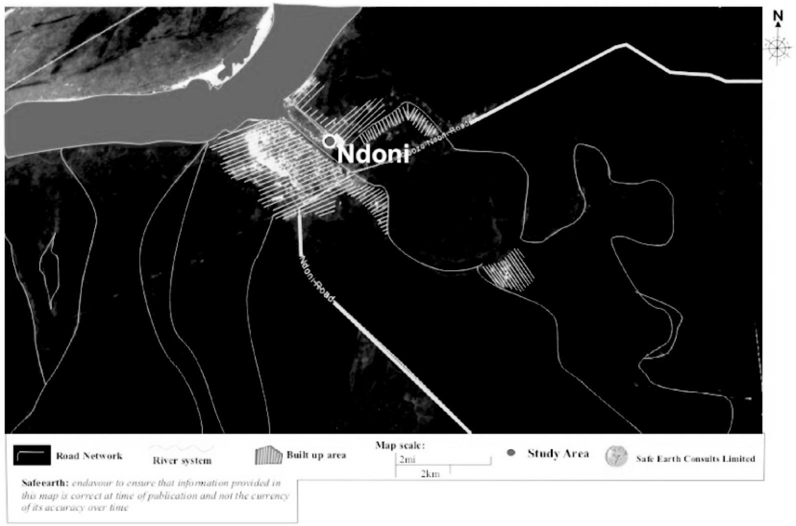


Fig. 3.6: Satellite Map of Rivers State Showing Ndoni Axis, Vulnerable Area in the 2012 Flood

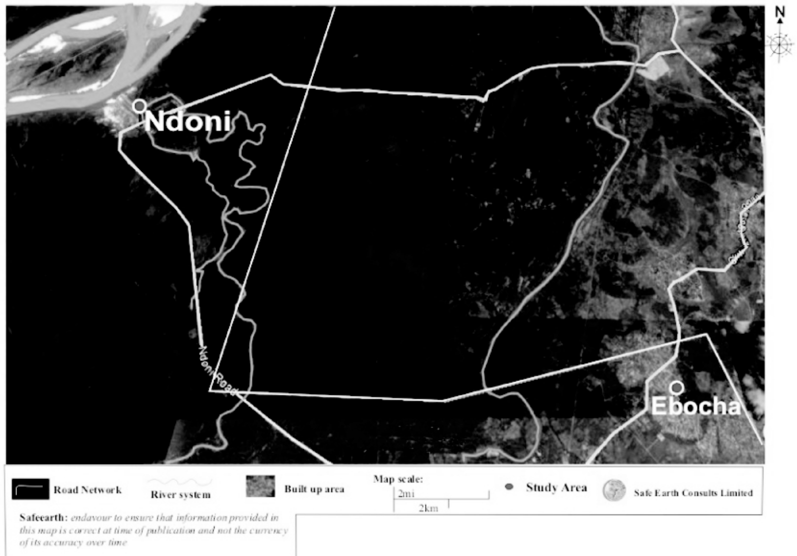


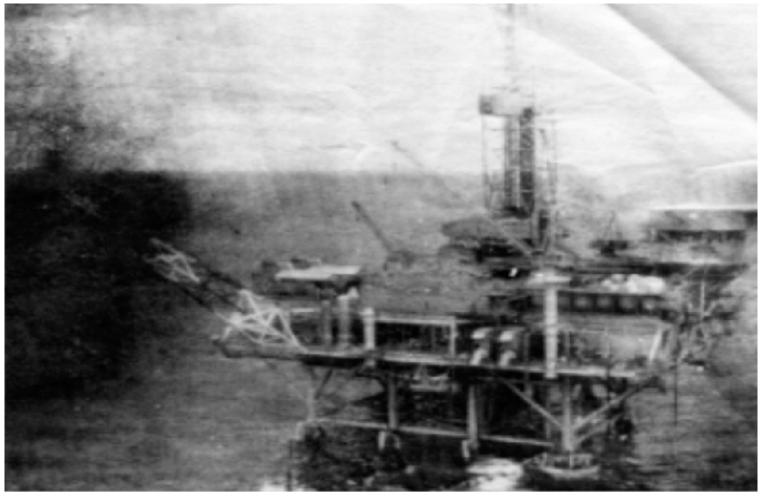
Fig. 3.7: Satellite Map of Rivers State Showing Ndoni Axis, Vulnerable Area in the 2012 Flood

In Siberia rainfall and rapid spring thaw following an anomalously cold winter resulted in widespread flooding. The homes of more than 300,000 people were lost or damaged in the Siberian Republic of Yarkutia including 14,000 people in the city of Lensk. In the upper midwest region of United States as a result of heavy rainfall and rapidly melting snow heavy spring flooding was noticed. Boat and Barge traffic was closed along a 640km stretch of the Mississippi River and a state of emergency was declared, in many areas. Three consecutive months of above-average rainfall in Argentina and adjacent areas of Uruguay from August to October led to flooding in the Pampas region, inundating more than 3.2 million hectares of Agricultural land. Parts of Bolivia also received heavy rainfall that caused flooding in early 2001, more than 40 lives were lost and thousands were left homeless (WMO, 2002).

Heavy rainfall and flooding in the Southern African countries of Mozambique, Zimbabwe, Malawi and Zambia during February – April 2000 caused at least 200 deaths, destroyed crops and left hundreds of thousands homeless. In West Africa (WMO, 2002) heavy rains in September brought the worst flooding in 10years along the Niger River in Guinea. Nearly 70,000 people were affected with 17,000 hectares of Agricultural land submerged. Thousands of homes were also damaged or destroyed and at least 100 people killed in Chad as the Lagone Chari and Batha Rivers over flowed their banks. Algeria's worst flooding in almost 40 years killed hundreds of people in Algiers in November, 2001. More than 100mm of rain fell in the span of a few hours exceeding the normal monthly total for the city (Gobo.2002).

In 2002, Morocco's largest Oil Refinery was forced to shut down following flash floods which also killed at least 37 people (Nigerian tide of Monday, December, 9 2002). The Samir Plant in the town of Mohammedia – which processes up to 90 percent of the country's crude oil export was severely damaged after the flash floods triggered a major blaze. This was as a result of unusual heavy rain in the previous few days.

Terrestrial rains occurred in Lava, western Indonesia in February 2002 producing flooding and devastating land slides in at least 19 districts leading to great loss of life and reports of more than 20,000 homes and thousands of hectares of rice fields destroyed in Vinh. In Viet-Nam 685mm of rain fell in one week in late October 2000, contributing to flooding in the Mekong Delta region that caused at least several hundred deaths between August and October 2000. This followed some of Viet-Nam's worst flooding on record in 2000 (Gobo & Abam, 2002).



Morocco floods hit Oil Plant

Plate 1.1: Flooded Oil Field in Morocco

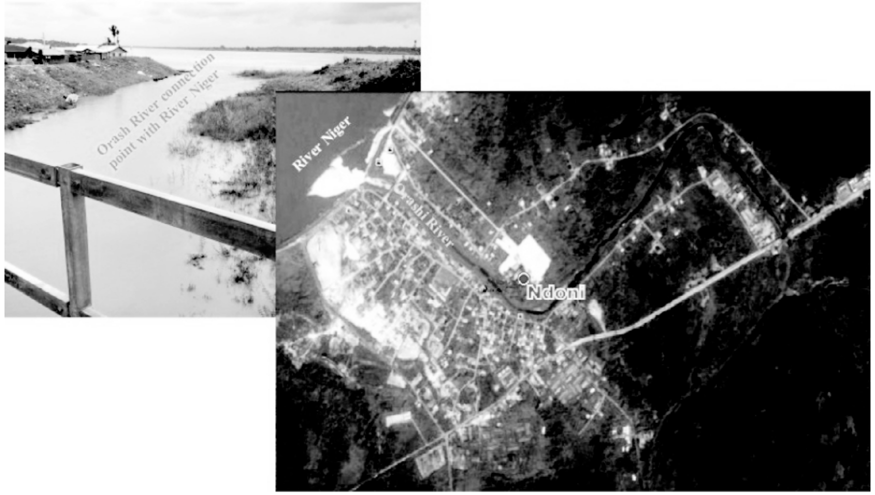


Fig. 3.4: Picture and Satellite imagery of **Ndoni River bank showing the link to Orashi River**

[This link is also manifest on satellite imagery. The head waters of Orashi River as it progresses east and then southwards]

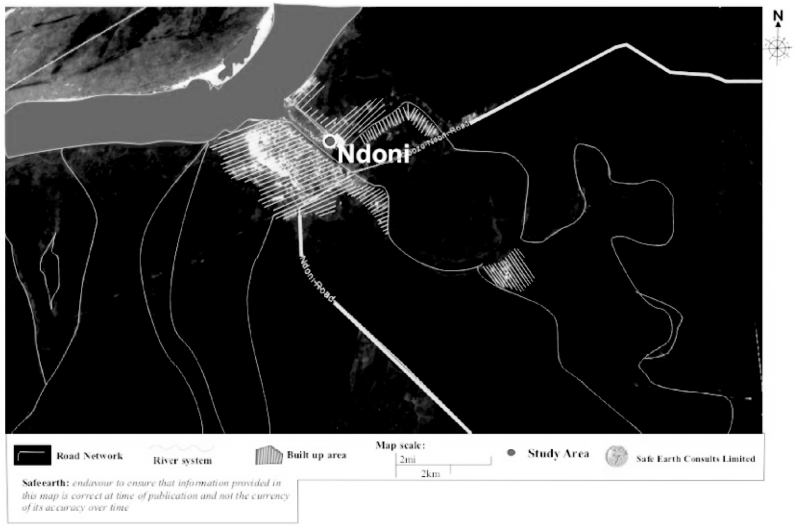


Fig. 3.5: Satellite Map of Rivers State Showing Ndoni Axis, Vulnerable Area in the 2012 Flood

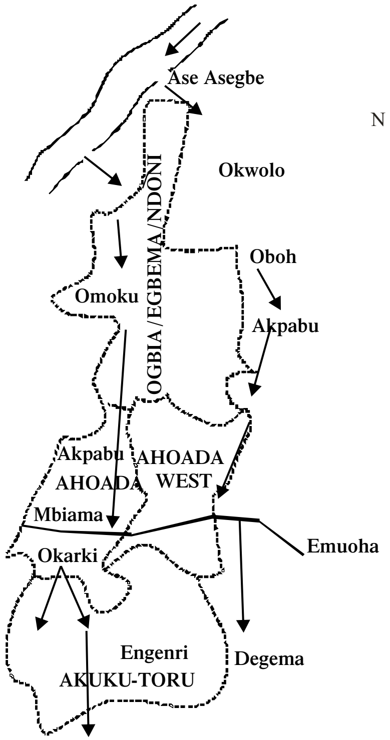


Fig. 3.3: The Trajectory of 2012 Flood Wave In Rivers State

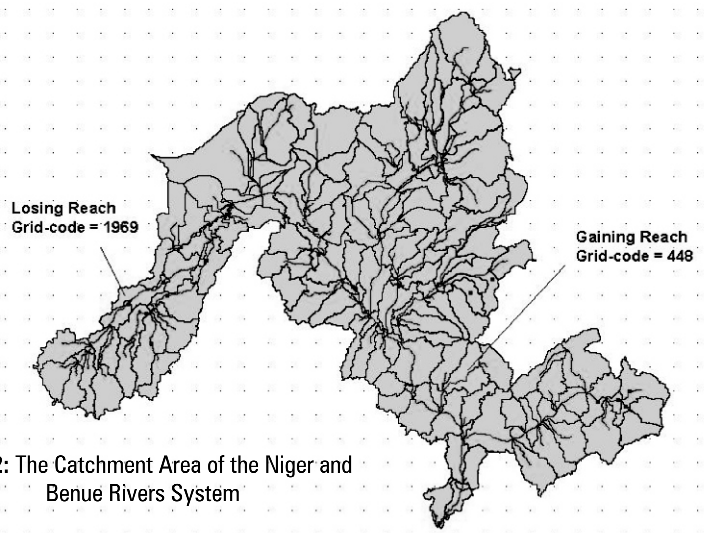


Fig. 3.2: The Catchment Area of the Niger and Benue Rivers System

It was also reported that the worst ever flooding in Venice Italy occurred in late 2002 destroying foundation of most of the ancient edifice buildings in the Ancient City.

In Nigeria, 1999, recorded very high losses of infrastructure, farm produce and human lives caused by flooding (during the 1999 rainy season). Rehabilitation of damaged homes, offices, schools and community properties will gulp amount in excess of N50 Billion nation–wide. Loss of farm produce exceeded 100million tons of grains and other cereals (Adefolalu, 2001).

Summary of flood related Disaster in 1996 and 1999 are shown below

Disaster type	**1996** (whole year)	**1999** (July, Aug., Sept.
Death	14	65
Property loss(N x 10^6ha)	1,000	50,000
Wasted Farmlands Lost ($x10^6$ mtons)	12,000	50,000
Farm Produce Lost ($x10^6$ mtons)	10	100

(Source, Adefolalu, 2001)

Recent years such as 2012, 2014, 2017 have had worse incidences of flood than the 1996 and 1999.

Flooding was also severe in the Niger Delta in 2000 forcing thousands of people to seek shelter at high elevations, leaving houses and crops destroyed, large areas of valuable land could not be cultivated. Infact, up to 80 percent of the delta's population had to migrate to higher ground while oil and gas production and agricultural and fisheries activities were disrupted (Ologunorisa, 2001).

Recent years have experienced some of the world's worst flood disasters. The devastation associated with flood in India, parts of Africa, Pakistan, China and Bangladesh and of course, the recent and wide spread flood events in Europe in 2002 are some notable episodes to remember. These events have raised global awareness of the increasing degree of devastation and insecurity to lives and property caused by meteorological hazards (Obasi, 1991). The resulting impacts on the socio-economic development of nations are immense. While floods and related problems are giving the present generation much concern owing to their renewed intensities, they are not totally new phenomena since they are prehistoric (Dick, 1990). Each time these hazards occur, many lives are lost or swept away. In some instances, entire villages or towns and farmlands are destroyed (Igbozurike, 1993). While flood disasters occur in all parts of the world, their impact has been particularly very severe in developing countries like Nigeria and the Niger Delta in particular due to its low-lying flood (plain); low level of technology and relatively underfunded rescue institutions.

Meteorological and hydrological hazards form part of a group of phenomena which result in natural disasters in many countries. Their unmitigated effects have led to setbacks in the socio-economic progress particularly in terms of lives lost, property damaged, disruption of essential services and dislocation of the local economy (Obasi, 1991). During the past two decades, flood disasters have resulted in about 3 million deaths and have adversely affected at least 800 million people, through homelessness, disease, serious economic loss and other hardships (WMO, 1996). On top of this is added immediate damage in the order of Trillion of billions of dollars.

Floods produced by meteorological hazards such as heavy rain showers or prolonged rainfall and short duration falls with high rainfall intensity etc, not only damage property, but also take a

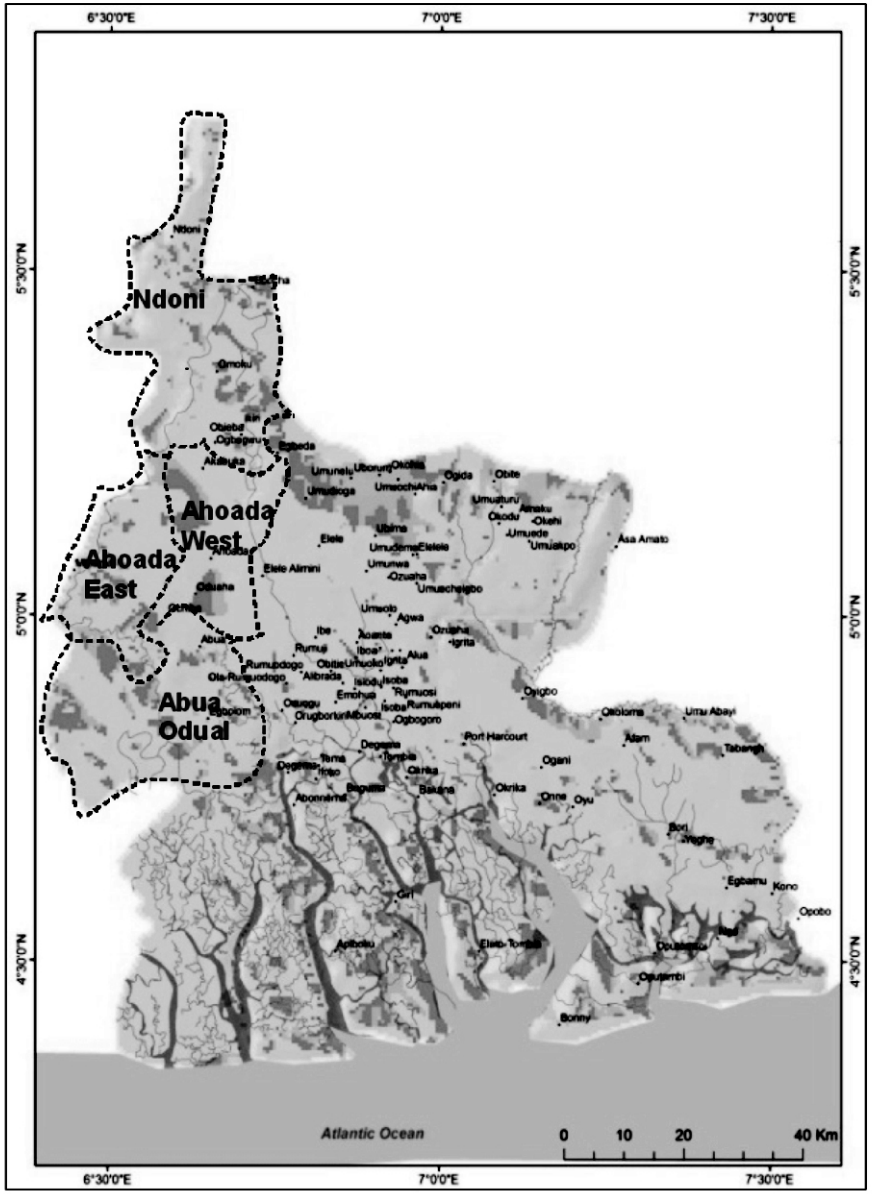


Fig. 3.1: Map of the Study Area showing the River system and the Drainage Network that links to the Atlantic Ocean

Plate 3.9: Aerial photograph of typical scenario of dam failure in Nigeria
(Source: NEMA, 2012)

The challenge here is that if we are able to control or manage the challenges from our own environment, the issue is how do we take charge of those from external sources e.g the Ladgo dam issue. There is need for constant dialogue and international diplomacy.

The Post Impact Assessment Study for Rivers State was carried out through a sponsorship in 2013 by United Nations Development Programme (UNDP). The study indicated that four local Government Areas were affected more. These include Ogbia/Egnbema/Ndoni LGA, Ahoada East, Ahoada West and Abua/Odua Local Government Areas. These four LGS's are located and link to River Niger and Benue which hinges on Ndoni area and connected through Orashi and Sombrerio Rivers which discharge or flow into these 4 Local Government Areas

regular toll of life in many countries. These problems in most cases are exacerbated by increased settlements in flood plains rich in life support systems. In Africa the estimated average annual cost of flood damage amounts to over 42 billion naira (US $300 million) (WMO, 1995).

In Nigeria and in the Niger Delta area in particular, various factors, including topographic conditions, rainfall characteristics, land use patterns and human factors such as refuse disposal habit, occupation of the flood plain and increase in paved areas, have been advanced by various authors for causing different types of flooding in the Niger Delta towns and villages (Gobo, 1988, Gobo, 1991; Olaniran, 1983; Omiunu, 1981; Ojo, 1991; Oriola, 1995). These results in the following type of floods, in the Niger Delta. They include Backswamp flooding, River floods, caused by precipitation acting either directly by rainfall and those resulting from dam failures or collapse and earth slides (Ward, 1978).

Floods in the Niger Delta have had a devastating impact on the quality of life. They have affected rural and urban residents, farmlands, infrastructures, residential/industrial buildings, road, bridges, power plants, commercial and socio-economic activities. Plate 1.2 for example is a scene of a farmland in Kaiama, Bayelsa State, that is submerged by flood leading to premature harvesting of crops with poor yield and market value.

In Plate 1.3, an access road in the community is made impassable by flood thereby disrupting free movement and socio-economic activities.

There are instances when the functioning of important facilities such as power plants are disrupted by flood (Plate 1.4). Power driven economy activities in the communities are comatose as long as the flood lasts and this could last as long as 3 months.

Plate 1.2: Farm land destroyed by flooding in *Kaiama (Bayelsa State) (1988)*.
(Researcher Prof. Gobo and a Village farmer at Kaiama)

Plate 1.3: Farm land becoming passable only by Canoe (1998)

Plate 3.7: Typical scenarios of urban flooding in Lagos, Nigeria, NEMA (2012)

Plate 3.8: Typical scenario of urban flooding in Lagos, Nigeria
(Source: NEMA, 2012)

Plate: 3.4: Agricultural produce damaged during 2012 Flood

Plate 3.5: Coastal flooding in Nigeria (NEMA, 2012)

Plate 3.6: River Flooding in Nigeria's Benue River, NEMA (2012)

Sometimes, entire communities are submerged (Plate 1.5), polluting sources of drinking water and spreading water borne diseases and epidemics, schools are shot to forestall drowning of pupils, scheduled burial are suspended.

The submergence have on occasions resulted in the weakening of foundations and collapse of buildings (Plate 1.6).

In urban areas, floods result in heavy traffic jams (Plate 1.7), weaken the foundations of the roads and result in eventual increase in government budgets on road maintenance cost.

These Floods are prevalent during the wet season. Government efforts at flood control and management have not been far-reaching and uncoordinated successive governments frequently abandoned flood control projects of past administrations to start new ones. Part of the reason for this is the absence of a national policy on flood control and the lack of understanding of the problem.

The research will also provide an input for a better understanding of the problem and the implication for socio-economic stability in the Niger Delta.

The stability of river banks has also been adversely affected, particularly when the heights of the banks are high > 3.5m and comprise of clay soil (Abam, 1995). Plate 1.8 depict a failed bank in the Nun River at Odi that was induced by receding floods.

Plate 1.4: Flooded generator house at *Kaiama, Bayelsa State (1998).*
The Researcher, Prof. Gobo is seen here paddling around the flooded generator house

Plate 1.5: Flooded areas around *Marine Base, Eastern Bye – Pass Port Harcourt, Rivers State (2003)*

Plate 3.2: Flood Scenarios in Rivers State during the 2012 flooding episode

Plate 3.3: Displaced community members during 2012 flood in camp area

The Post Impact Assessment of Flooded Area in Rivers State indicated the extent of damage on housing, infrastructure, health, water, sanitation, education, crops and livestock, and biodiversity in the affected 206 communities in the four Local Government Areas in Rivers State.

SOME OF THE FLOODED SCENERIORS IN 2012

Plate 3.1: Household devastated by flooding

Plate 1.6: Collapsed building during flooding at *Marine Base Eastern – bye Pass, Port Harcourt, R/S (2003)*

Plate 1.7: Heavy traffic problem as a result of heavy down pour (flooding) along *Olu-Obasanjo/Omuko Streets, Port Harcourt (2003)*

Plate 1.8: Bank collapse in Odi (1988), induced by receding floods

DEFINITION OF SOME TERMS

Flood is also considered as a large quantity of water covering an area after held capacity is reached (Ward, 1978). It is defined as any relatively high stream flow, which overtops the natural or artificial banks in any reach of streams. It is unusually high stage in a river, normally the level at which the river overflow its banks and inundates the adjourning area. (Subramanya, 1991) It is a theoretical greatest depth of precipitation for a given duration that is physically possible (WMO, 1973). Faniran (1972) argued that flooding results when an excessive quantity of water derived from runoff and underground sources spreads beyond the banks of a stream channel. Also that a flood is an unusual high stage in a River-normally the level at which the river overflows its banks and inundates the adjoining area. Hewit and Burton (1971) defined flood hazard as comprising loading and abrasional damage that is the mechanical effects of flood waves and currents in the over

3.0 THE 2012 FLOODS CONSIDERED ONE OF THE WORST FLOODS IN RECENT TIMES

The Nigeria Metrological Agency sounded warning in early 2012 that there would be heavy rains that will lead to flooding. The predicted rainfall took all its forms as high intensity rainfall, long and short duration rainfall and a combination of the various types.

The flooding of 2012 was considered as most vicious in recent times, devastating communities and having severe effect on life and property. It is estimated that floods affected about 7.7 million people with as many as two million people rendered homeless (Shuaib, 2012). Apart form the disruption on human activities, there was tremendous destruction of infrastructure. Agricultural land, open recreational space and Biodiversity (Onuah & Cooks, 2012). The social economic and environmental consequences of this flood, described as the “worst flood in 40 or 50 years, were simply enormous (Plates 3.1 – 3.9).

The 2012 was considered as worst since 1958 in Rivers State. Over 100 villages or communities fell to the rampaging flooding. This was aggravated by the release of water from the Ladgo Dam. This dam is 308m long, 40m in height and 9m thick. It is located 50km South of the city of Garoua in the Northern province of Cameroun along the co-ordinates 8°53'N 13°58'E, had both its primary inflow and out flow in River Benue, the second largest river in Nigeria. The dam was constructed between 1977 and 1982 and supplies electricity to the Northern part of Cameroun and also provides water for irrigation of crops downstream.

The discharge from the Ladgo Dam into the river Benue overflowing Orashi and Sombrero River in North West Areas of Ohaji/Ogba Egbema/Ndoni; Ahoada West and Ahoada East and Abua Odual (Figs. 3.1 – 3.10).

Plate 2.1: Building Materials Area Opposite RSU Main Gate

Plate 2.2: Building Materials Area Opposite RSU Main Gate

bank flow, contamination of water, food and deterioration of materials of all types.

Types of Flooding

Flooding can be classified into the following categories:

a. Within channel flooding (*occurring on major rivers like River Niger and it's major distributaries)***.**

This is as a result of over flow of the banks during peak flooding period. Channel flooding is also caused by unusual heavy rainfall beyond channel capacity, channel meandering clogged channel tributary, administration, siltation etc. especially in the Niger Delta.

b. Backswamps Flooding or Back Land (Farm lands) Flooding

Backswamp occupies the depressions between the levee and the flooded plain bluff and it is either permanently or partially flooded (IFERT, 1988). When there is no bluff as is the case in the lower Niger Delta region, the back swamp extends into the Backland or Farmlands. The Back land or farm land is part of the depression but it is of higher elevation than the back swamp and is generally available for cultivation because during most years, these portions are not flooded. Within the channel, that is, between the leeves, large areas including banks bars, shoals etc.; lie above water during the dry season when the water level is low; such areas become intensively cultivated during the dry period. However when the water in the channel rises, the entire farmland become flooded.

The only use of it this period is fish farming through fish traps, fish ponding etc.

c. Tidal Flooding

This is flooding within the tidal zone, which is diurnal in nature and consisting of two highs and one low or two lows and one high with a twenty four (24) hour cycle. Flooding in this area are aggravated by the very low permeability of most surface soils increases the residence time of water on the surface thus leading to, or further aggravating flooding.

d. Urban Flooding

This occur, mostly as a result of expansion of urban areas, without proper planning, non-provision and non-maintenance of drainage facilities with correspondence increase in infrastructure and population explosions. These expansions on urban areas, increases the extent of impervious surfaces which also increases surface run-off, causing floods in the cities. Added to these are the indiscriminate canalization and the attendant creation of ingress channels for flood waters.

Human activities also aggravate flooding in urban cities. It is generally, believed that urbanization, particularly when it encroaches on areas which were once farmlands or forests causes the most remarkable flood-intensifying landuse change (Akintola, 1978; Odemerho, 1988). The removal of natural vegetation cover from a forested area during construction work can lower the infiltration capacity to a point when rainfall intensity becomes higher (Dunne and Leopard, 1978). It is also argued that volume and timing of run off are substantially modified by forest clearing. Infact, this is the inundating of land and property in a built environment, particularly in more densely populated areas; caused by rainfall overwhelming the capacity of the drainage systems.

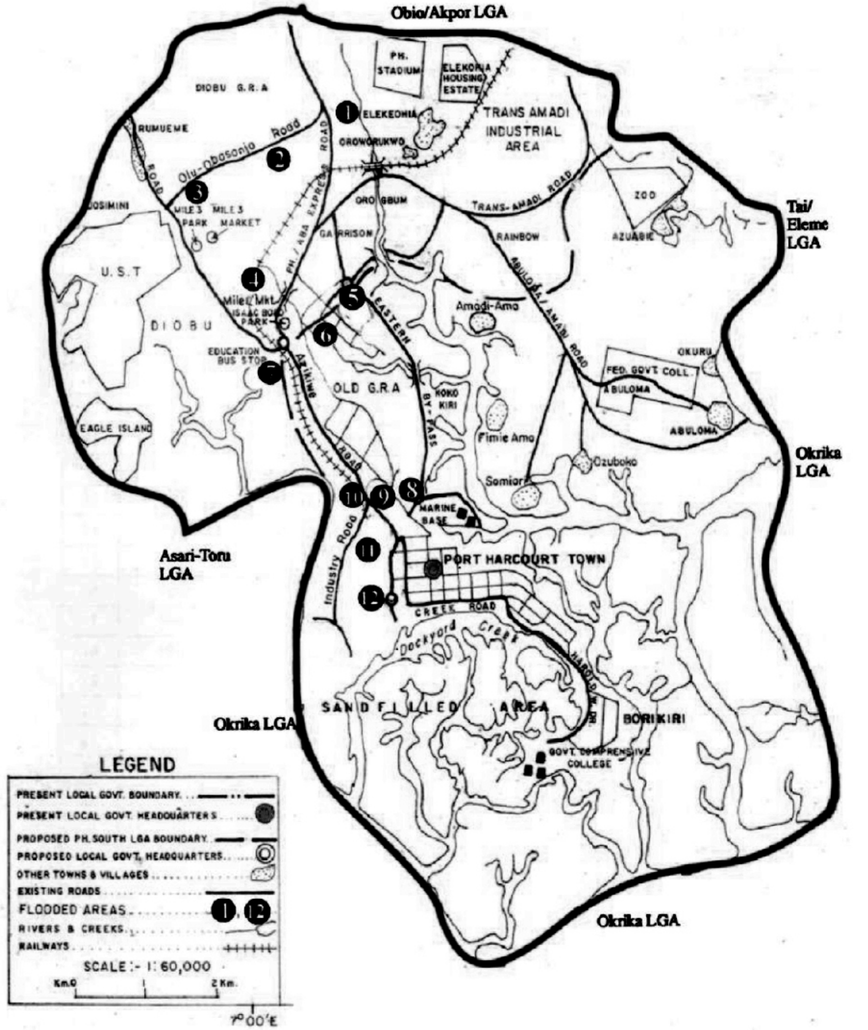


Fig. 2.5: Map of Port Harcourt Local Government Area showing areas prone to flooding

Despite construction works that had taken place over recent years, why should places like:

1. Olu-Obasanjo (Police Station by Omoku Street Junction in D-Line)
2. Diobu Mile I Market Area
3. Diobu Mile III opposite RSU Main gate; Building Material Area
4. Herbert Macauley/Yola Street Amadi Flats Old GRA

be flooded after the least rains. The funny and exciting thing about these places is the fact they are surrounded by rivers and creeks. What would it take to link Olu-Obasanjo/Omoku drainages and Diobu (Mile III Building Material Areas) to Ntawogba creek? Also that of Mile I Market to be drained by Ntawogba or Abonnema Wharf creek? Also Herbert Maculey/Yola street be linked to Ntawogba creek which are very close to each other.

The monthly sanitation in Rivers State, has not been very successful. This is because you clean your part of the drainage and your neighbour refuses to clean the other side, or his own side, definitely there is no work done because water will not flow to its final or discharge point.

Espey et al (1966) found that the replacement of permeable by impervious surface through urbanization results in peak discharges which were from 100 to 300 per cent greater than those from undeveloped areas. Wolman and Schick (1967) and Alfesehi (1990) on the changes in the urban landscape which aggravated flows have shown that urbanization process not only increases surface run-off but also sediment load in basins, along streets and storm channels resulting in change in channel morphology. Increase in urban floods are also related to building along water path, impervious urban surfaces, inadequate storm drains and dumping of refuse in drains and drainage paths, uncoordinated build-up areas; absence of storm sewers.

e. Flash Floods

This is associated with 50mm rainfall that lasts for about 30 minutes (Oyebande, 1980). This is common during heavy thunderstorms at the onset and ceasation periods of the rainy season (Adefolalu,1981). At these times the rate of fall is much higher than the infiltration capacity of the soil. The total amount over the short duration, of thunder storms is often very high with the result that the intensity of fall per hour is high. In order words, flash floods are often the result of conventional storms.

Flash flooding are the most destructive and can be fatal as people are usually taken by surprise. Usually no warning and no preparation. Impact can be very swift and devastating.

f. Sheet Flow or Annual floods

This other type of flooding occur when the soil has reached its field capacity and excess water will then constitute surface flow and where through flow is impossible due to landscape features, flooding occurs. This may result in swell beyond normal channel levels when rivers over flow their banks. The worst periods for such to occur are months of prolonged duration of rainfall that is, when precipitation usually last for hours at the peak of the summer monsoon in Nigeria (Ireland, 1962)

Generally, under flash-floods, excess surface runoff from areas with steep gradient into valley flow is a major course while for other types of floods, the more continuous falls over longer periods will cause sheet flow in very flat terrains near sea level like the Niger Delta (Adefolalu, 1981).

CAUSES OF FLOODING (NATURAL & ARTIFICIAL)

Natural Causes

This is as a result of excessive and or prolonged rainfall. Caused also by a land surface becomes inundated as a result of localized high intensity rainfall, over an extended time period. Also when over flow of river channel occurs or rivers over flows its banks.

This could also occur when the ecosystem is disturbed, example landslide (the recent Tsunami in India where the earth crush was disturbed) and dam failures.

Floods as earlier indicated are recurrent phenomena in the world, resulting from a number of causes of which the most frequent are climatological in nature. Ward, (1978) argues that excessively heavy and or prolonged rainfall is the most common universal cause of floods. In the Niger Delta, floods occur whenever a land surface is inundated, arising from

Why Persistent or Frequent Flooding Problems in Port Harcourt

The drainages / roads do not last as a result of poor supervisions, also the various professionals do not take into consideration different or necessary design parameters such as meteorological/hydrological, geotechnical, survey, slopes into considerations. Also existing River, creeks, topography, discharge points and flow patterns were not always considered.

Most times, political pressures, urgent need to meet up political considerations to quickly complete and commission the project. Also, the need to maximize profit thereby cutting costs and not keeping or following the terms in the bill of quantities (BOQ).

Consider a study carried out on Urban Flood Prediction in the Niger Delta (Gobo & Abam, 2006). Some of the identified flooded areas in Port Harcourt are as listed below:

(1) Waterline Junction (by former College of Education) (2) Olu-Obasanjo Road (Police Station by Omoku Street D/Line (3) Diobu (Mile three building material area) (4) Diobu (Mile One Market Area) (5) Amadi Flat (Nzimiro Street) (6) Amadi Flat ((Herbert Macauley by Yola Street) (7) Diobu (Education Bus Stop Area) (8) Civic Centre by hospital road (9) Azikiwe by Industry Road (10) SUPABOD Bus Stop by First Bank (11) Port Harcourt Main Post Office by Central Bank (12) Station Bus Stop by Hospital Road (Roundabout). The spatial distributions of these locations are shown in the Fig. 2.5 and Plates 2.1 and 2.2.

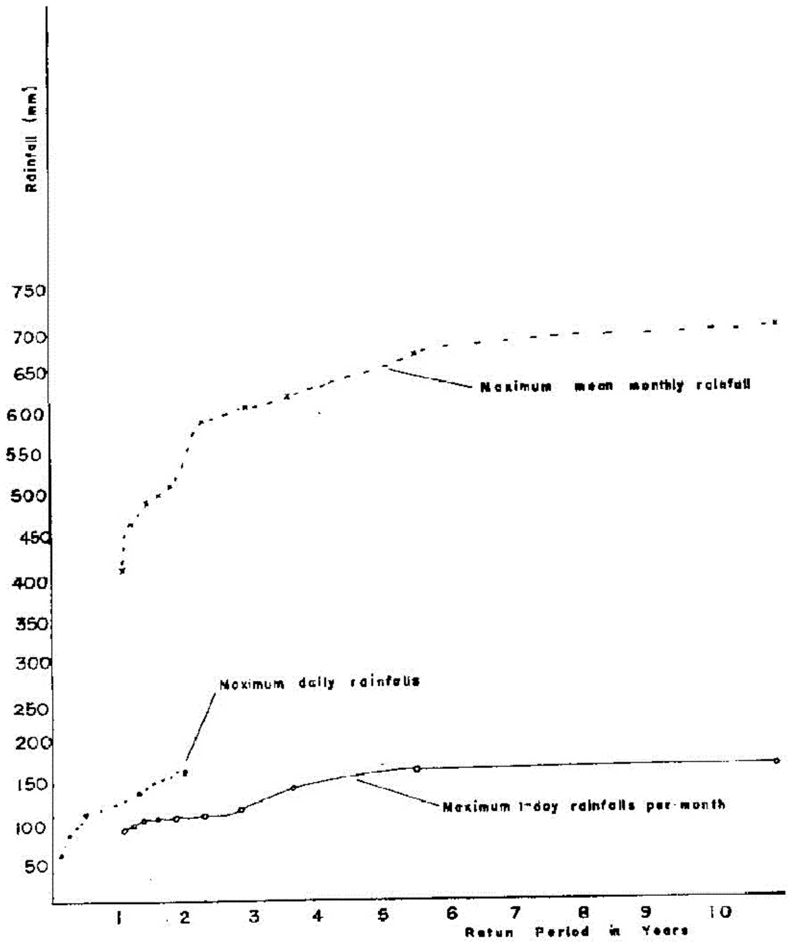


Fig. 2.4: Given return periods as derived from Table 2.5, 2.6, 2.7

The study has thrown more light on some basic calculations that could be carried out when designing for maximum drainage and flood control works. In the study area, it would take an average of 2 years in the month of September (30 days) to exceed a rainfall value of 150.5 mm (Table 2.5).

a. localized high intensity rainfall over an extended time period

b. rainfall over a flat terrain underlain by impermeable substrate and

c. over flowing of river channels, or drains or swells from creeks or streams around, due to high water level or heavy discharge (Gobo, 1988; Amakiri, 1998). These factors act singularly or in combination to give rise to frequent flooding of our environment.

In effect this occur when the level of the land is low relative to the maximum flood height.

In urban centres this is characterized by poorly planned aggregation of roads, buildings and other infrastructure which concentrate precipitation run off. This is aggravated also by the poor road grades, uncoordinated road alignments, and poor situation of drainage channels

A major cause of flooding in urban city could also be related to direct precipitation as a result of underlain soils of low permeability which do not encourage infiltration added to the poorly, and inadequately maintained water outlets channels and drainages (Gobo, 1990). As a result of excessive and or frequent rainfall, the soil becomes saturated and therefore, infiltration capacity is reduced to minimum. During this period also, suspended geomorphic debris (materials) may become deposited in the channels or drainages resulting to the reduction of the capacity the channels. Progressive in the height of water and the inability of the drainage channels to accommodate this, excessive water has to flow out into the surrounding lands. The higher the flow velocity, consequently the more the disastrous the floods.

Combination of high tides and heavy rainfall also add to over flow of banks into hinter lands. Other causes of flood include tidal effects as a result of excessive high tides associated with storm surge, landslide into enclosed or semi-enclosed water bodies; over flow of dams or dam failures and other water control structures.

Artificial Causes or Man Made

The artificial flooding is also considered as man made in some cases. This is more of urban flooding arising from lack of provision or poor management of water draining system. Under this category include things like inadequate drainage systems, blockage of water drainages, poor channeling of the drainage system and other unhealthy environmental practices such as poor sanitary habits.

Effect of Flooding

The aftermath of flooding are always very devastating and far reaching. Some of the damages brought about by flooding including destruction of houses and building, damage of farm lands, leading to premature harvesting Plates 1.9 – 1.14. Also in most cases, water ways are made impassable because of blockage, by debris. Floods contaminates drinking water leading to disease. Floods results in loss of lives and destruction of properties., social and economic hardships and famine. Floods carry away soil from valuable farms

In the Niger Delta area for instance, this has caused great socio-economic losses (Hewit and Burton, 1971) such as drowning, communication barrier, loss homes, disruption of economic activities, interference with general transportation causing heavy traffic hold ups on land and blockages of our water; destruction of Agricultural lands; contamination of ground water and in recent times.

Heavy rainfall that leads to numerous hazards such as flooding, including risk to human life, damage to building and infrastructure, and loss of crops leading to premature harvest) livestock, landslide, destruction of transportation and

Table 2.6: Frequency Distributions based on depth ranking of maximum 1-day rainfall per Month derived from Table 2.4.

Rank no. (r) (1)	Rainfall descending P_r (2)	P_r^2 (3)	Year (4)	Frequency of Exceedence $F(P > P_r)$ r/n +1) (5)	Frequency of non Exceedence F(P > Pr) 1-F(P >)P_r (6)	$TP_{r\ (years)}$ (7)
1	701.3	491821.69	1979	0.091	0.909	10.99
2	671.2	450509.44	1978	0.182	0.818	5.49
3	622.2	387132.84	1977	0.273	0.727	3.66
4	696.8	368206.24	1976	0.364	0.636	2.75
5	597.1	356528.41	1975	0.455	0.545	2.20
6	512.1	262246.41	1974	0.545	0.455	1.83
7	502.3	252305.29	1973	0.636	0.364	1.57
8	492.4	242457.78	1972	0.727	0.273	1.38
9	469.2	220148.44	1971	0.818	0.182	1.22
10	409.7	167845.09	1970	0.909	0.091	1.10

Table 2.7: Frequency Distributions Based on Depth Ranking of Maximum Mean Monthly Rainfall Derived from Table 2.4.

Rank no. (r) (1)	Rainfall descending P_r (2)	P_r^2 (3)	Year (4)	Frequency of Exceedence $F(P > P_r)$ r/n +1) (5)	Frequency of non Exceedence F(P > Pr) 1-F(P > P_r) (6)	$TP_{r\ (years)}$ 1/(5) (7)
1	162.9	26536.41	1975	0.091	0.909	10.99
2	162.8	26503.84	1970	0.182	0.818	5.49
3	141.5	2002225	1974	0.273	0.727	3.66
4	115.3	13294.09	1979	0.364	0.636	2.75
5	108.7	11815.69	1975	0.455	0.545	2.20
6	108.2	11707.24	1977	0.545	0.455	1.83
7	103.0	10609.0	1979	0.636	0.364	1.57
8	102.5	10506.25	1977	0.727	0.273	1.38
9	98.5	9702.25	1971	0.818	0.182	1.22
10	93.7	8779.69	1970	0.909	0.091	1.10

Table 2.4: Maximum Daily Rainfall Value (mm)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL
1970	1.30^{24}	1.09^{4}	0.46^{15}	2.35^{12}	1.85^{13}	1.44^{15}	162.8^{11}	55.9^{21}	93.7^{10}	57.2^{9}	31.9^{20}	0.0	409.79
1971	11.9^{1}	15.0^{27}	14.7^{14}	15.8^{11}	22.1^{4}	55.6^{15}	73.2^{7}	83.5^{30}	98.5^{22}	30.2^{21}	15.5^{30}	56.6^{4}	492.4
1972	9.2^{20}	41.2^{3}	72.6^{11}	41.8^{15}	46.2^{3}	53.9^{4}	68.6^{8}	84.3^{4}	58.2^{25}	35.8^{19}	50.1^{3}	35.3^{7}	597.1
1973	25.7^{2}	59.5^{27}	65.8^{15}	28.4^{27}	46.7^{17}	22.3^{3}	27.9^{11}	58.4^{20}	67.1^{3}	42.4^{19}	37.3^{9}	30.6^{7}	512.1
1974	34.3^{27}	24.4^{17}	71.9^{19}	38.6^{4}	141.5^{31}	36.8^{27}	64.5^{13}	52.1^{12}	72.5^{5}	79.5^{30}	38.0^{13}	17.1^{25}	671.2
1975	0.0	22.8^{19}	162.9^{17}	54.6^{2}	36.0^{17}	53.4^{1}	108.7^{20}	45.7^{5}	36.1^{27}	45.8^{25}	43.5^{1}	12.5^{23}	622.0
1976	0.7^{14}	37.7^{15}	63.5^{31}	48.9^{29}	24.1^{21}	55.1^{17}	26.4^{20}	78.7^{15}	34.8^{12}	50.9^{22}	72.4^{6}	0.1^{31}	502.3
1977	26.9^{22}	33.4^{4}	24.0^{12}	21.3^{5}	27.6^{30}	86.8^{19}	65.1^{3}	108.2^{11}	82.3^{15}	102.5^{18}	10.2^{30}	19.3^{10}	606.8
1978	26.9^{22}	40.1^{6}	42.0^{24}	46.1^{24}	48.7^{12}	58.2^{20}	29.2^{8}	27.3^{21}	76.1^{28}	37.7^{25}	28.5^{8}	9.4^{24}	469.2
1979	0.3^{29}	61.1^{5}	49.4^{27}	55.7^{22}	103.0^{8}	69.5^{5}	78.8^{16}	115.3^{3}	28.8^{8}	82.2^{6}	45.8^{7}	11.4^{29}	701.3

Table 2.5: Frequency Analysis, Based on Depth Intervals of Maximum Daily Rainfall Derived from **Table 2.4.** (The power represents the particular day the value occurred (was obtained)

Depth Serial No (i)	Interval (mm) Lower limit (a_i)	Upper limit (b_i)	No of observations $a_i < p < b_i$ (m_i)	Frequency $F(a_i < p < b_i)$ (m/n) Frequency of Occurrence P_r	Exceedence Frequency $F(p < a_i)$ (m/n)	Cumulative Frequency (non-exceedence) $F(p < a_i)$ $1 - F(p < a_i)$	Return period Ta_i (days) 1/(6)	Ta_i (years) (8)/30
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	0.0 -	25.5	30	0.25	1.000	0.000	1.000	0.033
2	25.5 -	50.5	45	0.358	0.75	0.25	1.333	0.044
3	50.5 -	75.5	28	0.233	0.392	0.608	2.551	0.085
4	75.5 -	100.5	11	0.092	0.158	0.842	6.329	0.211
5	100.5 -	125.5	5	0.042	0.067	0.933	14.925	0.498
6	125.5 -	150.5	1	0.008	0.025	0.975	40.000	1.333
7	**150.5 -**	**175.5**	**2/120**	**0.017**	**0.017**	**0.983**	**58.824**	**1.961**

communication system, causes damage to buildings and infrastructures.

Despite loss of life, and damage to buildings and other structures, including Bridges, Swages systems Roadways, Railways and Canal. Also frequently damaged are power transportation and power generation (Loss of power).

Infact flood effects could be summarized into economy, environment of the people, decreased purchasing and production power, psychological effects, political implications, health, etc.

Economy:

During flooding especially Flash floods, Roads, Bridges, and peoples are rendered homeless. A lot of man hour and finances are spent on the deployment of emergency measures, military, police men, fire fighters; it takes lot of years to rebuild destroyed business and economy. http://www.nws.noga.gov/inc/. Also recurrent flooding in a region may discourage long term investments by the government and private sector.

Decreased Purchasing and Production Power

Disruption to clean water and electricity, transport, communication, education and health care. Lots of livelihoods, reduction in purchasing power and loss of land values in the flood plains leads to increase vulnerabilities of the communities living in the areas. The additional cost of rehabilitation, relocation of people and removal of property from flood affected areas can be divert the capital required for maintaining products.

Psychological Effects

The psycho-social effects on flood victims and families can traumatize them for long period of time. The loss of loved ones can generate deep impact especially on children. The memories are never easy to forget or over come. Displacements from homes, loss of property and livelihoods and disruption to business and social affairs can cause continuous stress that can never be imagined.

Political Implications

The effective response to relief operations during major flood events may lead to public discontent or loss of trust in the authorities, state or national governments. Lack of development or delayed response in flood prone areas may cause or lead to social inequality or social unrest posing threat to peace and stability in the affected region.

Environment

Chemicals and other hazardous substances end up in the water and eventually contaminate the water bodies. It causes massive leakages in nuclear plants and high radiation in such areas. It kills animals, and other insects are introduced to the affected areas, destroying the natural balance of the ecosystem.

Health

People and animals die and are injured; many made homeless; water supply and electricity are disrupted and destroyed. It results to a lot of diseases, fever, pneumonia, invasion of insects and snakes which cause a lot of havoc in affected areas.

$$T_r = \frac{1}{F(P > r)}$$

$$T_{years} = \frac{T}{no.of\ observations\ per\ year}$$

Considering Table 2.2, the frequency of exceedence of maximum 1-day rainfall of more than 125.5 mm was F(P > 125.5 mm) = 0.025 (Table 2.2, column 6) (Kesser and Read, 1980). For this, return period was:

$$T_{years} = \frac{1}{F(P>125.5)} = \frac{1}{0.025} = any\ 40\ days.$$

Daily rainfalls can be generally considered as independent of each other. The month of September is chosen because this is a typical month for design for drainage and flood control works for the area of study as indicated in Fig. 2.1. Thus:

$$T_{years} = T_{(125.5)}\ (September\ days) = \frac{40}{30}$$

= 1.333 years

Consider also for

$$T_{years} = T_{(125.5)}\ (September\ days) = \frac{58.824}{30}$$

= 1.961 years
= 2.0 years

Fig. 4 gives the various return periods as derived from Tables 2.2, 2.3 and 2.4

$$F(p > a_i) = \frac{m_i}{n}$$

The frequency of non-exceedence was obtained by 1 - F(P > a_i). See Table 2.2 column 7.

Frequency based on depth ranking

The data (P) was ranked in descending order, starting with the highest value first to the lowest last. A serial rank (r) was attached to each value (P_r, r = l,2....n). The frequency of exceedence was then obtained by

$$F(P > P_r) = \left(\frac{r}{n+1}\right) \quad \text{(Table 2.3 column 5)}$$

while that of non-exceedence was obtained by

$$1 - F(P > P_r) = 1 - \frac{r}{n+1}$$

Table 2.3 shows how this was applied to the maximum mean monthly rainfalls (Table 2.1 and Table 2.4) for the * maximum 1-day rainfalls given in Table 2.1.

Recurrence predictions and return periods

Recurrence predictions are often calculated in terms of return periods. The return period of a given event is the average number of years within which the event is expected to be equaled or exceeded (i.e., the expected average frequency of occurrence of an event over a long period of years) (W.M.O., 1983).

In designing for maximum drainage, flood control works and hydrological practices, the frequency of exceedence is often considered. The return period is obtained from the frequency of exceedence as follows:

RAINFALL, CLIMATE CHANGE AND FLOODING: A BLESSING OR A CURSE

Source: The Conversion, (2017)

Plate 1.9: Flooded parts of Lagos

The current weather situation across Northern NSW and Tropical Queensland right now is by no means ideal. The aftermath of Cyclone Debbie and the torrential rain that ensued its path has been a test of locals and our Government Services

Source: The Conversion, (2017)

Plate 1.10: A canoe ride on a flooded street in Ajegunle, a densely populated area in Lagos, Nigeria

Plate 1.11: Flooded Experience at Bayelsa, (Premium Times: Monday, February 18, 2019)

Plate 1.12: Various Flood Scenarios in Warri and Environs between 1987 and 2007

The regression equation and the correlation coefficient obtained were

$y = 11.254 + 0.091x$ and $r = 0.56$ respectively,

While the coefficient of determination was 0.32 and

$(\bar{x}, \bar{y}) = (11.564,\ 12.484)$ (Fig. 2.3).

This indicted that with the same period of recurrence, rainfall intensity had a linear relationship with the number of rain days.

Frequency analysis of rainfall and recurrence prediction

The frequency analysis of rainfall was done directly by assigning a frequency to each measured rainfall or to a group of rainfall values in the observation. Table 2.1 presents the maximum daily rainfall values for ten consecutive years. The frequency of occurrence were obtained by

$$F(a_i < p < b_i) = \frac{m_i}{n}$$

Where m_i = Number of data in each interval
n = Total number of data
n_i = Lower limit
p = Mid value
and b_i = Upper limit

Since our interest is the design for critical or peak situations, we will concentrate on the number or frequency of rainfalls exceeding certain values. The frequency of exceedence was obtained by adding the number of all rainfall values exceeding a, (i.e. M,) and dividing this by the total number (n) of rainfalls, e.g. the value 0.025 in Table 2.2 column (6) row 6 was obtained by adding 1 and 2 of column (4) and dividing by 120:

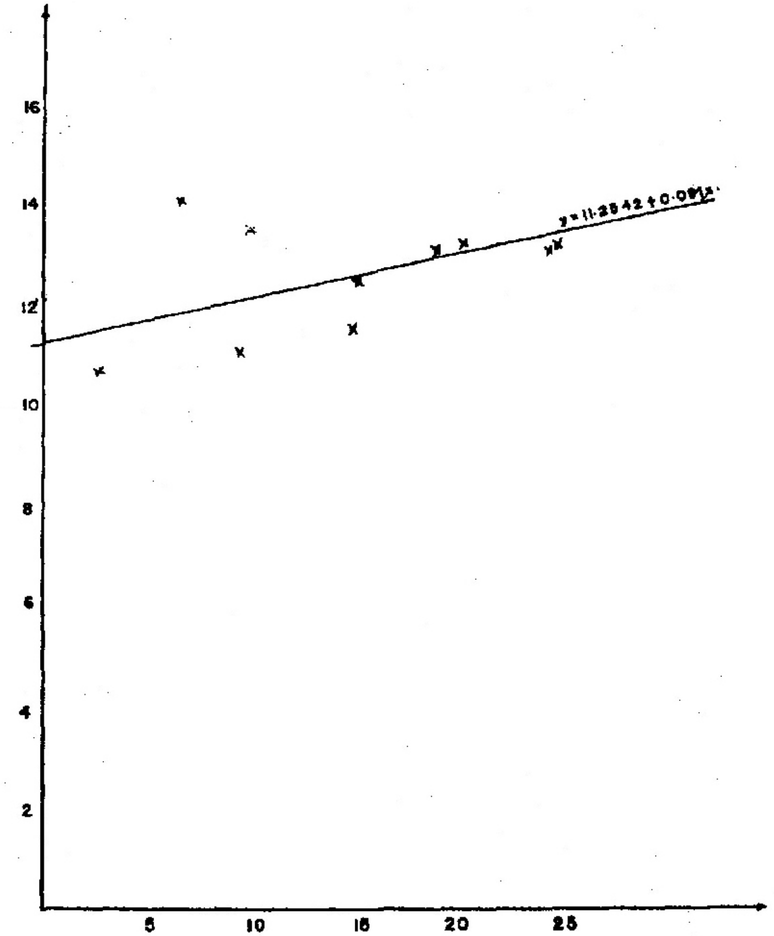


Fig. 2.3: Mean Monthly Rainfall Intensity Regressed against the Number of Rain Days

Critical duration

The mean monthly rainfall intensity was regressed against the number of rainy days. This is important for the study of the water availability for crop growing or of general water excesses.

Some recent flooding phenomenon in Port Harcourt and Environment

Plate 1.13: Fed. Rd Safety Corps Head Office in Port Harcourt Flooded by Rainfall in 2017
Source hyyp://www.nairaland.com

Plate 1.14: Flooded Street in Nkpolu Rumuigbo by Rainfall in 2017
Source hyyp://www.nairaland.com

Some Positive Effects of Flooding

And God said let the waters under the heaven be gathered under one place, and let the dry land appear; and it was. And God called the land Earth; the waters, He called Seas. And God saw that it was good (Genesis 1:10). Flooding events could be devastating to humans. They are natural and sometimes man made occurrence that provide negative and positive impacts. Flooding help to spread organic materials, nutrients, and sediment which enrich flood plains.

It also provides water for crops as there is friction between the water and the surface of the land, the water shows down and loses its energy. These losses of energy result in the deposition of rich fertile soil resulting in providing important nutrient for crops growth or growing of crops

Floods especially those that occur in flood plains and farm lands the flood water carry lots of nutrients that are deposited in the plains, such soils are perfect for cultivating some kind of crops.

The Bayelsa Experience 2012 Flooding

During flooding especially Backswamp Flooding consists of the flow direction, the higher ground (levee) and the lower land that is flooded. When the floods receed, the lower land behind the higher ground become fish traps where lots of fishing activities take place (see pictures of fish catch after flooding in Bayelsa 2012) (Plates 1.15 – 1.17).

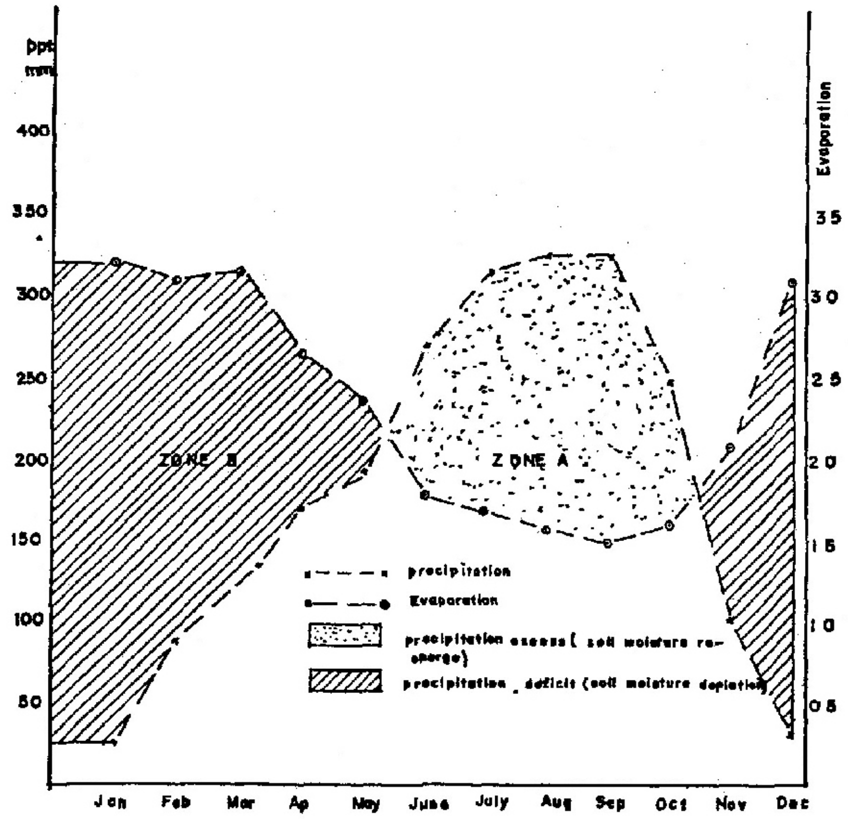


Fig. 2.2: Critical Design Period

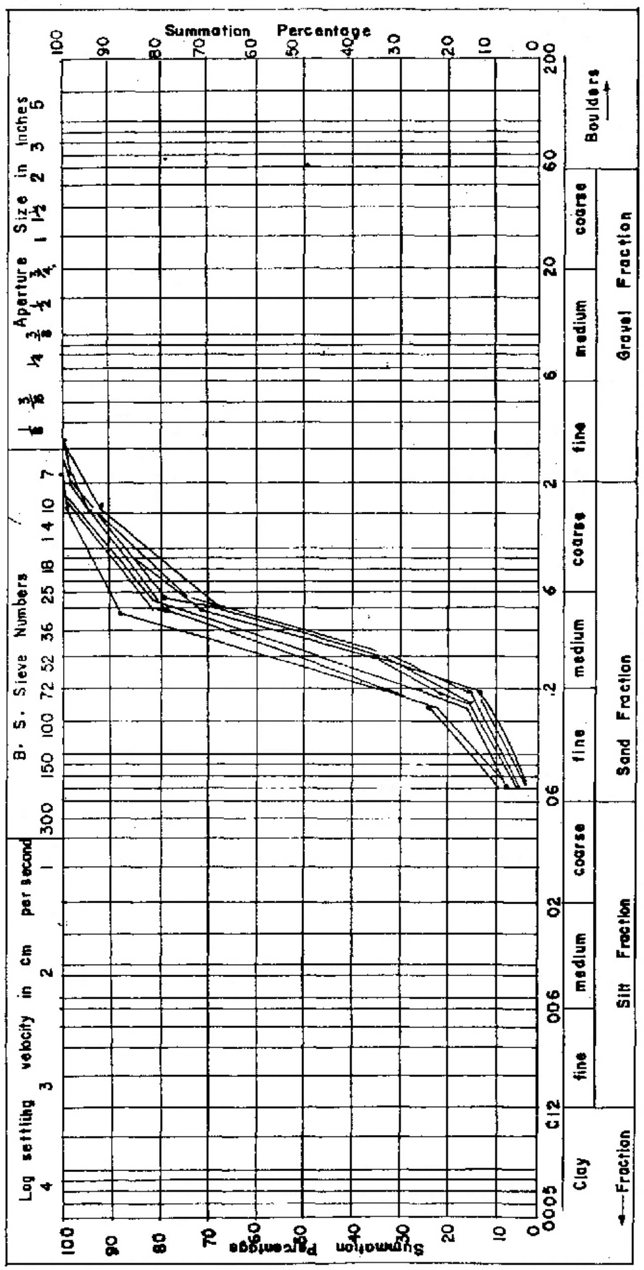


Fig. 2.1b: Grain Size Distribution Enveloped for Port Harcourt (IFERT, 1988)

Plate 1.15: Trapped fish from the flood turn into bumper fish harvest for some communities in Bayelsa State (2019)

Plate 1.16: Trapped fish from the flood turn into bumper fish harvest for some communities in Bayelsa State (2019)

Plate 1.17: Stingray Fish caught with the Flood waters

While some residents in Bayelsa State were lamenting over the havoc wrecked by the surging floods in their communities, some toke advantage of the situation to make money.

Some villagers in a Riverine community reportedly caught big and massive fishes after their community was over flooded. The villages who were over joyous, posed with the big catch, with plans to sell them. Meanwhile, some affected residents along the Epie Creek in Yenagoa, Bayelsa State, bemoaned their losses and the discomfort caused by the floods that submerged their houses. It was gathered that the impact of flooding caused by the overflow of the State from Taylor Creek, tributaries of Orashi and Niger River, dealt devastating blow to the residents.

illustrated in Fig. 2.2. The mean monthly temperature varied between 27.54°C (April) and 26.19°C (October) while the relative humidity ranged from 84% in April to 89% in October during the study period.

Considering precipitation and evaporation, one of the factors related to drainage designs and flooding between the months of April and October, in general, is excess evaporation and infiltration rates, leading to excess surface runoff and recharge of soil moisture (Fig. 2.2, Zone A). From October to April, less rainfall is experienced, in which case, evaporation in most cases exceeds precipitation. In this case, there is precipitation deficit (Fig. 2.2, Zone B).

$\frac{R_i}{n_i}$ is the mean rank of the values of i^{th} sample. This test is usually based on the large-sample theory that the sampling distribution of W can be approximated closely with a chi-square distribution with K-1 degree of freedom (Ebdon, 1985, Ogam, 2000 & Gobo *et al.*, 2006).

Flood Frequency Studies, Justification of Data Analyses Techniques and Problems of Modeling in the Niger Delta Environment

Hydrologic processes such as floods are exceedingly complex natural events. They are resultants of number of component parameters and are therefore very difficult to model analytically. For example, the floods in a catchment depend upon the characteristics of the catchment, rainfall and antecedent conditions, each one of these factors in turn depend upon a host of constituent parameters. This makes the estimation of peak flood a very complex problem leading to many different approaches. Therefore the most useful approach (Subramanya, 1991) to the prediction of flood flows, and also applicable to other hydrologic processes etc. is the statistical method of frequency analysis.

Critical season for Design for Drainage and Flooding

Rainfall data analyses for designs of drainage and flood protection works could be restricted to the period of the hydrological section during which excessive rainfall may cause damage. In Port Harcourt, this critical period is when rainfall exceeds evaporation (Kesser and Read, 1980).

A typical Port Harcourt soil has a grain size distribution envelope as shown in Fig. 2.1 (IFERT, 1988) and a range of permeability coefficient of 1.0 x l0^cm/sec to 1.0 x 10"^{3}cm/sec. This soil characteristic is tied to the phenomenon

The Okochiri in Okrika Local Government Area Experience (2018)

Also aftermath of flooding, sands were washed into the drainages. Our experiences at Okochiri community in Okrika LGA where we had a waste management project. The sand from the drainage was brought out cleaned or washed, bagged and sold. Infact, it is believed that this sand is very good; infact better plastering sand (Plates 1.18 – 1.20).

Plate 1.18: Sand mining aspect of drainage De-silting Activities witnessed at Okochiri in Okrika LGA (2018)

Plate 1.19: Sand mining aspect of drainage De-silting Activities witnessed at Okochiri in Okrika LGA (2018)

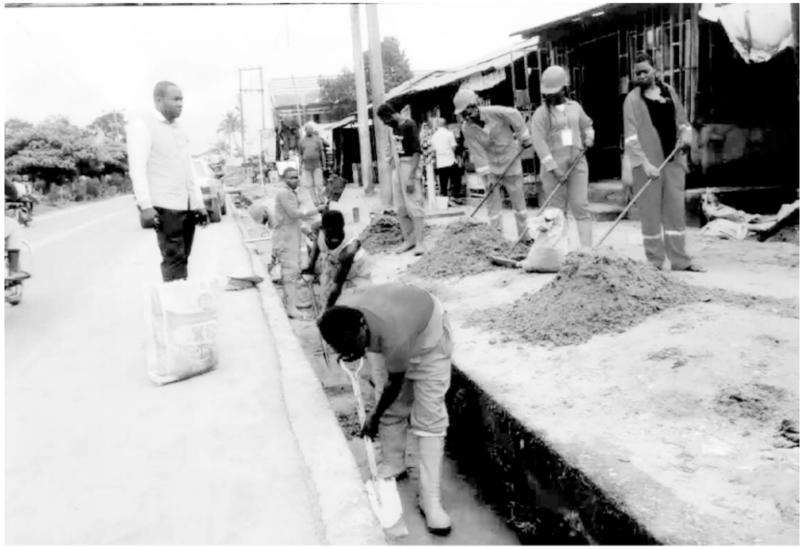


Plate 1.20: Sand mining aspect of drainage De-silting Activities witnessed at Okochiri in Okrika LGA (2018)

Rainfall Intensity (RI)

Salau *et al*., (1986) calculated Rainfall Intensity (RI) through Rainfall Rates (RR) divided by the Duration (Hours). This was calculated for some selected communities in southern Nigeria as to provide insight to the distribution of Rainfall in the Niger Delta.

Analyses Techniques for Socio-economic Issues Related to Flooding

We use Kruskal Wallis Test to carry out this for the following reasons:

1. The data points in the contingency table are large especially the number of rows which makes the Kruskal Wallis Test more appropriate
2. Kruskal Wallis like Chi-square test is used mainly on normal or ordinal data, but since the data we analysed was ordinal, we were free to use Kruskal Wallis formula.
3. For large sample data points the use of Kruskal Wallis Test is faster and more convenient than the Chi-square since we only need to get the sum of rankings for each column of the contingency table and substituted into the test function.

The Kruskal-Wallis test statistic is given by

$$W = \frac{12}{n(n+1)} \cdot \sum_{i=1}^{K} \frac{R_i^2}{n_i} - 3(n+1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (3.11)$$

Where: "n" is the size of the sampled data and K is the number of states sampled.

Rank (r)	Rainfall (mm)	Frequency of Exeedence (P = r/n+1)	TYear = 1/P	Log rp	Log rainfall
26	2068.9	0.8125	1.23	0.207014	7.6347723
27	1991.5	0.8438	1.19	0.173953	7.5966434
28	1965.1	0.8750	1.14	0.131028	7.5832984
29	1962.2	0.9063	1.10	0.09531	7.5818216
30	1836.0	0.9375	1.07	0.067659	7.5153446
31	**1632.6**	**0.9688**	**1.03**	**0.029559**	**7.3979291**

This implied, it will take just 2.0 years for us to have rainfall of 2,283.1mm and 1.03 year or every year we are sure of rainfall value of 1,632.0mm in Port Harcourt. (Table, 2.3)

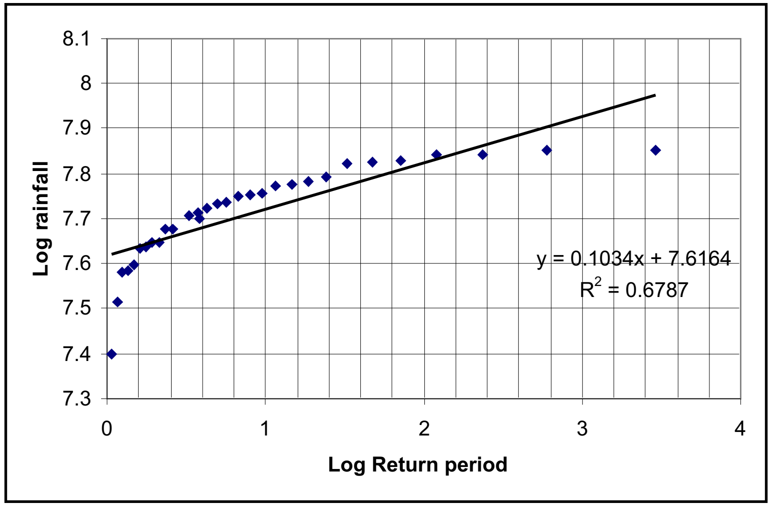


Fig. 2.1a: Return Periods - Frequency based on depth ranking of Annual maximum rainfall for Port-Harcourt

2.0 SOME TECHNIQUES OF ANALYSES OF DATA RELATED TO FLOOD PREDICTION

2.1 Time Series Analyses (Estimation of Trends):

Time series analyses to determine trends through five-year, ten-year etc. moving averages were always carried out. This gives an indication of variations with the passage of time. Analyses of times series is of great significance in many ways, one of which being its ability at solving the problem of forecasting, future movements (Spiegel, 1972).

Applying the moving average method or technique implies that:

$$\frac{Y_1 + Y_2 - - - - + Y_{N1}}{N}; \quad \frac{Y_2 + Y_3 - - - - + Y_{N+1_1}}{N}; \quad \frac{Y_3 + Y_4 - - - - + Y_{N+2_1}}{N} +$$

is the moving average of order N.

Time trend analyses are also computed to enable us compare the rainfall data for the area of study and discharge measurement. This was to also show whether there was considerable evidence of persistence or coherence in the incidence of floods and or droughts; and also whether there are underlying patterns or rhythms in the data. Five-years moving average are mostly chosen as longer averaging would destroy the significant features of the curves (Stringer, 1972).

Deviation from Mean

Definition of variables/symbols

$$= \sum_{i=1}^{N} (x - \bar{x}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.2a)}$$

$$= \sum_{i=1}^{N} [x_i - (\frac{\sum x_i}{N})] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.2b)}$$

$$= \frac{1}{N} \sum_{i=1}^{N} (Nx_i - \sum x_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.2c)}$$

2.2 Frequency Analysis of Rainfall, Recurrence Predictions and Return Periods

The frequency (F) analysis of rainfall was done directly by assigning a frequency to each measured rainfall or to a group of rainfall values in the observation. The frequency of occurrence is given by

$$\mathbf{F(a_i < P < b_i) = \frac{m_i}{n}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.3)}$$

Where mi = number of data in each interval
n = the total number of data
a_i = lower limit
P = the mid value
and b_i = the upper limit

Since our interest is the design for critical or peak situations, we will concentrate on the number or frequency of rainfalls exceeding certain values.

Return Period (Annual Maximum)

Table 2.3: Return Periods - Frequency based on depth ranking of Annual Maximum Rainfall (mm) as derived from Table 2.2 (Rainfall descending) (Port Harcourt)

Rank (r)	Rainfall (mm)	Frequency of Exeedence (P = r/n+1)	^{T}Year = 1/P	Log rp	Log rainfall
1	2569.3	0.0313	32.0	3.465736	7.8513888
2	2569.3	0.0625	16.0	2.772589	7.8513888
3	2544.9	0.0938	10.67	2.367436	7.8418466
4	2542.4	0.1250	8.0	2.079442	7.8408638
5	2511.5	0.1563	6.4	1.856298	7.8286355
6	2502.3	0.1875	5.3333	1.67397	7.8249656
7	2499.6	0.2188	4.57	1.519513	7.823886
8	2420.9	0.2500	4.0	1.386294	7.7918947
9	2395.6	0.2813	3.56	1.269761	7.781389
10	2381.7	0.3129	3.20	1.163151	7.7755698
11	2374.2	0.3438	2.91	1.068153	7.7724158
12	2339.7	0.3750	2.67	0.982078	7.757778
13	2329.4	0.4063	2.46	0.900161	7.753366
14	2321.8	0.4375	2.29	0.828552	7.750098
15	2291.2	0.4688	2.13	0.756122	7.736831
16	**2283.1**	**0.5000**	**2.0**	**0.693147**	**7.7332894**
17	2261.3	0.5313	1.88	0.631272	7.7236951
18	2235.5	0.5625	187	0.576613	7.7122202
19	2226.5	0.5938	1.68	0.518794	7.7081861
20	2206.2	0.6250	1.80	0.587787	7.6990269
21	2160.2	0.6563	1.52	0.41871	7.6779561
22	2158.3	0.6875	1.45	0.371564	7.6770762
23	2096.8	0.7188	1.39	0.329304	7.6481677
24	2094.4	0.7500	1.33	0.285179	7.6470224
25	2073.3	0.7813	1.28	0.24686	7.6368968

Table 2.2: Annual maximum Rainfall (mm) Totals for Port Harcourt as Derived from Table 2.1

S/No.	YEAR	Rainfall (mm)	S/No.	YEAR	Rainfall (mm)
1	1970	2381.7	17	1986	2283.10
2	1971	1965.10	18	1987	2261.30
3	1972	2226.50	19	1988	2420.90
4	1973	1836.00	20	1989	2160.20
5	1974	2206.20	21	1990	2073.30
6	1975	2511.50	22	1991	2094.40
7	1976	2321.80	23	1992	1962.20
8	1977	2235.50	24	1993	2542.40
9	1978	2291.20	25	1994	2374.20
10	1979	2502.30	26	1995	2569.30
11	1980	2544.90	27	1996	2339.70
12	1981	2158.30	28	1997	2329.40
13	1982	1991.50	29	1998	2569.30
14	1983	1632.00	30	1999	2499.60
15	1984	2096.80	31	2000	2068.90
16	1985	2395.60			

Design Rainfall

Thus, the frequency of exceedence was obtained by counting or adding the number M_i of all rainfall values, exceeding a_i, and dividing this by the total number (n) of rainfalls. Thus:

$$F(p > a_i) = \frac{M_i}{n} \quad \text{.......................................} \quad (3.4)$$

While the frequency of non-exceedence was obtained by

$$1 - F(p > a_1) \quad \text{......................................} \quad (3.5)$$

Frequency Based on Depth Ranking:

Rank the data (p) in descending order, the highest value first and the lowest last. Attach a serial rank (r) to each value (P_r, r = 1 ------ n). The frequency of exceedence was then obtained by:

$$F(p > p_r) = \frac{r}{n+1} \quad \text{...................................} \quad (3.6)$$

While that of non-exeedence was

$$1 - F(p > p_r) = 1 - \frac{r}{n+1} \quad \text{..........................} \quad (3.7)$$

Recurrence Predictions and Return Periods:

Recurrence predictions are often, calculated in terms of return periods. The return period of a given event is the average number of years within which the event is expected to be equaled or exceeded (that is, the expected average frequency of occurrence of an event over a long period of years) (W.M.O, 1983).

In designing for maximum drainage, flood control works, and hydrological practices, the frequencies of exeedence is often considered. The return period is obtained from the frequency of exceedence as

$$T_r = \frac{1}{F(P > r)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (3.8)$$

$$T_{years} = \frac{1}{\text{no. of observations per year}} \quad \text{(Kesser et al, 1980).} \ldots \; (3.9)$$

Return Period / Exceedence frequencies values are important for the designs of channels, bridges, culverts, water ways and spillways for dams and estimation of scours at hydraulic structures.

RAINFALL, CLIMATE CHANGE AND FLOODING: A BLESSING OR A CURSE

Table 2.1: Typical Example of Calculation of Return Periods

Maximum (1-month) Rain fall distribution pattern for (Port Harcourt) [1970-2000] (31 Years inclusive)

YEAR	JAN	FEB.	MAR.	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1970	59.69	39.88	60.2	199.64	183.89	212.1	540.3	414.7	268.2	320.9	82.20	0	2381.7
1971	14.70	32.30	68.20	43.70	168.20	283.60	311.70	443.40	313.50	136.60	42.20	107.00	1965.10
1972	10.40	128.10	85.80	116.40	168.60	263.10	411.80	453.60	282.10	168.80	76.00	61.80	2226.50
1973	32.10	89.10	92.50	124.30	243.40	124.20	193.40	273.50	316.70	195.40	82.30	69.10	1836.00
1974	35.60	59.50	47.60	162.30	240.40	217.20	320.30	361.30	380.50	242.40	115.90	23.20	2206.20
1975	TRACE	36.10	337.10	229.10	193.20	287.20	533.90	178.70	274.40	192.60	216.50	12.70	2511.50
1976	0.90	180.20	181.80	171.10	97.30	287.60	204.40	356.80	238.50	401.80	201.30	0.10	2321.80
1977	61.60	55.70	40.80	107.50	204.90	260.00	272.00	358.70	526.60	308.90	11.50	27.30	2235.50
1978	29.30	85.10	178.60	310.10	224.00	375.30	91.80	187.40	456.20	247.20	91.60	14.60	2291.20
1979	0.30	186.90	221.50	255.20	191.00	407.30	295.90	316.50	215.10	120.70	120.70	11.40	2502.30
1980	7.60	27.80	64.00	158.70	360.80	265.40	375.30	281.70	359.30	431.70	212.10	0.50	2544.90
1981	75.50	27.50	140.20	102.10	311.40	272.60	348.50	305.70	337.40	171.40	66.00	0.00	2158.30
1982	30.20	37.90	107.60	147.00	238.30	204.20	431.40	230.00	360.20	143.20	58.30	3.20	1991.50
1983	0.00	TR	33.10	114.20	141.30	183.50	310.90	154.40	324.40	304.70	19.80	45.70	1632.00
1984	0.00	61.60	71.20	170.00	250.90	321.20	255.10	232.80	502.70	143.60	111.40	6.30	2096.80
1985	9.50	8.90	154.80	208.00	296.80	402.50	397.20	344.30	359.00	161.30	51.50	1.80	2395.60
1986	12.50	60.10	97.30	121.40	156.70	168.70	513.90	282.10	401.10	361.50	107.8	0.00	2283.10
1987	0.50	119.50	166.70	90.50	121.40	337.80	308.00	381.10	410.50	213.10	95.40	16.80	2261.30
1988	5.40	4.50	119.90	165.80	274.90	467.40	329.60	307.10	463.90	226.60	34.70	21.10	2420.90
1989	0.00	56.90	77.90	249.10	311.50	284.20	180.70	430.70	341.70	171.90	55.60	0.00	2160.20
1990	21.00	15.40	14.70	122.70	144.00	127.50	446.70	578.10	323.40	148.50	59.10	72.20	2073.30
1991	0.00	80.90	105.00	107.50	432.10	256.50	360.20	310.10	139.10	171.60	111.10	20.30	2094.40
1992	58.70	3.60	178.00	89.90	178.80	170.20	388.50	271.10	260.30	271.50	77.90	13.70	1962.20
1993	0.00	43.00	158.00	247.50	138.50	287.20	438.50	426.30	368.70	266.80	147.00	20.90	2542.40
1994	37.40	66.80	80.90	128.90	372.60	256.30	462.30	314.30	342.00	218.80	93.90	0.00	2374.20
1995	79.60	15.60	118.30	120.10	362.50	286.80	393.60	333.60	319.60	413.10	72.90	53.60	2569.30
1996	TR	130.40	113.90	320.90	363.50	160.50	241.30	229.40	478.00	272.80	22.80	5.90	2339.70
1997	23.30	18.60	96.40	174.50	380.10	353.10	360.00	305.20	207.40	133.20	247.70	29.90	2329.40
1998	22.60	36.90	87.60	188.00	279.10	414.60	369.80	247.30	489.30	265.40	136.70	32.00	2569.30
1999	40.90	52.10	106.60	186.40	291.60	232.90	294.10	257.40	453.50	510.60	73.50	TR	2499.60
2000	11.60	7.20	59.20	190.20	202.30	181.50	420.30	245.40	454.90	153.10	126.30	16.90	2068.90

Source: Meteorological (Archives) services department, Federal Ministry of Aviation, Oshodi, Lagos.