COMPARISON OF SOME PROBABILITY DISTRIBUTION MODEL FOR RAINFALL FREQUENCY ANALYSIS

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CERTIFICATION

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DEDICATION

This work is dedicated to God almighty for giving me the strength through the period of this program.

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My appreciation goes to God almighty, for his provision and grace throughout the period of my project.

My profound gratitude goes to my Supervisor Professor O.C Izinyon for taking out time from his busy schedule to put me through and ensure I was doing the right thing,

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ABSTRACT

Flood frequency analysis is the most important statistical technique in understanding the nature and magnitude of high discharge in a river. The objective of frequency analysis is to relate the magnitude of events to their frequency of occurrence through probability distribution.The various methods used in the estimation of design flood as a criterion for the design and construction of hydraulic structures which in most countries is undermined during the planning of such infrastructure thereby causing significant damages and loss of lifes and properties. Log Pearson type III distribution model and Gumbel probability along side with three plotting position s of Weibull, Gringorten and Cunnane was used. The Gumbel probability distribution and Log Pearson type III distribution values were similar.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF STUDY

In terms of lives lost and property damaged, floods are just behind tornadoes as the top natural disaster. If there is heavy rain fall there is less chance of it being soaked up by the soil (infiltration) so it runs off into the river. The faster the water reaches the river, the more likely it will flood. This will increase the flood risk, as the water will not be intercepted and flow into the river.

A Flood is an overflow of water that submerges land this is typically dry. In the experience of "flowing water", the phrase can also be implemented to the influx of the tide. Floods are a place of look at of the discipline hydrology and are of considerable difficulty in agriculture, civil engineering and public fitness Human adjustments to the environment regularly boom the depth and frequency of flooding, as an instance land use modifications which include deforestation and elimination of wetlands, adjustments in waterway direction or flood controls together with with levees, and large environmental troubles along with weather change and sea degree rise.

Flooding might also additionally arise as an overflow of water from water bodies, which includes a river, lake, or ocean, wherein the water overtops or breaks levees, ensuing in a number of that water escaping its standard boundaries, or it is able to arise because of an accumulation of rainwater on saturated floor in an area flood. While the scale of a lake or different frame of water will range with seasonal modifications in precipitation and snow melt, those adjustments in length are not going to be taken into consideration sizeable except they flood property or drown home animal.

Flood can appear on flat or low-mendacity regions whilst water is provided with the aid of using rainfall or snowmelt greater hastily than it could both infiltrate or run off. The extra accumulates in place, once in a while to unsafe depths. Surface soil can emerge as saturated, which efficiently stops infiltration, wherein the water desk is shallow, together with a flood plain, or from extreme rain from one or a sequence of storms. Infiltration is also gradual to negligible thru frozen ground, rock, concrete, paving, or roofs. Areal flooding starts in flat regions like floodplains and in Floods nearby depressions now no longer related to a circulate channel, due to the fact the speed of overland glide relies upon at the floor slope. Endorheic basins can also additionally revel in areal flooding all through durations while precipitation exceeds evaporation.

Water running downhill into channels and stream begins to ‘pile up’ eventually overrunning the slides of those channel. How quickly this happens depends on the strength of precipitation and the slope of the land. Sometimes flooding causes deep water to move quickly, while other times, shallow water may linger, taking days to dissipate.

Water from flood can take time to build up allowing the population in an area time to be warned in advance. But sometimes flooding occurs quickly.

Heavy downpour are defined as event where the precipitation dropped from the skies is more than the amount that accumulates from the top 1 percent of all rain days over the study period. These burst of precipitation which usually fell as rain but sometimes as snow, the analysis found are tough on infrastructure and can cause flooding.

Why do flood happen? The first factor in flood occurrence is the local source of water. Excessive rainfall, a damaged dam, or snow melting too quickly are all events that can result to floods. The movement of excess water can overwhelm local bodies of water, and spread inland towards floodplains or coastlines.

Examples of types of flood are:

River

Floods arise in all sorts of river and circulate channels, from the smallest ephemeral streams in humid zones to normally-dry channels in arid climates to the world's biggest rivers. When overland waft takes place on tilled fields, it could bring about a muddy flood in which sediments are picked up through run off and carried as suspended rely or mattress load. Localized flooding can be triggered or exacerbated through drainage obstructions inclusive of landslides, ice, debris, or beaver dams.

Slow-growing floods maximum usually arise in huge rivers with huge catchment regions. The boom in float can be the end result of sustained rainfall, fast snow melt, monsoons, or tropical cyclones. However, big rivers might also additionally have speedy flooding occasions in regions with dry climate, considering the fact that they'll have big basins however small river channels and rainfall may be very excessive in smaller regions of these basins.

Rapid flooding activities, together with flash floods, greater regularly arise on smaller rivers, rivers with steep valleys, rivers that go with the drift for an awful lot in their duration over impermeable terrain, or normally-dry channels. The motive can be localized convective precipitation (severe thunderstorms) or unexpected launch from an upstream impoundment created at the back of a dam, landslide, or glacier.

Urban Flooding

Urban flooding is the inundation of land or belongings in a constructed environment, specifically in greater densely populated regions, resulting from rainfall overwhelming the ability of drainage systems, including typhoon sewers. Although from time to time prompted through occasions consisting of flash flooding or snowmelt, city flooding is a condition, characterized through its repetitive and systemic influences on groups, that could occur irrespective of whether or not or now no longer affected groups are positioned inside distinctive floodplains or close to any frame of water. Aside from ability overflow of rivers and lakes, snowmelt, typhoon water or water launched from broken water mains might also additionally collect on assets and in public rights-of-way, seep thru constructing partitions and floors, or backup into homes thru sewer pipes, lavatories and sinks.

In city regions, flood outcomes may be exacerbated with the aid of using present paved streets and roads, which boom the rate of flowing water. Impervious surfaces save you rainfall from infiltrating into the ground, thereby inflicting a better floor run-off that can be in extra of nearby drainage ability.

The flood go with the drift in urbanized regions constitutes a chance to each the populace and infrastructure. Some current catastrophes consist of the inundations of Nîmes (France) in 1998 and Vaison-la-Romaine (France) in 1992, the flooding of New Orleans (USA) in 2005, and the flooding in Rockhampton, Bundaberg, Brisbane at some point of the 2010–2011 summer time season in Queensland (Australia). Flood flows in city environments had been studied pretty currently regardless of many centuries of flood occasions. Some latest studies has taken into consideration the standards for secure evacuation of people in flooded regions

1.2 STATEMENT OF THE PROBLEM

The amount, location, and timing of water attaining a drainage channel from herbal precipitation and managed or out of control reservoir releases determines the glide at downstream locations. Some precipitation evaporates, a few slowly percolates thru soil, a few can be quickly sequestered as snow or ice, and a few might also additionally produce speedy runoff from surfaces along with rock, pavement, roofs, and saturated or frozen floor. The fraction of incident precipitation directly accomplishing a drainage channel has been found from nil for mild rain on dry, degree floor to as excessive as one hundred seventy percentage for hot rain on accrued snow.

Most precipitation information are primarily based totally on a measured intensity of water acquired inside a hard and fast time c program languageperiod. Frequency of a precipitation threshold of hobby can be decided from the quantity of measurements exceeding that threshold price in the general term for which observations are available. Individual facts factors are transformed to depth with the aid of using dividing every measured intensity with the aid of using the time frame among observations. This depth might be much less than the real height depth if the length of the rainfall occasion changed into much less than the constant time c language for which measurements are reported. Convective precipitation occasions (thunderstorms) generally tend to supply shorter period hurricane occasions than orographic precipitation. Duration, depth, and frequency of rainfall activities are critical to flood prediction. Short period precipitation is greater great to flooding inside small drainage basins.

1.3 AIMS AND OBJECTIVE

The aim of this study is to evaluate the risk of existing development in flood hazard areas and identify actions to reduce risks to life and property with the use of rainfall frequency analysis as a statistical method

The objectives are:

(a) The fundamental objective of every frequency analysis is to determine the exceedance probability distribution function of rainfall intensity for every single rainfall duration. Intensity-duration- frequency) curves from Gumbel Distribution, Log-Normal Distribution, and Log Pearson type III distribution.

(b) To make adequate comparison of some probability distribution method.

(c) To compare the expected flood discharge magnitude of the probability distribution for future use in the design of hydraulic structures such as drainage, culvet, dams e.t.c.

(d) The objective of a rainfall-frequency analysis is to determine how often a particular area can consequences expect a flood of a certain size.

1.4 SCOPE OF STUDY

This work will consider the acquisition of hydrological flood data necessary for carrying out design flood estimation process. Determination of flood probability using various distribution models such as Gumbel Distribution, Log-Normal Distribution, and Log Pearson type III distribution will be considered.

1.5 SIGNIFICANCE OF STUDY

To minimize the future flood damages the river should be linked with land surrounding it, recharge ground water system, fill wetlands, increase the connectivity between aquatic habitats, and move sediments and nutrients around the landscape, and into marine environment. For many species, floods, e.t.c.

CHAPTER TWO

LITERATURE REVIEW

2.1 FLOOD

Various nations around the arena have suffered devastating flood issues from heavy rainfall whilst watercourse along with culverts, dams and many others do now no longer have the potential to bring extra water, as such, the breakdown or failure of the shape results in an overflow of water to close by areas.

The harm as a result of floods is growing via way of means of the year because of non-stop improvement and urbanization in those regions. Excessive rainfall takes place to be one of the foremost reasons for flooding in advanced regions and countries.

Flooding is arguably the weather-related hazard that is most widespread around the globe. It can occur virtually anywhere. A flood is defined as water overflowing onto land that usually is dry. Flooding is often thought of as a result of heavy rainfall, but floods can arise in several ways that are not directly related to ongoing weather events. Nevertheless, it is clear that in some ultimate sense, the water that is involved in flooding has fallen as precipitation at some time, perhaps long ago. The origins of flooding, therefore, ultimately lie in atmospheric processes creating precipitation, no matter what specific event causes the flooding.

Floods produce damage through the immense power of moving water and the deposition of dirt and debris when floodwaters finally recede. People who have not experienced a flood may have little or no appreciation for the dangers of moving water. The energy of that moving water goes up as the square of its speed; when the speed doubles, the energy associated with it increases by a factor of four. Flooding is typically coupled to water moving faster than normal, in part because of the weight of an increased amount of water upstream, leading to an increase in the pressure gradient that drives the flow. In most cases, the damage potential of the flood is magnified by the debris that the waters carry: trees, vehicles, boulders, buildings, etc. When the waters move fast enough, they can sweep away all before them, leaving behind scenes of terrible destruction.

The impact of the water itself may be devastating on systems and at the items inside them: books, furniture, photographs, digital equipment, and so forth may be broken truly through being immersed in water, even though they may be now no longer at once broken through the water movement. Moreover, floodwaters typically contain suspended silt and potentially toxic microorganisms and dissolved chemicals. This way floods normally compromise consuming water supplies, causing short-time period shortages of potable water, with the extra long-time period expenses in restoring consuming water carrier to the citizens of a flooded area. The dust and particles left in the back of whilst floodwaters recede may be highly-priced to ease up and additionally constitute a fitness hazard, particularly while there are decomposing bodies of drowned wild and home animals withinside the particles. In some situations, floods drive wild animals (including invertebrates of all sorts) from their normal habitats and into human habitations near and within the flooded areas, which can create various problems, especially when the animals are venomous or aggressive.

Numerous problems, particularly whilst the animals are venomous or aggressive. Although flooding has a few huge terrible results on human beings, it's also a part of the herbal tactics shaping the Earth. Floodplains alongside rivers and streams are the various maximum fertile areas known. Most of the so-called ‘cradles of civilization’ are inside floodplains for this very reason (e.g., the Nile River, the Tigris–Euphrates River, amongst others. Hence, people were laid low with flooding each definitely and negatively given that earlier than ancient times, on every occasion they locate themselves withinside the course of those herbal events.

Floods can arise in flat or low-mendacity regions while the water is furnished through rainfall or snowmelt extra swiftly than it could both infiltrate or runoff. The extra accumulates in place, once in a while to dangerous depth. Surface soil can grow to be saturated, wherein the desk water is shallow, which includes floodplains.

Flood impacts community and have social-economic and environmental consequences. The consequences of floods, both negative and positive vary greatly depending on their location, duration depth, and speed, as well as the vulnerability and value of the affected environments.

2.2 FLOOD AS A DIRECT RESULT OF PRECIPITATION

When the water of a flood arises directly from precipitation, atmospheric processes can be identified as directly responsible for the event. That is, rainfalls occur that are well beyond the average values for the affected area. It is only when those rainfalls above the average value that land which is usually dry can be affected; that is, a flood occurs. Thus, the rainfall amounts needed for floods cannot be defined in absolute terms. A precipitation event that causes a flood in one location might be well within the bounds of what is typical for another location. Generally speaking, the threshold for flood-producing rainfalls increases as the annual average rainfall for a region increase.

2.3. FLOOD AS A DIRECT RESULT OF NON PRECIPITATION

Apart from floods resulting directly from rainfall, there are many ways in which precipitation can cause floods, perhaps long after it has fallen. When flowing water is impounded by the construction of dams, there is some risk that the dams will fail.

A flood can also arise through the melting of snowfall. In situations where the preceding winter’s snowpack is deep, a sudden change to warm temperatures in the spring can result in abnormally rapid melting and runoff of the snowmelt.

During the winter and late spring, when ice can build up on rivers in cold climates, the breakup of the ice can create ice dams on the river. The ice dams cause the waters to back up, sometimes flooding the land upstream of the ice dam. Then, the breakup of the ice dam can result in a flash flood wave that surges downstream of the ice dam’s position.

Other flood situations can develop along the shores of the world’s oceans and even with large freshwater lakes. Tsunamis, typically caused by underwater earthquakes and landslides, can flood the shorelines with huge waves that break on the shallow waters near the shore. Storms of all sorts, including tropical cyclones, can drive the waters before the winds into storm surges that inundate shore areas when the storms are near the land. Large lakes can experience flooding on their shores due to seiches, which are surges of water (usually oscillatory) within enclosed bodies of water. Seiches can be caused by earthquakes or by atmospheric processes.

2.4 TYPES OF FLOOD

2.4.1 OVER BANK FLOODING

What most people think of when they hear the word "flood." Filled largely because of heavy rain or melting snow, the water within a river overflows its banks and spreads across the land around it. Sometimes the area covered is wide and flat; water tends to spread out and be slow-moving, and may not appear to travel at all. Common in the Midwest, this kind of flooding can take days to dissipate. In mountainous areas, where water flows together through steep valleys, the flood water tends to move faster and linger for a shorter duration.

Fig 4.1 An example of an over bank flooding

2.4.2 RIVERINE FLOODING

Floods arise in all styles of river and circulate channels, from the smallest ephemeral streams in humid zones to generally dry channels in arid climates to the world's biggest rivers. When overland float happens on tilled fields, it may bring about muddy flood sediments are picked up with the aid of using runoff and carried as suspended count or mattress load. Localized flooding can be prompted or exacerbated via way of means of drainage obstructions together with landslides, ice, debris, or beaver dams.

Slow-growing floods maximum usually arise in huge rivers with big catchment regions. The growth in waft can be the end result of sustained rainfall, speedy snowmelt, monsoons, or tropical cyclones. However, huge rivers may also have speedy flooding activities in regions with dry climates, due to the fact they'll have big basins however small river channels and rainfall may be very excessive in smaller regions of these basins.

Rapid flooding occasions, inclusive of flash floods, extra frequently arise on smaller rivers, rivers with steep valleys, rivers that waft for a lot in their period over impermeable terrain, or typically dry channels. The reason can be localized convective precipitation (severe thunderstorms) or surprising launch from an upstream impoundment created in the back of a dam, landslide, or glacier.

Fig 4.2 An example of a riverine flooding

2.4.3 URBAN FLOODING: Local heavy rains over a city and large towns may lead to damaging and disruptive flooding due to poor or inadequate stormunter drainage system and rapid runoff.

Fig 4.3 An example of an urban flooding

4.4 COASTAL FLOODING.

This type of flooding occurs along the edges of oceans and is driven predominantly by storm surges and wave damage. This kind of flooding is usually connected to hurricanes, tsunamis, or tropical storms. When low pressures occur in a storm over the ocean, they suck the water toward the center. As long as the eye is over deep water, problems are minimized, but as the storm moves toward land it carries a dome of water that can exceed 25 feet (7.6 meters) in diameter. When the dome reaches the shoreline, it can cause significant damage. At the same time, waves breaking along the shoreline assault beaches and structures, with destructive potential. In a hurricane, 9 out of 10 deaths are caused not by wind but by fast-moving storm surge.

Fig 4.4 An example of a coastal flooding

2.4.5. ICE JAM FLOODING

In cold temperatures, bodies of water are often frozen. Heavy precipitation can cause chunks of ice to push together and create a dam in what is known as ice jam flooding. Behind the dam, water begins to pile up, spilling over to the plains nearby. Eventually, the wall of ice breaks, and fast-moving water rushes downstream much like a conventional flash flood, destroying objects in its path. The water carries huge chunks of ice, which can increase damage to surrounding structures.

2.4.6 TIDAL FLOODING

Both sea and river defences may be overtopped by the combination of low pressure weather systems and peak tides. Storms with high wind speeds causes tall and powerful waves and low pressure fronts cause sea levels to rise above normal levels. High tides vary through the lunar and solar cycle and when superimposed upon other tidal variations exceptionally high tides result.

It is often possible to forecast with reasonable accuracy this type of flooding due to the predictability of the tide and trackability of low pressure systems. The duration of this type of flooding is also limited by the circle of the tides where drainage is available

2.4.7 DAM BREAKS FLOODING

Dam failure can occur as a result of structural failures such as progressive erosion of an embankment or over topping and breaching by a severe flood. Earthquakes may weaken dams. Flood caused by dams failure have caused great loss of life and properties.

Fig 2.5 An example of recent flood in Bayelsa road caused by dam break

Fig 2.6 An example of recent flood in Oleh, also caused by dam breaks.

2.5 EFFECT OF HUMAN ACTIVITIES ON FLOODING.

In addition to the risks to lives and property that people take by moving into flood-prone areas, development for human use often involves clearing the land of its native vegetation and altering the characteristics of the ground cover. Vegetation works together with the soil to store rainfall, so when that vegetation is cleared, rainfall-runoff can increase substantially. Rather than being absorbed by the soil and its natural vegetation, in areas where that vegetation has been cleared (either for construction or for agriculture), heavy rainfall is more likely to run off and pour into streams and rivers, increasing the potential threat from flash floods and river floods. Construction of roads and buildings also acts to increase runoff and leads to an increased likelihood of localized urban flooding. Such construction dramatically increases the fraction of the rainfall that runs off, regardless of antecedent rainfall. Human-caused fires can also produce at least temporary increases in the runoff potential in the headwater regions of streams and rivers. Human activities are increasing the potential for floods around the world.

2.6 GROUNDWATER

Lying areas sitting over aquifers may periodically flood as ground water level rises. This type of flooding is often seasonal and therefore can be forecasted with good accuracy. It is often slow in its onset.

2.7 SURFACE WATER RUNOFF

Surface runoff is water, from rain, snowmelt, or different sources, that flows over the land surface, and is a chief factor of the water cycle.

Runoff that happens on surfaces earlier than achieving a channel is likewise referred to as overland flow.

A land place which produces runoff draining to a not unusual place factor is referred to as a watershed.

When runoff flows alongside the ground, it is able to select out up soil contaminants inclusive of petroleum, pesticides, or fertilizers that end up discharge or overland flow.

Urbanization increases surface runoff, by creating more impervious surfaces such as pavement and buildings do not allow percolation of the water down through the soil to the aquifer.

It is instead forced directly into streams, where erosion and siltation can be major problems, even when flooding is not.

2.7.1 GENERATION OF SURFACE RUNOFF

Surface runoff may be generated both through rainfall, snow fall or through the melting of snow, or glaciers.

Snow and glacier soften arise best in regions bloodless sufficient for those to shape permanently. Typically snowmelt will top within side the spring and glacier soften within side the summer, main to stated float maxima in rivers suffering from them. The figuring out thing of the charge of melting of snow or glaciers is each air temperature and the period of sunlight. In excessive mountain regions, streams often upward push on sunny days and fall on cloudy ones for this reason.

In areas where there is no snow, runoff will come from rainfall. However, not all rainfall will produce runoff because storage from soils can absorb light showers. On the extremely ancient soils of Australia and Southern Africa, proteoid roots with their extremely dense networks of root hairs can absorb so much rainwater as to prevent runoff even when substantial amounts of rain fall. In these regions, even on less infertile cracking clay soils, high amounts of rainfall and potential evaporation are needed to generate any surface runoff, leading to specialised adaptations to extremely variable (usually ephemeral) streams.

2.8 SOCIALTAL IMPACTS AND THEIR MITIGATION

The consequences of floods on society are substantial. Flooding is chargeable for many drowning fatalities in tropical cyclones, both from hurricane surges or from freshwater rain-precipitated flash floods. Flash floods and river floods normally produce greater fatalities each year than both tornadoes or hurricanes within-side the USA. In many components of the world, flood fatalities are related to the maximum sizeable weather-associated disasters.

Flood harm value within-side the USA is now at the order of numerous billion bucks annually, and this determine keeps to rise

Many humans now stay and play in flood-susceptible regions: for example, inside floodplains of rivers and their tributaries, in addition to alongside coastlines which might be susceptible to hurricane-brought about flooding from tsunamis, tropical cyclones, and nontropical storms. Development of flood-susceptible regions for habitation and recreation has been increasing, with a corresponding boom within side the dangers to lifestyles and property. The 1993 Upper Mississippi and Lower Missouri River floods supplied a grim reminder of the dangers of constructing everlasting systems inside floodplains, even if flood-manage measures were taken.

Forecasting the details of flooding events is an important part of mitigation. Knowing precisely when and where a flood will occur would no doubt be helpful, but it is also

important to be able to anticipate.

An instance of that is the tragedy of the 1997 Grand Forks, North Dakota case, wherein the river degree changed into just a few ft better than that forecast. Those few ft, however, had a big impact, due to the fact the flood-manage operations had been primarily based totally at the decrease forecast value. When the river rose above that degree, the flood-manipulate measures failed catastrophically. In reality, the sort of forecast can in no way be a unique statement; uncertainty is implicitly part of each forecast, a factor that possibly wishes extra emphasis withinside the future.

Flooding, via way of means of its very nature, is mostly a end result of each meteorological and hydrologic processes; the individual of a flood is decided each with the aid of using the designated conduct of the precipitation and with the aid of using the character of state of affairs wherein the occasion is probably to occur (soil conditions, quantity of antecedent rainfall, and so on). It isn't always in all likelihood that exactly distinctive forecasts of flooding activities will ever be possible, even though it is virtually nicely inside our functionality to count on the opportunity of maximum flood occasions. The undertaking for lowering the social affects of floods is how fine to utilize the unsure meteorological and hydro- logical forecasts which can be inside realistic means. The project is to make powerful use of anything fore- casting functionality we have, at the same time as we are trying to find to enhance that functionality.

Floods have many associated problems such as inundating property, endargering human lives prolonged high floods causes dismatum to traffic and cause inconvenience and human suffering.It interfers with efficient drainage system and economic use of lands for agricultural and industrial purposes. Floods causes damages to drainage channels, bridges and fewer outfalls and other structures.

2.9 FACTORS THAT CONTRIBUTE TO FLOOD

Rainfall is the most important factor in creating a flood, but there are many other contributing factors. When rain falls on a catchment, the amount of rainwater that reaches the waterways depends on the characteristics of the catchment, particularly its size, shape and land use. Some rainfall is 'captured' by soil and vegetation, and the remainder enters waterways as flow. River characteristics such as size and shape, the vegetation in and around the river, and the presence of structures in and adjacent to the waterway all affect the level of water in the waterway.

2.10 DESIGN FLOOD

Defining the design flood

The Design Flood for a hydraulic structure may also be defined in a number of ways, like:

- The maximum flood that any structure can safely pass.
- The flood is considered for the design of a structure corresponding to maximum tolerable risk.
- The flood which a project (involving a hydraulic structure) can sustain without any substantial damage, either to the objects which it protects or to its own structures.
- The largest flood that may be selected for design as safety evaluation of a structure.

Design Flood is also known as the Inflow Design Flood (IDF). It is the flood adopted for design purposes, and could be:

- The entire flood hydrograph, that is, the possible values of the discharge as a function of time.
- The peak discharge of the flood hydrograph

2.10.1 CHOICE OF DESIGN FLOOD.

The Bureau of Indian standard guidelines IS: 5477 (Part IV) recommends that the Inflow Design Flood (IDF) of a structure, depending on its importance or risk involved, may be chosen from either one of the following:

- Probable Maximum Flood (PMF):

This is the flood resulting from the most severe combination of critical meteorological and hydrological conditions that are reasonably possible in the region. The PMF is computed by using the Probable Maximum Storm (PMS) which is an estimate of the physical upper limit to storm rainfall over the catchment. This is obtained from the studies of all the storms that have occurred over the region and maximizing them for the most critical atmospheric conditions.

- Standard Project Flood (SPF):

This is the flood resulting from the most severe combination of meteorological and hydrological conditions considered reasonably characteristic of the region. The SPF is computed from the Standard Project Storm (SPS) over the watershed considered and may be taken as the largest storm observed in the region of the watershed. It is not maximized for the most critical atmospheric conditions but it may be transposed from an adjacent region to the watershed under consideration.

- Flood of a specific return period:

This flood is estimated by frequency analysis of the annual flood values of adequate length. Sometimes when the flood data is inadequate, frequency analysis recorded storm data is made, and the some of a particular frequency is applied to the unit hydrograph to derive the design flood. This flood usually has a return period greater than the storm.

2.11 FREQUENCY ANALYSIS

Frequency Analysis is part of descriptive information. In facts, frequency is the variety of instances an occasion occurs. Frequency Analysis is a crucial location of data that offers with the quantity of occurrences (frequency) and analyzes measures of significant tendency, dispersion, percentiles, etc.

Frequency Analysis typically offers with 3 kinds of measures

Measures of Central Tendency It is an unmarried degree that attempts to explain the set of facts via a price that represents the critical role inside that information set. Most famous measures of vital tendency used for frequency evaluation are Mean, Median and Mode. While the suggest is the common cost of the information set, the median is the center commentary (commentary which has an same variety of values mendacity above and beneath it) withinside the records set. Mode is the price that happens the maximum wide variety of instances in a statistics set.

While Mean has been calculated by mathematicians and astrologers since ages, Median was first introduced by Edward Wright in his book on navigation in 1599; and Mode originated in 1895 by Karl Pearson's efforts.

Measures of Dispersion These mirror the unfold or variability of records inside a information set. Most famous measures of dispersion used for frequency evaluation are Standard Deviation, Variance and Range. While Standard Deviation have been round for a long term and were utilized by others with exceptional names (like 'imply error' through Gauss); Karl Pearson first used the time period Standard Deviation in 1894. Variance became first utilized by Ronald Fisher in 1918.

Percentile Values A percentile price suggests what percentage of values in a records set fall under a sure percentage. Frequency Analysis typically makes use of percentile values like Quartiles, Deciles, Percentiles, etc. While the tenth percentile price indicates that 10% of the observations fall under it in a information set, it's also referred to as the first Decile (in which the statistics set is split into 10 Deciles at periods of 10% each). Similarly the 25th, fiftieth and seventy fifth percentiles also are referred to as the first, 2d and third Quartile respectively (wherein the records set is split into four Quartiles at durations of 25% each).

The design of Water resources system is carried out such that it can withstand extreme events such as extreme rainfall events , extreme floods and droughts. Thus in hydrologic design , the magnitude an extreme hydrologic event must be determined for a certain frequency of occurrence . The aim of conducting frequency analysis is to establish a relationship between the magnitude of variable and its frequency of occurrence(Srivastava and Jain, 2017). The frequency of occurrence is normally expressed using return period which is also called Recurrence interval . Return period or recurrence interval is the average time interval during which the magnitude of a hydrologic variable will be equalled or exceeded. Return period is expressed in years and it is the reciprocal of exceedance probability.

$T = \frac{1}{P} = P\ (X > x)$ where T is the recurrence interval in years and p is the exceedance probability. Observed hydrologic data is required in carrying out frequency analysis. In carrying out frequency analysis, the data to be used is assumed to be independent of each other as the case with annual series data and to follow the same probability distribution or in other words identically distributed. In addition, the hydrologic variable is assumed to be stochastic in nature and spatially and temporally uncorrelated though such assumptions may not occur in real life situation.

Frequency analysis is an analytical technique that involves the estimation of how often a specified event will occur. The analysis involves using observed annual series data to calculate statistical information such as mean values, standard deviation, skewness and recurrence interval . Reliable flood frequency estimates are vital for flood plain management , to protection of public infrastructure, minimize flood related cost to government and private enterprises, for designing and locating hydraulic structures and assessing hazards related to the development of flood plains and epidemic control.

Theoretical frequency distributions are most commonly applied to extreme time series , either of rainfall, floods or droughts. The objective of flood frequency analysis is to assess the magnitude of a flood of given probability of return period of occurrence. A return period is an estimate of the probability of an event, such as storm. earthquake, flood or river discharge glide to occur. It is a statistical size generally primarily based totally on anciental data which denotes the common recurrence c program languageperiod over an prolonged time frame and is typically used for danger analysis.

Return period is the reciprocal of probability and may also be defined as the average interval between floods of a specified magnitude. A large number of different or related flood frequency distributions have been devised for extreme value analysis.

Rainfall frequency analysis involves fitting of probability model to a set of annual rainfall peaks for a catchment from which future prediction of extreme events can be determined. After procuring the required data, the conventional procedure for the analysis involve determining the right probability distribution for modelling the data , parameter estimation of the distribution and calculating the goodness of fit of the said model . Accordingly, the desired model can be used for estimating future extreme events after validation for desired return period. There are many probability distribution models that is used in frequency analysis; common ones are : Normal ,Log Normal , Gumbel (or Extreme value type 1) Log Pearson type III

Rainfall frequency estimation techniques using these methods may not be free from errors and problems. These problems may be due to short data length , corrupted data, oversimplified assumptions. Probability distribution models may be wrongly selected which can lead to uncertainty and inaccuracy in the results obtained thereby can affect the design flood and hence the design of the hydraulic structure. Therefore it is important that an appropriate and right model is fitted to the observed data to achieve results with minimum errors.

2.11.1 FREQUENCY FACTORS

Frequency or probability distribution is helpful in relating the magnitude of extreme hydrological events such as floods, droughts and heavy rainfall along with number of occurrences such that their chances of occurrence with time can be predicted (Singh *et al.,* 2012) . The Chow (1951) general frequency formula was used in obtaining observed rainfall statistically. The formula used for the evaluation of frequency of occurrence may be expressed in terms of frequency factor as follows:

$$X_T = \overline{X} + K_T\sigma \qquad (1)$$

where X_T is the rainfall magnitude which corresponds to the return period (T) , K_T the frequency factor, $\overline{X}$ is the mean of all rainfall values in the annual series. σ is the standard deviation, T is the return period. Equation (1) is the frequency factor equation utilized in computing the expected value of rainfall with return period of T years. The frequency factor K_T is dependent on the return period T and the frequency distribution model assumed and K_T can be computed by LN distribution, Log Normal distribution, Log Pearson type III distribution and Extreme Value type I distributions.

2.11.2 FITTING PROBABLITY DISTRIBUTION MODELS

The probability distribution namely: Log Normal, Log Pearson type III and Gumbel (Extreme Value type type I (EV-1) were used to determine the best fit probability distribution for rainfall.

2.11.3 FREQUENCY FACTOR METHOD

The determination of the magnitude of a hydrologic variable for a given return period T (X_T) requires the probability distribution to be invertible. For such probability distributions , the frequency factor method can be for any probability distribution. For such probability distributions, the frequency factor method is used. However, in general the frequency factor method is used. However, in general the frequency factor method can be used for any probability distribution .

For the frequency factor method , the magnitude (X_T) is expressed in the form (Chow, 1951):

$X_T = \mu + K_T \sigma$ (1)

Equation (1) is for the population and for a sample of finite size , sample estimates of population mean and standard deviation can be used as follows:

$X_T = \overline{X} + K_T S$ (2)

where X_T is magnitude of the hydrologic variable corresponding to a return period of T- years, $\overline{X}$ is the sample mean , S is the sample standard deviation and K_T is the frequency factor. The frequency factor is dependent on the return period and the type of the probability distribution used in the frequency analysis.

For probability distributions used in hydrology which involves logarithm; such as log Normal and log Pearson type III , the frequency factor method is applied to log transformed data y = log (x) . In those situations, the general frequency equation is given as :

$\boldsymbol{y_T = \overline{y} + K_T S_y}$ (3)

where, $\boldsymbol{y_T}$ is the value of the log-transformed hydrologic variable corresponding to a return period of T -years, $\boldsymbol{\overline{y}}$ is the sample mean of log transformed series, $\boldsymbol{S_y}$ is the standard deviation of the log transformed series and $\boldsymbol{K_T}$ is the frequency factor. The value of $\boldsymbol{X_T}$ which is required to be determined is estimated by taking the antilog of $\boldsymbol{y_T}$.

The values of the frequency factor ($\boldsymbol{K_T}$) for different return periods are published as standard statistical tables for different probability distributions. The procedure for computation of $\boldsymbol{x_T}$ by frequency factor involves three steps as follows (Srivastava and Jain, 2017):

(i) Computation of the statistical parameters of the concerned distribution using sample data.

(ii) Obtain the frequency factor $\boldsymbol{K_T}$ from standard table for the given distribution and

(iii) Compute the value of $\boldsymbol{x_T}$ using equation (1) or (2) as the case may be

1) EXTREME VALUE TYPE 1 Distribution OR GUMBEL

Extreme values are selected maximum or minimum values of sets of data. For example, the annual maximum discharge at a given location is the largest recorded discharge value during a year, and the annual maximum discharge values for each year of historical record make up a set of extreme values that can be analyzed statistically.

Chow (1951) has shown that most frequency distribution functions applicable in hydrological studies can be expressed in the form of :

$$\boldsymbol{X_T = \bar{X} + KS_x}$$

where $\boldsymbol{X_T}$ is the value of variate X of a random hydrologic series with a return period T, $\boldsymbol{\bar{X}}$ is the mean of the variate , $\boldsymbol{S_x}$ is the standard deviation of the variate , $\boldsymbol{K}$ is the frequency factor which depends on the return period T and the assumed frequency distribution.

Extreme value type 1 or Gumbel distribution is the most commonly used for analysing flood data. It is one of the most widely used for extreme values in hydrological and meteorological studies for prediction of flood peaks, maximum rainfall, maximum wind speed etc (Onem *et al.,* 2017 , Bhat *et al.,* 2019).

For EV1 or Gumbel distribution, the expression of frequency factor is derived by Chow (1953):

$$\boldsymbol{K_T = -\ \frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left[ln\left(\frac{T}{T-1}\right)\right]\right\}}$$

2) LOG PEARSON TYPE III PROBABILITY DISTRIBUTION

This is one of the probability distributions developed by Karl Pearson. It is utilized by US Water Resources Council for hydrological analysis by federal agencies. (Farooq et al., 2018). In the LPIII distribution, the variates are converted into logarithmic form and the transformed variates are analyzed .

If X represents the variate of the sample, then the transformed variate is represented by Z expressed as :

$$\boldsymbol{Z = \log X}$$

For this Z series, the expected variate for any return period is given by :

$$\boldsymbol{Z_T = \overline{Z}\ +\ K_T\,\sigma_Z}$$

where $\boldsymbol{K_Z}$ is frequency factor which is a function of T and $\boldsymbol{C_S}$ (Coefficient of skew of Z)

$\boldsymbol{\sigma_Z}$ is the standard deviation of the Z variates series.

$$\boldsymbol{\sigma_Z = \sqrt{\frac{\sum(Z-\overline{Z})^2}{(N-1)}}}$$

$$\boldsymbol{C_S = \frac{N\sum\left(Z-\bar{\bar{\bar{Z}}}\right)^2}{(N-1)(N-2)(\sigma_Z)^3}}$$

where $\boldsymbol{\overline{Z}}$ is the mean of Z values

$\boldsymbol{N}$ is the sample size.

After computing the value of Z_T, the value of X_T is obtained from the relation given by :

X_T = antilog (Z_T)

2.11.5 APPLICATION OF LOG PEARSON DISTRIBUTION

If log X follows a Pearson Type III distribution, then X is said to follow a log-Pearson Type III distribution. This distribution is the standard distribution for frequency analysis of annual maximum floods in the United States (Benson, 1968). As a special case, when log X is symmetric about its mean, the log-Pearson Type III distribution reduces to the lognormal distribution.

The location of the bound in the log-Pearson Type III distribution depends on the skewness of the data.

For the Log Pearson distribution, the values of the variate X_T for different return periods may be determined by means of the relationship given by :

$\log X_T = \overline{\log X} + k\sigma_{\log X}$ (3)

From where X_T is obtained as the antilog of $\log X_T$.

$\overline{\log X}$ is the mean of the logarithm values of observed rainfall values and $\sigma_{\log X}$ is the standard deviation of the logarithm of the observed rainfall values and K is the frequency factor.

Log Pearson PDF is used extensively in frequency analysis and for precipitation analysis following procedure is utilized (Zekai Sen ,-----) :

(i) The logarithm of the annual rainfall series is calculated using the relation :

$Y_i = \log R_i$

(ii) The arithmetic average and standard deviation $\sigma_{\log R}$ and coefficient of skewness is calculated by means of the following relations:

$$\overline{LogR_i} = \frac{1}{n}\sum_{i=1}^{n} \log R_i$$

$$\sigma_{\log R} = \left(\frac{\sum (\log R_i - \overline{LogR_i})^2}{n-1}\right)^{0.5}$$ and

$$Cs = \frac{n\sum_{i=1}^{n}\left((\log R_i - \overline{LogR_i})^3\right)^3}{(n-1)(n-2)(\sigma_{\log R})^3}$$

The design rainfall for any given recurrence interval , T may be estimated as:

$\log (R_T) = \overline{LogR_i} + K\,\sigma_{\log R}$

The frequency factor can obtained from table 6.8 {Page 270 [(Sen)]

$$\sigma = \left(\frac{\sum [X_i - \bar{X}]^2}{N-1}\right)^{1/2}$$

The probability distribution namely : Log Normal , Log Pearson type III and Extreme Value type I or gumbel (EV-1) were used to determine the best fit probability distribution for rainfall .

3) Log -Normal Distribution

If the random variable $Y = \log X$ is normally distributed, then X is said to be lognormally distributed.

For the log Normal distribution, the normal values were transformed into logarithmic form that is $Y = \ln X$, where Y is normally distributed (the value of the variate X is replaced by its natural logarithm). In this study, Y is the values of rainfalls and T is the return period (time) in years

$X_T = \overline{X} + K_T\sigma$ where $\overline{X}$ is the mean values and K is the frequency factor and σ is the standard deviation which is computed using the equation:

$$\sigma = \left(\frac{\sum [X_i - \overline{X}]^2}{N-1}\right)^{1/2} \qquad (2)$$

N is the sample size. The value of K is determined on the basis of the coefficient of skewness being zero.

2.11.6 GOODNESS OF FIT (GOF) TESTS

Goodness of fit test determine whether a particular probability distribution fit the observed data. This is a statistical algorithm that may be used to check the distance between the observed data and predicted data. Goodness of fit tests is widely used in flood frequency analysis to compare different probability distribution models and to determine the best model for the given data set

One of the best methods of selecting the best distribution and fitting values is Residual sum squares (RSS) for each distribution. R.S.S is computed by use of the equation:

$$R.S.S. = \sqrt{\frac{\sum (Q_e - Q_O)^2}{(n-m)}}$$

where Q_e is the predicted value for each data.

Q_O is the observed value for each data , n is the number of data and m is the number of distribution parameters. which is 2 for Normal and EV1 distributions and 3 for LPIII. The distribution with the lowest value of RSS is considered the best and used/ selected for prediction purposes.

CHAPTER THREE

3.0 METHODOLOGY

The frequency analysis was conducted using probability distribution of Log-Pearson and Gumbel to model flood data of past records and plotting position equation of Weibull, Cunnane ang Gringorten was also applied to for the distributions.

3.1 Study area

The rainfall data used for this work was collected at Warri, Benin City and Calabar.

3.2 Data Collection

The annual maximum series rainfall data for Warri, Benin City and Calabar that was obtained by the project supervisor whereby the larger rainfall data for Warri, Benin, Calabar for each year was selected to form an annual series below

Table 3.1 Annual rainfall Data for Warri, Benin city and Calabar (1964-2013)

YEAR	WARRI	BENIN	CALABAR
1964	86.1	73.4	112.8
1965	124.5	94.2	127.5
1966	159.3	82.3	91.4
1967	125.2	66.8	
1968	136.7		172
1969	128.5	63	92.5
1970	141.7	149.3	83.3
1971	135.1	92.2	192.5
1972	112.8	73.1	77.2
1973	78.2	87.1	95.3
1974	134.4	96.5	120.4
1975	81.6	94.7	117.6
1976	100.1		97.5
1977	61.4	76.5	106.7
1978	105.2	99.9	216
1979	95.2	83.1	126.6
1980	116.7	83.3	171.3
1981	93.1	82	123.2
1982	117.4	164.3	111.1
1983	116.7	93.7	126.1
1984	99.2	54.7	78.4
1985	104.2	52	179.8

1986	**182.1**	**59.6**	**122**
1987	**113.2**	**93.1**	**101**
1988	**125**	**88.5**	**118.8**
1989	**123**	**88.4**	**181**
1990	**120.6**	**72.7**	**112.2**
1991	**87.6**	**95.8**	**117.8**
1992	**91.8**	**70.6**	**162.5**
1993	**175.6**	**79.9**	**104.1**
1994	**107.5**	**78.8**	**146.6**
1995	**125.4**	**91.9**	**168.9**
1996	**109.1**	**105.8**	**97.5**
1997	**121**	**97.4**	**173.8**
1998	**92.3**	**87.8**	**175.5**
1999	**98.4**	**66**	**89.5**
2000	**111.5**	**99.1**	**94.8**
2001	**125.5**	**96.9**	**137**
2002	**144.2**	**95.8**	
2003	**138.8**	**60.6**	**66**
2004	**160.3**	**97.3**	**98**
2005	**108.5**	**91.3**	**148.2**
2006	**146**	**96.4**	**101.5**
2007	**144.3**	**74.5**	**98.3**
2008	**97.6**	**86.6**	**123.6**
2009	**66.9**	**84.1**	**122.6**

2010	**126.5**	**118.4**	**128.4**
2011	**133.7**	**117.3**	**126.8**
2012	**113.6**	**70.3**	**132.8**
2013	**99.8**		**140.4**

The plotting position of Weibull, Cunnane and Gringorten, was then applied to the rainfall data to calculate the return period and their exceedance probability. The various plotting position formula and their relationships are shown below.

Table 3.2: Plotting equations formula

Proponent	Formula
Weibull (1939)	$\frac{n+1}{m}$
Cunnane (1977)	$\frac{n+0.20}{m-0.40}$
Gringorten (1963)	$\frac{n+0.12}{m-0.44}$

3.3: The step-by-step procedure used for calculating the position formulae are as follows

i. Select the highest peak flood in the hydrological year.
ii. The highest peak flood in each year is then arranged in descending order of magnitude and ranks were assigned. usually, data occurred more than once are given the rank.
iii. The return period of each of the ordered value and the probability of each event equaled to or exceeded is calculated using the plotting position formula as shown in table 3.2 above. where m is the rank, n is the number of years of the record.
iv. The value obtained is then plotted against the rainfall of each year. Extrapolation is carried out to estimate different flood levels, 2yrs, 5yrs, 10yrs, 20yrs, 25yrs, 100yrs and 200yrs.

3.4 **Summary of the probability models used for the flood frequency analysis**

The observed annual maximum series was fitted using Log-Pearson type III and Gumbel's distribution which gives the correlation between the ordered observations and the corresponding value extrapolated from the plotting position formulae.

3.5 **Gumbel's or Extreme value type 1 distribution (EV1) model**

Gumbel 1941 introduced EVI as a concept of extreme value distribution and as a model for prediction of hydrologic events such as flood peaks. It is basically used for the estimation of floods of higher recurrence interval and probability.

The procedures used in estimating the expected rainfall analysis for the various return periods is given as follows;

i. The annual maximum rainfall data for was assembled from 1964 to 2013(50 years in Warri), 1964 to 2012(47 years) in Benin city and 1964 to 2013(48 years) in Calabar and arranged in descending order of magnitude.

ii. From the ordered series of data, the mean discharge in using the Gumbel's distribution, the mean of the ordered peak discharge, Q, the variance and standard deviation, s_x of the series is calculated using,

Mean, $Q = \sum_{i=1}^{n} Q_{max}$ ………………………………………………………… (3.1)

Variance $= \frac{\sum_{i=1}^{n}(Q - Q)2}{n}$ ………………………………………………………… (3.2)

Where n is the total number of years collected for the distribution.

Q_{max} = maximum rainfall data of each year, And Q is the mean of the distribution.

iii. The standard deviation is calculated by taking the square root of the variance. The values gotten are tabled below.

The value of y_n and σ_n corresponding to n values are obtained from the table shown below

Table 3.3: Values of σn and yn for

N	Yn	σn
10	0.4952	0.9497
15	0.5128	1.0206
20	0.5236	1.0620
25	0.5309	1.0915
30	0.5362	1.1124
35	0.5403	1.1285
40	0.5436	1.1413

45	0.5463	1.1518
50	0.5465	1.1607
55	0.5504	1.1681
60	0.5521	1.1747

σ_n= Reduced standard deviation.

Y_n = Reduced mean.

The reduced variate is then calculated for seven return period of 2yrs, 5yrs, 10yrs, 20yrs, 25yrs, 50yrs and 100yrs using the expression;

Y= Y= $-[0.834+2.303\log_e(\frac{\mathrm{Tr}-1}{\mathrm{Tr}})]$ …………………………………………(3.3)

Obtained by taking the logarithms of the expression;

1-P= $e - e^{-e-y}$ …………………………………………………………… (3.4)

But,P= $\frac{1}{T}$……………………………………………………………………(3.5)

Therefore, $e - e^{-e-y} = \log_e(\frac{\mathrm{Tr}-1}{\mathrm{Tr}})$

Taking logarithm of both sides $-e^{-e-y} = \log_e(\frac{\mathrm{Tr}-1}{\mathrm{Tr}})$

$e^{-e-y} = \log_e(\frac{\mathrm{Tr}-1}{\mathrm{Tr}})$

$-2.303\log_e\left(\frac{\mathrm{Tr}-1}{\mathrm{Tr}}\right) = 2.303\log_{10}(\frac{\mathrm{Tr}-1}{\mathrm{Tr}})$

Again, if we take logarithms of both sides.

$-y = \log_e 2.303 + \log_e\left(\frac{\mathrm{Tr}-1}{\mathrm{Tr}}\right)$

$y = -\left[\log_e 2.303 + \log_e\left(\frac{\mathrm{Tr}-1}{\mathrm{Tr}}\right)\right]$

$y = -\left[0.834 + 2.303 \log_e\left(\frac{\mathrm{Tr}-1}{\mathrm{Tr}}\right)\right]$

the flood discharge magnitude for the seven return periods was calculated using the expression;

$Q_T = Q + ks_X$

And $k_T = \left[\frac{yr - yn}{\sigma n}\right]$

Where;

Q_T = the expected discharge

Q = the mean discharge of the discharge series.

Y_t = the reduced variate of the series, and y_n and σ_n depends on n

y_n and σ_n are parameters which depend on the values of n from the table above.

3.6: Log-Pearson type 3 distribution model

Step by step procedures used in carrying out the Log-Pearson type 3 distribution is as follows;

i. The observed rainfall annual series of the n-years are assembled and arranged in descending order.
ii. The observed rainfall data for each year is transformed into logarithmic series taking the base to 10. The values obtained are tabulated in the table below;
iii. For the log series, the me

$$Q = \frac{\sum logQ}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..3.14$$

iv. And the variance is obtained by squaring the difference between the mean and the log values of the discharge series using

$$V = \frac{\sum (logQ - \log Q)^2}{n}$$

v. The standard deviation is then calculated by taking the square root of the variance, i.e $s_x = \sqrt{variance} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..3.16$

vi. The skewness co efficient is given by equation

$$g = \frac{\sum (\log Q_{10} - log_{10} Q)}{(n-1)(n-2)s_x^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.3.17$$

and the value obtained which corresponds to the seven-return period, 2yrs, 5yrs, 10yrs, 20yrs, 25yrs, 50yrs and 100yrs is used to compute the values of the frequency factor for each return period. Th e reduced variate was computed using the expression;

$$y_t = y + ks_x \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots3.18$$

where $y =$ meanLog$_{10}$Q, $k = skewness\ cofficient$, s_x = standard deviation. The various values of k which corresponds to the seven return periods were obtained from the trable below. Thereafter, the expected rainfall data is calculated by taking the anti-log of the reduced variate using the expression;

$$Q_T = \text{InLog}y_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Table 3.4 Various K values

Different values for K (frequency factor)							
G	Return Periods, T_r (years)						
	2	5	10	25	50	100	200
3.0	-0.396	0.420	1.180	2.278	3.152	4.501	4.970
2.5	-0.36	0.518	1.250	2.262	3.048	3.845	4.652
2.0	-0.307	0.609	1.302	2.219	2.912	3.605	4.298
1.5	-0.240	0.690	1.333	2.146	2.743	3.330	3.910
1.0	-0.164	0.756	1.340	2.043	2.542	3.022	3.489
0.5	-0.083	0.808	1.323	1.910	2.311	2.686	3.041
0.0	0.000	0.842	1.282	1.751	2.054	2.326	2.576
-0.5	0.083	0.856	1.216	1.567	1.777	1.955	2.108
-1.0	0.164	0.853	1.123	1.366	1.492	1.588	1.664
-1.5	0.240	0.825	1.018	1.157	1.217	1.256	1.282
-2.0	0.307	0.777	0.895	0.959	0.980	0.990	0.995
-2.5	0.360	0.711	0.771	0.793	0.798	0.799	0.800
-3.0	0.396	0.636	0.660	0.666	0.666	0.667	0.667

CHAPTER FOUR

4.0 RESULT AND RESULT ANALYSIS

4.1 Presentation of result

The annual maximum series collected for this work ranges from 1964 to 2013 , with the maximum rainfall data of 182.1 was observed in the year 1986 for Warri , and the lowest 61.4 in the year 1977,maximum rainfall data of 104.3 was observed in the year 1982 for Benin, and the lowest 52 in the year 1985, maximum rainfall of 216 in the year 1978 in Calabar, and the lowest 66 in the year 2003. The hydrograph for the series is given below.

However, the maximum rainfall data were fitted to the Gumbel and Log Pearson type III distribution method and the magnitude for various return periods were obtained was then compared.

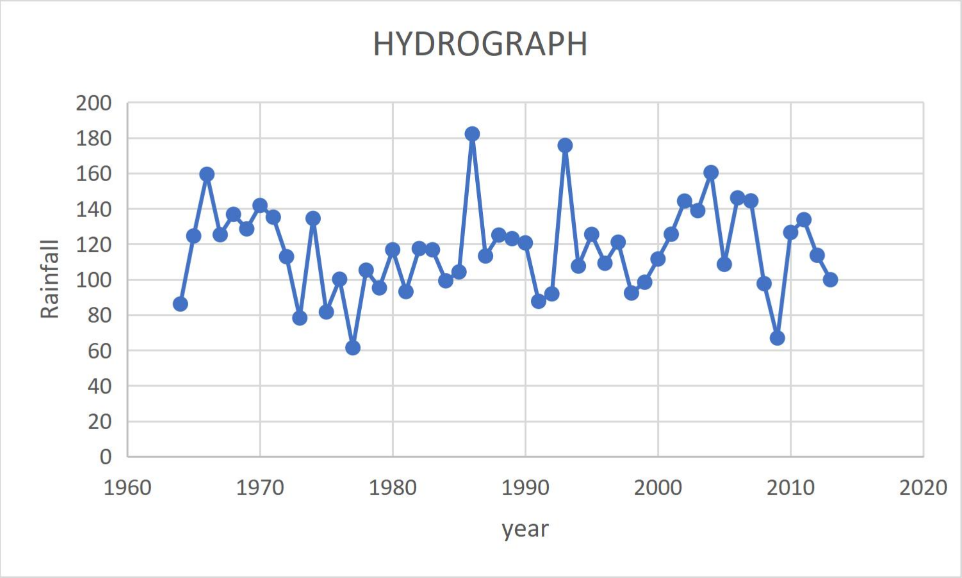

Fig 4.1 Hydrograph of the annual maximum series for rainfall data for Warri

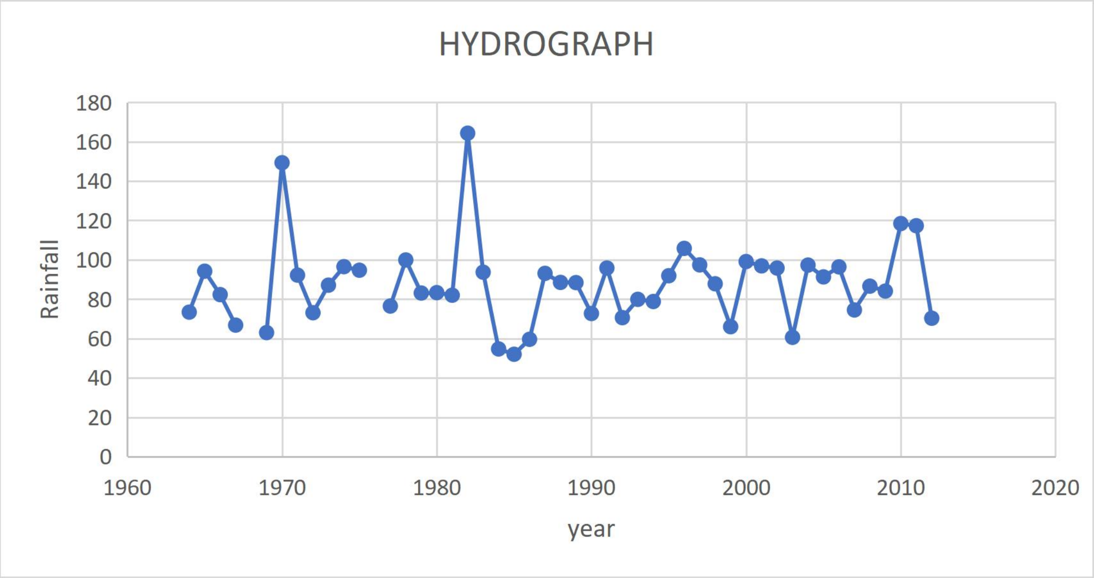

Fig 4.2 Hydrograph of the annual maximum series for rainfall data for Benin city

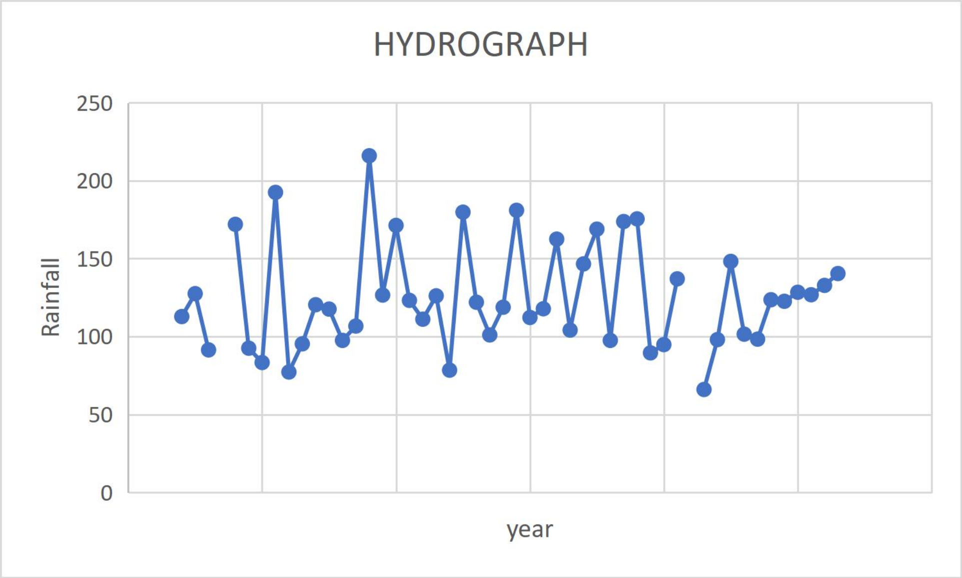

Fig 4.3 Hydrograph of the annual maximum series for rainfall data for Calabar

4.1 Plotting position equation probability for Warri

YEAR	RAINFALL	RANK (M)	WEIBULL $\frac{n+1}{m}$	CUNNANE $\frac{n+0.20}{m-0.40}$	GRING ORTEN $\frac{n+0.12}{m-0.44}$	WEIBUL P=1/T	GRIGON RTEN P=1/T	CUNNANE P=1/T	n
1986	182.4	1	51	89.5	83.67	0.0196	0.0111	0.012	50
1993	175.6	2	25.5	32.12	31.375	0.0392	0.0311	0.0319	50
2004	160.3	3	17	19.58	19.31	0.0588	0.0511	0.0518	50
1966	159.3	4	12.75	14.08	13.94	0.078	0.071	0.0717	50
2006	146	5	10.2	10.99	10.91	0.098	0.091	0.0917	50
2007	144.3	6	8.5	9.01	8.96	0.1176	0.111	0.1116	50

2002	144.2	7	7.3	7.64	7.61	0.1369	0.1309	0.1314	50
1970	141.7	8	6.4	6.63	6.61	0.1563	0.1501	0.1513	50
2003	138.8	9	5.7	5.86	5.84	0.1754	0.1706	0.1712	50
1968	136.7	10	5.1	5.24	2.21	0.196	0.1908	0.4523	50
1971	135.1	11	4.6	4.75	4.74	0.2174	0.2105	0.211	50
1974	134.4	12	4.3	4.34	4.33	0.2326	0.2304	0.2309	50
2011	133.7	13	3.9	3.99	3.98	0.2564	0.2506	0.2513	50
1969	128.5	14	3.6	3.7	3.69	0.2778	0.2778	0.271	50
2010	126.5	15	3.4	3.44	3.44	0.2941	0.2941	0.2907	50
2001	125.5	16	3.2	3.22	3.22	0.3125	0.3106	0.3106	50
1995	125.4	17	3	3.03	3.02	0.3333	0.33	0.3311	50
1967	125.2	18	2.8	2.85	2.85	0.3571	0.3509	0.3571	50
1988	125	19	2.7	2.7	2.7	0.3704	0.3704	0.3704	50
1965	124.5	20	2.6	2.56	2.56	0.3846	0.3906	0.3906	50
1989	123	21	2.4	2.44	2.44	0.4167	0.4098	0.4098	50
1997	121	22	2.3	2.32	2.32	0.4368	0.431	0.431	50
1990	120.6	23	2.2	2.22	2.22	0.4545	0.4505	0.4505	50
1982	117.4	24	2.1	2.13	2.13	0.4762	0.4695	0.4695	50
1983	116.7	25	2	2.04	2.04	0.5	0.4902	0.4902	50
1980	116.7	26	1.96	1.96	1.96	0.5102	0.5102	0.5102	50
2012	113.6	27	1.88	1.89	1.89	0.5319	0.5291	0.5291	50
1987	113.2	28	1.82	1.82	1.82	0.5495	0.5495	0.5495	50
1972	112.8	29	1.76	1.75	1.76	0.5682	0.5714	0.5682	50
2000	111.5	30	1.7	1.7	1.7	0.5882	0.5882	0.5882	50

1996	109.1	31	1.64	1.64	1.64	0.6098	0.6098	0.6098	50
2005	108.5	32	1.59	1.59	1.59	0.6289	0.6289	0.6289	50
1994	107.5	33	1.55	1.54	1.54	0.6452	0.6452	0.6452	50
1978	105.2	34	1.5	1.5	1.5	0.6667	0.6667	0.6667	50
1985	104.2	35	1.46	1.45	1.45	0.6849	0.6897	0.6897	50
1976	100.1	36	1.41	1.41	1.41	0.7092	0.7092	0.7092	50
2013	99.8	37	1.38	1.37	1.37	0.7246	0.7299	0.7299	50
1984	99.2	38	1.34	1.33	1.34	0.7463	0.7519	0.7463	50
1999	98.4	39	1.31	1.3	1.3	0.8842	0.7692	0.7692	50
2008	97.7	40	1.275	1.27	1.27	0.7843	0.7874	0.7874	50
1979	95.2	41	1.24	1.24	1.24	0.8065	0.8065	0.8065	50
1981	93.1	42	1.21	1.21	1.21	0.8264	0.8264	0.8264	50
1998	92.3	43	1.19	1.78	1.18	0.8403	0.5618	0.8475	50
1992	91.8	44	1.16	1.15	1.15	0.8621	0.8696	0.8696	50
1991	87.6	45	1.13	1.12	1.13	0.885	0.8929	0.885	50
1964	86.1	46	1.1	1.1	1.1	0.9091	0.9091	0.9091	50
1975	86.1	47	1.09	1.08	1.08	0.9174	0.9259	0.9259	50
1973	78.2	48	1.06	1.05	1.05	0.9434	0.9524	0.9524	50
2009	66.9	49	1.04	1.03	1.03	0.9615	0.9709	0.9709	50
1977	61.4	50	1.02	1.01	1.01	0.9804	0.9901	0.9901	50

4.2 Plotting position equation probability for Benin city

YEAR	RAINFALL	RANK (M)	WEIBULL $\frac{n+1}{m}$	CUNNANE $\frac{n+0.20}{m-0.40}$	GRING ORTEN	WEIBUL P=1/T	GRIGON RTEN	CUNNANE P=1/T	n

					$\frac{n+0.12}{m-0.44}$		P=1/T		
YEAR	RAINFALL	RANK	WEIBULL	GRINGORTEN	CUNNANE	WEIBULL P=1/T	GRINGORTEN P=1/T	CUNNANE P=1/T	n
1982	164.3	1	48	80.3	83.67	0.0196	0.0111	0.012	47
1970	149.3	2	24	32.12	31.37	0.0392	0.0311	0.0319	47
2010	118.4	3	16	19.58	19.31	0.0588	0.0511	0.0518	47
2011	117.3	4	12	14.08	13.94	0.078	0.071	0.0717	47
1996	105.8	5	9.6	10.99	10.91	0.098	0.091	0.0917	47
1978	99.9	6	8	9.01	8.96	0.1176	0.111	0.1116	47
2000	99.1	7	6.9	7.64	7.61	0.1369	0.1309	0.1314	47
1997	97.4	8	6	6.63	6.61	0.1563	0.1501	0.1513	47
2004	97.3	9	5.33	5.86	5.84	0.1754	0.1706	0.1712	47
1974	96.5	10	4.8	5.24	2.21	0.196	0.1908	0.4523	47
2006	96.4	11	4.4	4.75	4.74	0.2174	0.2105	0.211	47
2001	96.1	12	4	4.34	4.33	0.2326	0.2304	0.2309	47
2002	95.8	13	3.7	3.99	3.98	0.2564	0.2506	0.2513	47
1991	95.8	14	3.42	3.7	3.69	0.2778	0.2778	0.271	47
1975	94.7	15	3.2	3.44	3.44	0.2941	0.2941	0.2907	47
1965	94.2	16	3	3.22	3.22	0.3125	0.3106	0.3106	47
1983	93.7	17	2.8	3.03	3.02	0.3333	0.33	0.3311	47
1987	93.1	18	2.67	2.85	2.85	0.3571	0.3509	0.3571	47
1971	92.2	19	2.52	2.7	2.7	0.3704	0.3704	0.3704	47
1995	91.9	20	2.4	2.56	2.56	0.3846	0.3906	0.3906	47

2005	91.3	21	2.29	2.44	2.44	0.4167	0.4098	0.4098	47
1988	88.5	22	2.18	2.32	2.32	0.4368	0.431	0.431	47
1989	88.4	23	2	2.22	2.22	0.4545	0.4505	0.4505	47
1998	87.8	24	2	2.13	2.13	0.4762	0.4695	0.4695	47
1973	87.1	25	1.92	2.04	2.04	0.5	0.4902	0.4902	47
2008	86.6	26	1.85	1.96	1.96	0.5102	0.5102	0.5102	47
2009	84.1	27	1.78	1.89	1.89	0.5319	0.5291	0.5291	47
1980	83.3	28	1.71	1.82	1.82	0.5495	0.5495	0.5495	47
1979	83.1	29	1.66	1.75	1.76	0.5682	0.5714	0.5682	47
1966	82.3	30	1.6	1.7	1.7	0.5882	0.5882	0.5882	47
1981	82	31	1.6	1.64	1.64	0.6098	0.6098	0.6098	47
1993	79.9	32	1.5	1.59	1.59	0.6289	0.6289	0.6289	47
1994	78.8	33	1.45	1.54	1.54	0.6452	0.6452	0.6452	47
1977	76.5	34	1.41	1.5	1.5	0.6667	0.6667	0.6667	47
2007	74.5	35	1.37	1.45	1.45	0.6849	0.6897	0.6897	47
1964	73.4	36	1.33	1.41	1.41	0.7092	0.7092	0.7092	47
1972	73.1	37	1.3	1.37	1.37	0.7246	0.7299	0.7299	47
1990	72.7	38	1.26	1.33	1.34	0.7463	0.7519	0.7463	47
1992	70.6	39	1.23	1.3	1.3	0.8842	0.7692	0.7692	47
2012	70.3	40	1.2	1.27	1.27	0.7843	0.7874	0.7874	47
197	66.8	41	1.17	1.24	1.24	0.8065	0.8065	0.8065	47
1999	66	42	1.14	1.21	1.21	0.8264	0.8264	0.8264	47
1969	63	43	1.12	1.78	1.18	0.8403	0.5618	0.8475	47

2003	60.6	44	1.09	1.15	1.15	0.8621	0.8696	0.8696	47
1986	59.6	45	1.07	1.12	1.13	0.885	0.8929	0.885	47
1984	54.7	46	1.04	1.1	1.1	0.9091	0.9091	0.9091	47
1985	52	47	1.02	1.08	1.08	0.9174	0.9259	0.9259	47

4.3 Plotting position equation probability for Calabar

YEAR	RAINFALL	RANK (M)	WEIBULL $\frac{n+1}{m}$	CUNNANE $\frac{n+0.20}{m-0.40}$	GRING ORTEN $\frac{n+0.12}{m-0.44}$	WEIBUL P=1/T	GRIGON RTEN P=1/T	CUNNANE P=1/T	n
1978	216	1	49	80.3	83.67	0.02	0.013	0.012	48
1971	192.5	2	24.5	30.125	31.375	0.041	0.033	0.0319	48
1989	181	3	16.3	18.54	19.31	0.061	0.054	0.0518	48
1985	179.8	4	12.25	13.39	13.94	0.082	0.075	0.0717	48
1998	175.5	5	9.8	10.48	10.91	0.102	0.095	0.0917	48
1997	173.8	6	8.17	8.6	8.96	0.122	0.116	0.1116	48
1968	172	7	7	7.3	7.61	0.143	0.143	0.1314	48
1980	171.3	8	6.12	6.3	6.61	0.163	0.159	0.1513	48
1995	168.9	9	5.4	5.6	5.84	0.185	0.179	0.1712	48
1992	162.5	10	4.9	5	2.21	0.2	0.2	0.4523	48
2005	148.2	11	4.45	4.5	4.74	0.222	0.222	0.211	48
1994	146.6	12	4	4.15	4.33	0.25	0.241	0.2309	48
2013	140.4	13	3.7	3.8	3.98	0.27	0.263	0.2513	48
2001	137	14	3.5	3.5	3.69	0.286	0.286	0.271	48

2012	132.8	15	3.3	3.3	3.44	0.303	0.303	0.2907	48
2010	128.4	16	3	3	3.22	0.333	0.333	0.3106	48
1965	127.5	17	2.8	2.9	3.02	0.345	0.345	0.3311	48
2011	126.8	18	2.7	2.7	2.85	0.37	0.37	0.3571	48
1979	126.6	19	2.5	2.6	2.7	0.4	0.385	0.3704	48
1983	126.1	20	2.45	2.5	2.56	0.408	0.4	0.3906	48
2008	123.6	21	2.3	2.3	2.44	0.435	0.435	0.4098	48
1979	123.2	22	2.2	2.2	2.32	0.455	0.455	0.431	48
2009	122.6	23	2.1	2.1	2.22	0.476	0.476	0.4505	48
1986	122	24	2	2	2.13	0.5	0.5	0.4695	48
1974	120.4	25	1.96	1.96	2.04	0.51	0.51	0.4902	48
1988	118.8	26	1.88	1.9	1.96	0.532	0.526	0.5102	48
1991	117.8	27	1.81	1.8	1.89	0.552	0.552	0.5291	48
1975	117.6	28	1.75	1.7	1.82	0.571	0.588	0.5495	48
1964	112.8	29	1.69	1.7	1.76	0.592	0.588	0.5682	48
1990	112.2	30	1.63	1.6	1.7	0.613	0.625	0.5882	48
1982	111.1	31	1.58	1.6	1.64	0.633	0.652	0.6098	48
1977	106.7	32	1.53	1.5	1.59	0.654	0.667	0.6289	48
1993	104.1	33	1.48	1.5	1.54	0.676	0.667	0.6452	48
2006	101.5	34	1.44	1.4	1.5	0.694	0.714	0.6667	48
1987	101	35	1.4	1.4	1.45	0.714	0.714	0.6897	48
2007	98.3	36	1.36	1.4	1.41	0.735	0.714	0.7092	48
2004	98	37	1.32	1.3	1.37	0.758	0.769	0.7299	48

1996	97.5	38	1.29	1.3	1.34	0.775	0.769	0.7463	48
1976	97.5	39	1.26	1.2	1.3	0.794	0.833	0.7692	48
1973	95.3	40	1.22	1.2	1.27	0.819	0.833	0.7874	48
2000	94.8	41	1.19	1.2	1.24	0.806	0.833	0.8065	48
1969	92.5	42	1.16	1.2	1.1	0.862	0.833	0.8264	48
1966	91.4	43	1.13	1.1	1.13	0.885	0.909	0.8475	48
1999	89.5	44	1.11	1.1	1.15	0.9001	0.909	0.8696	48
1970	83.3	45	1.08	1	1.13	0.926	1	0.885	48
1984	78.4	46	1.06	1.05	1.1	0.943	0.952	0.9091	48
1972	77.2	47	1.04	1.03	1.08	0.962	0.926	0.9259	48
2003	66	48	1.02	1.01	1.05	0.98	0.99	0.9524	48

Table 4.4 Computation for Log Pearson type III probability distribution for Warri, Benin city and Calabar.

Rank	Year	Rainfall	L0g$_{10}$Q	(Log$_{10}$Q-log$_{10}\bar{Q}$)^2	Log$_{10}$Q-log$_{10}\bar{Q}$)^3
1	1986	182.4		0.024948139	0.003940554
2	1993	175.6	2.244524512	0.020007955	0.002803011
3	2004	160.3	2.204933522	0.010375152	0.001056797
4	1966	159.3	2.202215776	0.009828887	0.000974443
5	2006	146	2.164352856	0.003754972	0.000023009
6	2007	144.3	2.159266331	0.003157496	0.0001
7	2002	144.2	2.15896526	0.003123717	0.000174585

8	1970	141.7	2.15136985	0.002332389	0.000112642
9	2003	138.8	2.142389466	0.001545625	0.000034944
10	1968	136.7	2.135768515	0.001068863	0.000034945
11	1971	135.1	2.130655349	0.000760674	0.00002098
12	1974	134.4	2.128399269	0.000641317	0.000016241
13	2011	133.7	2.126131407	0.000531596	0.000012257
14	1969	128.5	2.108903128	0.000033967	0.000000198
15	2010	126.5	2.102090526	0.000000969	0
16	2001	125.5	2.098643726	0.000019636	-0.000000087
17	1995	125.4	2.098297536	0.000022824	-0.000000109
18	1967	125.2	2.097604329	0.000099286	-0.000000164
19	1988	125	2.096910013	0.000038007	-0.000000234
20	1965	124.5	2.095169351	0.0000625	-0.000000494
21	1989	123	2.089905111	0.000173447	-0.000002284
22	1997	121	2.08278537	0.00041167	-0.000008353
23	1990	120.6	2.081347308	0.000472094	-0.000010258
24	1982	117.4	2.069668097	0.001116023	-0.000037283
25	1983	116.7	2.067070856	0.00111342	-0.000046672
26	1980	116.7	2.067070856	0.00012963	-0.000046672
27	2012	113.6	2.055378331	0.002274975	-0.000108509
28	1987	113.2	2.053846427	0.002423456	-0.000119303
29	1972	112.8	2.0523091	0.00257718	-0.000130833
30	2000	111.5	2.047274867	0.003113659	-0.000173743
31	1996	109.1	2.037824751	0.004257599	-0.000277809
32	2005	108.5	2.035429738	0.004575886	-0.000309537
33	1994	107.5	2.031408464	0.005136097	-0.000368086
34	1978	105.2	2.02201574	0.006570609	-0.000532609
35	1985	104.2	2.017867719	0.007260287	-0.00006186
36	1976	100.1	2.000434077	0.010535166	-0.001093734
37	2013	99.8	1.999130541	0.010804458	-0.001123064
38	1984	99.2	1.996511672	0.01135575	0.001210107

39	1999	98.4	1.992995098	0.012117592	-0.001333904
40	2008	97.7	1.989894564	0.012809819	-0.001449821
41	1979	95.2	1.978636948	0.015484837	0.001926904
42	1981	93.1	1.968949681	0.01798961	-0.002412863
43	1998	92.3	1.965201701	0.019009906	0.002620929
44	1992	91.8	1.962842681	0.031254975	0.002757685
45	1991	87.6	1.942504106	0.025783023	-0.004140004
46	1964	86.1	1.935003151	0.028248158	-0.00487622
47	1975	86.1	1.935003151	0.028248158	-0.00487622
48	1973	78.2	1.893206753	0.044044695	-0.009243585
49	2009	66.9	1.825426118	0.077088921	-0.021403655
50	1977	61.4	1.788168371	0.099166206	-0.031228099
Average		120.606	1.788168371		
Mean				0.062057173	-0.013643773
Variance				0.002754161	
Standard deviation				0.052480098	

Table 4.5 Computation for Log Pearson type III probability distribution for Benin city

Rank	Year	Rainfall	$\text{Log}_{10}Q$	$\text{Log}_{10}Q-\log_{10}\bar{Q})^2$	$(\text{Log}_{10}Q-\log_{10}\bar{Q})^3$
1	1982	164.3	2.215637563	0.125848696	0.044645026
2	1970	149.3	2.174059808	0.098077856	0.030715417
3	2010	118.4	2.073351702	0.045141689	0.009591062
4	2011	117.3	2.069298012	0.043435581	0.009052498
5	1996	105.8	2.024485668	0.026764863	0.004378724
6	1978	99.9	1.999565488	0.01923201	0.002667086
7	2000	99.1	1.996073654	0.018275711	0.002470651

8	1997	97.4	1.988558957	0.016300393	0.00208112
9	2004	97.3	1.98811284	0.016186678	0.00205938
10	1974	96.5	1.984527313	0.015287183	0.001890128
11	2006	96.4	1.984077034	0.015176039	0.001869553
12	2001	96.1	1.982723388	0.014844358	0.001808598
13	2002	95.8	1.981365509	0.014515321	0.001748799
14	1991	95.8	1.981365509	0.014515321	0.001748799
15	1975	94.7	1.976349979	0.013331939	0.001539359
16	1965	94.2	1.974050903	0.012806303	0.001449225
17	1983	93.7	1.971739591	0.012288526	0.001362228
18	1987	93.1	1.968949681	0.011677767	0.001261943
19	1971	92.2	1.964730921	0.010783775	0.001119841
20	1995	91.9	1.963315511	0.010491812	0.000107467
21	2005	91.3	1.960470778	0.009917135	0.000987596
22	1988	88.5	1.946943271	0.00740586	0.000637328
23	1989	88.4	1.946452265	0.007321592	0.000626482
24	1998	87.8	1.943494516	0.006824173	0.000563735
25	1973	87.1	1.940018155	0.006261903	0.000495518
26	2008	86.6	1.937517892	0.005872452	0.000450017
27	2009	84.1	1.924795996	0.004084492	0.00026104
28	1980	83.3	1.920645001	0.003511424	0.000213408
29	1979	83.1	1.919601024	0.003447458	0.000202418
30	1966	82.3	1.915399835	0.002971762	0.000162002
31	1981	82	1.913813852	0.002801361	0.00014827
32	1993	79.9	1.902546779	0.001735623	0.000072307
33	1994	78.8	1.896526217	0.001270228	0.000045271
34	1977	76.5	1.883661435	0.000518722	0.000011814
35	2007	74.5	1.872156273	0.000127019	0.000001432
36	1964	73.4	1.86569606	0.000023137	0.000000111
37	1972	73.1	1.863917377	0.000009189	0.000000028
38	1990	72.7	1.861534411	0.00000042	0

39	1992	70.6	1.848804701	0.000145957	-0.000001763
40	2012	70.3	1.846955325	0.000194062	-0.000002703
41	197	66.8	1.824776462	0.001303896	-0.000047083
42	1999	66	1.819543936	0.001709163	-0.00007066
43	1969	63	1.799340549	0.003787838	-0.000233124
44	2003	60.6	1.782472624	0.006148652	-0.000482136
45	1986	59.6	1.77524626	0.007334159	-0.000628095
46	1984	54.7	1.737987326	0.015104075	-0.00185627
47	1985	52	1.716003344	0.020990974	-0.003041227
48	1963				
Average		85.81	1.860885965		
Mean				0.073419835	0.020801899
Variance				0.005497571	
Standard deviation				0.074145606	

Table 4.6 Computation for Log Pearson type III probability distribution for Calabar.

Rank	Year	Rainfall	Log10Q	$(Log_{10}Q-log_{10}\bar{Q})^2$	$Log_{10}Q-log_{10}\bar{Q})^3$
1	1978	216	2.334453751	0.083204378	0.024000444
2	1971	192.5	2.284430734	0.056848233	0.013554156
3	1989	181	2.257678575	0.044806716	0.00094845
4	1985	179.8	2.254789687	0.043592045	0.009101456
5	1998	175.5	2.244277121	0.039312783	0.007794723
6	1997	173.8	2.240049772	0.037654303	0.000730671
7	1968	172	2.235528447	0.035920044	0.006807777

8	1980	171.3	2.233757363	0.035251849	0.006618702
9	1995	168.9	2.22762965	0.032988383	0.005991583
10	1992	162.5	2.210853365	0.027175773	0.004479947
11	2005	148.2	2.170848204	0.015586423	0.001945896
12	1994	146.6	2.16613397	0.014431545	0.001733681
13	2013	140.4	2.147367108	0.001027476	0.001041496
14	2001	137	2.136720567	0.008229748	0.000746586
15	2012	132.8	2.123198075	0.00595914	0.000460019
16	2010	128.4	2.108565024	0.003914056	0.000244873
17	1965	127.5	2.105510185	0.003541152	0.000217254
18	2011	126.8	2.103119254	0.003262311	0.0001797
19	1979	126.6	2.102433706	0.003184469	0.000179703
20	1983	126.1	2.100715087	0.002993456	0.000163779
21	2008	123.6	2.092018471	0.00211746	0.000097437
22	1979	123.2	2.090610708	0.001989883	0.000088765
23	2009	122.6	2.08849047	0.001805219	0.000076699
24	1986	122	2.086359831	0.001628706	0.00006573
25	1974	120.4	2.080626487	0.00162105	0.000065267
26	1988	118.8	2.074816441	0.000830237	0.000023922
27	1991	117.8	2.07114529	0.000630609	0.000015836
28	1975	117.6	2.070407322	0.00059559	0.000014535
29	1964	112.8	2.0523091	0.000039771	0.000000251
30	1990	112.2	2.049992857	0.000015922	0.000000064
31	1982	111.1	2.045714059	0.000000083	0
32	1977	106.7	2.028164419	0.000318201	-0.000005676
33	1993	104.1	2.01745073	0.00081521	-0.000023275
34	2006	101.5	2.006466042	0.00156314	-0.000061801
35	1987	101	2.004321374	0.001737325	-0.000072414
36	2007	98.3	1.992553518	0.0028568	-0.000152694
37	2004	98	1.991226076	0.003000468	-0.000164355
38	1996	97.5	1.989004616	0.003248771	-0.000185173

39	1976	97.5	1.989004616	0.003248771	-0.000185173
40	1973	95.3	1.979092901	0.004476908	-0.000299548
41	2000	94.8	1.976808337	0.004787847	-0.000331292
42	1969	92.5	1.966141733	0.006377759	-0.000509333
43	1966	91.4	1.960946196	0.018643348	-0.002545575
44	1999	89.5	1.951823035	0.008869792	-0.000835353
45	1970	83.3	1.920645001	0.015714529	-0.001969936
46	1984	78.4	1.894316063	0.0230088	-0.003490126
47	1972	77.2	1.8876173	0.025085905	-0.003973239
48	2003	66	1.819543936	0.051283529	-0.01161359
Average		124.496	2.046002606		
Mean				0.067243954	0.012386854
Variance				0.00050947	
Standard deviation				0.022571449	

Table 4.7 Computation table for Log Pearson with 7 return periods for Warri

Return period	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
K	0.307	0.777	0.895	0.959	0.980	0.990	0.995
Y	2.0246	2.0246	2.0246	2.0246	2.0246	2.0246	2.0246
S_x	0.0524	0.0524	0.0524	0.0524	0.0524	0.0524	0.0524
$YT=Y=Ks_x$	2.0407	2.0653	2.0715	2.0749	2.0760	2.0765	2.0767
$QT=InLogY_T(m^3/s)$	139..01	143.23	148.25	151.16	158.78	162.32	171.31

Table 4.8 Computation table for Log Pearson with 7 return periods for Benin city

Return period	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
K	-0.164	0.758	1.340	2.043	2.542	3.022	3.489

Y	1.8609	1.8609	1.8609	1.8609	1.8609	1.8609	1.8609
S_x	0.07415	0.07415	0.07415	0.07415	0.07415	0.07415	0.07415
$YT=Y=Ks_x$	1.8730	1.9171	1.9603	2.0123	2.0493	2.0849	2.1110
QT=InLogY_T(m^3/s)	121.64	128.62	130.26	135.80	148.02	159.43	172.12

Table 4.9 Computation table for Log Pearson with 7 return periods for Calabar

Return period	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
K	0.000	0.842	1.282	1.751	2.054	2.326	2.576
Y	2.0246	2.0246	2.0246	2.0246	2.0246	2.0246	2.0246
S_x	0.02257	0.02257	0.02257	0.02257	0.02257	0.02257	0.02257
$YT=+Ks_x$	2.041	2.0436	2.0535	2.0641	2.0710	2.0771	2.0827
QT=InLogY_T(m^3/s)	109.07	110.56	119.11	123.90	132.76	138.43	140.98

Table 4.10 Computation for Gumbel Probability Distribution Model for Warri

Rank	Year	Rainfall	$\bar{Q}$	$(Q-\bar{Q})^2$	$(Q-\bar{Q}^{)3}$
1	1986	182.4	121.9	60.5	3660.25
2	1993	175.6	121.9	53.7	2883.69
3	2004	160.3	121.9	38.4	1474.56
4	1966	159.3	121.9	37.4	1398.76
5	2006	146	121.9	24.1	580.81
6	2007	144.3	121.9	22.4	501.76
7	2002	144.2	121.9	22.3	497.29
8	1970	141.7	121.9	19.8	392.04

9	2003	138.8	121.9	16.9	285.61
10	1968	136.7	121.9	14.8	219.04
11	1971	135.1	121.9	13.2	174.24
12	1974	134.4	121.9	12.5	156.25
13	2011	133.7	121.9	11.8	139.24
14	1969	128.5	121.9	6.6	43.56
15	2010	126.5	121.9	4.6	21.16
16	2001	125.5	121.9	3.6	12.96
17	1995	125.4	121.9	3.5	12.25
18	1967	125.2	121.9	3.3	10.89
19	1988	125	121.9	3.1	9.61
20	1965	124.5	121.9	2.6	6.76
21	1989	123	121.9	1.1	1.21
22	1997	121	121.9	-0.9	0.81
23	1990	120.6	121.9	-1.3	1.69
24	1982	117.4	121.9	-4.5	20.25
25	1983	116.7	121.9	-5.2	27.04
26	1980	116.7	121.9	-5.2	27.04
27	2012	113.6	121.9	-8.3	68.89
28	1987	113.2	121.9	-8.7	75.69
29	1972	112.8	121.9	-9.1	82.81
30	2000	111.5	121.9	-10.4	108.16
31	1996	109.1	121.9	-12.8	163.84
32	2005	108.5	121.9	-13.4	179.56
33	1994	107.5	121.9	-14.4	207.36
34	1978	105.2	121.9	-16.7	278.89
35	1985	104.2	121.9	-17.7	313.29
36	1976	100.1	121.9	-21.8	475.24
37	2013	99.8	121.9	-22.1	488.41
38	1984	99.2	121.9	-22.7	515.29
39	1999	98.4	121.9	-23.5	552.25

40	2008	97.7	121.9	-24.2	585.64
41	1979	95.2	121.9	-26.7	712.89
42	1981	93.1	121.9	-28.8	829.44
43	1998	92.3	121.9	-29.6	876.16
44	1992	91.8	121.9	-30.1	906.01
45	1991	87.6	121.9	-34.3	1176.49
46	1964	86.1	121.9	-35.8	1281.64
47	1975	86.1	121.9	-35.8	1281.64
48	1973	78.2	121.9	-43.7	1909.69
49	2009	66.9	121.9	-55	3025
50	1977	61.4	121.9	-60.5	3660.25
Mean		121.9			
Sum					7320.5
Variance					155.76
Standard dev					12.48

Table 4.11 Computation for Gumbel Probability Distribution for Benin

Rank	Year	Rainfall	$\bar{Q}$	$(Q-\bar{Q})^2$	$(Q-\bar{Q})^3$
1	1982	164.3	108.15	56.15	3152.8225
2	1970	149.3	108.15	41.15	1693.3225
3	2010	118.4	108.15	10.25	105.0625
4	2011	117.3	108.15	9.15	83.7225
5	1996	105.8	108.15	-2.35	5.5225
6	1978	99.9	108.15	-8.25	68.0625
7	2000	99.1	108.15	-9.05	81.9025
8	1997	97.4	108.15	-10.75	115.5625
9	2004	97.3	108.15	-10.85	117.7225
10	1974	96.5	108.15	-11.65	135.7225
11	2006	96.4	108.15	-11.75	138.0625
12	2001	96.1	108.15	-12.05	145.2025
13	2002	95.8	108.15	-12.35	152.5225

14	1991	95.8	108.15	-12.35	152.5225
15	1975	94.7	108.15	-13.45	180.9025
16	1965	94.2	108.15	-13.95	194.6025
17	1983	93.7	108.15	-14.45	208.8025
18	1987	93.1	108.15	-15.05	226.5025
19	1971	92.2	108.15	-15.95	254.4025
20	1995	91.9	108.15	-16.25	264.0625
21	2005	91.3	108.15	-16.85	283.9225
22	1988	88.5	108.15	-19.65	386.1225
23	1989	88.4	108.15	-19.75	390.0625
24	1998	87.8	108.15	-20.35	414.1225
25	1973	87.1	108.15	-21.05	443.1025
26	2008	86.6	108.15	-21.55	464.4025
27	2009	84.1	108.15	-24.05	578.4025
28	1980	83.3	108.15	-24.85	617.5225
29	1979	83.1	108.15	-25.05	627.5025
30	1966	82.3	108.15	-25.85	668.2225
31	1981	82	108.15	-26.15	683.8225
32	1993	79.9	108.15	-28.25	798.0625
33	1994	78.8	108.15	-29.35	861.4225
34	1977	76.5	108.15	-31.65	1001.7225
35	2007	74.5	108.15	-33.65	1132.3225
36	1964	73.4	108.15	-34.75	1207.5625
37	1972	73.1	108.15	-35.05	1228.5025
38	1990	72.7	108.15	-35.45	1256.7025
39	1992	70.6	108.15	-37.55	1410.0025
40	2012	70.3	108.15	-37.85	1432.6225
41	197	66.8	108.15	-41.35	1709.8225
42	1999	66	108.15	-42.15	1776.6225
43	1969	63	108.15	-45.15	2038.5225
44	2003	60.6	108.15	-47.55	2261.0025
45	1986	59.6	108.15	-48.55	2357.1025
46	1984	54.7	108.15	-53.45	2856.9025
47	1985	52	108.15	-56.15	3152.8225
Mean		108.15			
Sum					6305.645
Variance					134.16
Standard dev					11.58

Table 4.12 Computation for Gumbel Probability Distribution Model for Calabar

Rank	Year	Rainfall	Q	$(Q-\bar{Q})^2$	$(Q-\bar{Q})^3$
1	1978	216	141	75	5625
2	1971	192.5	141	51.5	2652.25
3	1989	181	141	40	1600
4	1985	179.8	141	38.8	1505.44
5	1998	175.5	141	34.5	1190.25
6	1997	173.8	141	32.8	1075.84
7	1968	172	141	31	961
8	1980	171.3	141	30.3	918.09
9	1995	168.9	141	27.9	778.41
10	1992	162.5	141	21.5	462.25
11	2005	148.2	141	7.2	51.84
12	1994	146.6	141	5.6	31.36
13	2013	140.4	141	-0.6	0.36
14	2001	137	141	-4	16
15	2012	132.8	141	-8.2	67.24
16	2010	128.4	141	-12.6	158.76
17	1965	127.5	141	-13.5	182.25
18	2011	126.8	141	-14.2	201.64
19	1979	126.6	141	-14.4	207.36
20	1983	126.1	141	-14.9	222.01
21	2008	123.6	141	-17.4	302.76
22	1979	123.2	141	-17.8	316.84
23	2009	122.6	141	-18.4	338.56
24	1986	122	141	-19	361
25	1974	120.4	141	-20.6	424.36
26	1988	118.8	141	-22.2	492.84
27	1991	117.8	141	-23.2	538.24
28	1975	117.6	141	-23.4	547.56
29	1964	112.8	141	-28.2	795.24
30	1990	112.2	141	-28.8	829.44
31	1982	111.1	141	-29.9	894.01
32	1977	106.7	141	-34.3	1176.49
33	1993	104.1	141	-36.9	1361.61
34	2006	101.5	141	-39.5	1560.25
35	1987	101	141	-40	1600
36	2007	98.3	141	-42.7	1823.29
37	2004	98	141	-43	1849
38	1996	97.5	141	-43.5	1892.25
39	1976	97.5	141	-43.5	1892.25
40	1973	95.3	141	-45.7	2088.49
41	2000	94.8	141	-46.2	2134.44
42	1969	92.5	141	-48.5	2352.25

43	1966	91.4	141	-49.6	2460.16
44	1999	89.5	141	-51.5	2652.25
45	1970	83.3	141	-57.7	3329.29
46	1984	78.4	141	-62.6	3918.76
47	1972	77.2	141	-63.8	4070.44
48	2003	66	141	-75	5625
Mean		141			
Sum					11250
Variance					229.59
Standard dev					15.15

Table 4.13 Computation for Gumbel distribution for the 7 return periods for Warri

Return period (Tr)	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
Q	141	141	141	141	141	141	141
Y_T	0.3665	1.4999	2.2504	3.1985	3.9091	4.6000	5.2958
Y_n	0.5465	0.5465	0.5465	0.5465	0.5465	0.5465	0.5465
Σn	1.1607	1.1607	1.1607	1.1607	1.1607	1.1607	1.1607
S_x	12.48	12.48	12.48	12.48	12.48	12.48	12.48
Y_{T}- Y_n	-0.18	0.9534	1.7039	2.652	3.3626	4.0535	4.7493
$\frac{\mathrm{YT-Yn}}{\sigma n}$	-0.1550	0.8214	1.4680	2.2848	2.8970	3.4922	4.0918
QT=Q+ S_x $[\frac{\mathrm{YT-Yn}}{\sigma n}](m^3/s)$	142.93	151.25	159.32	169.51	177.15	184.58	192.07

Return period (Tr)	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
Q	108.15	108.15	108.15	108.15	108.15	108.15	108.15
Y_T	0.3665	1.4999	2.2504	3.1985	3.9091	4.6000	5.2958
Y_n	0.5465	0.5465	0.5465	0.5465	0.5465	0.5465	0.5465
σn	1.1607	1.1607	1.1607	1.1607	1.1607	1.1607	1.1607
S_x	11.58	11.58	11.58	11.58	11.58	11.58	11.58
Y_T- Y_n	-0.18	0.9534	1.7039	2.652	3.3626	4.0535	4.7493
$\frac{YT-Yn}{\sigma n}$	-0.1550	0.8214	1.4680	2.2848	2.8970	3.4922	4.0918
QT=Q+ S_x $[\frac{YT-Yn}{\sigma n}](m^3/s)$	109.944	117.66	125.15	134.60	141.69	148.59	155.53

Table 4.14 Computation for Gumbel distribution for the 7 return periods for Benin city

Return period (Tr)	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
Q	121.9	121.9	121.9	121.9	121.9	121.9	121.9
Y_T	0.3665	1.4999	2.2504	3.1985	3.9091	4.6000	5.2958
Y_n	0.5465	0.5465	0.5465	0.5465	0.5465	0.5465	0.5465
σn	1.1607	1.1607	1.1607	1.1607	1.1607	1.1607	1.1607
S_x	15.15	15.15	15.15	15.15	15.15	15.15	15.15
Y_T- Y_n	-0.18	0.9534	1.7039	2.652	3.3626	4.0535	4.7493
$\frac{YT-Yn}{\sigma n}$	-0.1550	0.8214	1.4680	2.2848	2.8970	3.4922	4.0918
QT=Q+ S_x $[\frac{YT-Yn}{\sigma n}](m^3/s)$	124.25	134.34	144.14	156.51	165.79	174.80	183.89

Table 4.15 Computation for Gumbel distribution for the 7 return periods for Calabar

4.2 GOODNESS OF FIT (GOF) TESTS

Goodness of fit test determine whether a particular probability distribution fit the observed data. This is a statistical algorithm that may be used to check the distance between the observed data and predicted data. Goodness of fit tests is widely used in flood frequency analysis to compare different probability distribution models and to determine the best model for the given data set.

4.16 Comparison between the expected rainfall magnitude for Gumbel distribution and Log Pearson with their percentage difference for Warri.

Return period	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
Gumbel distribution	142.93	151.25	159.32	169.51	177.15	184.58	192.07
Log Pearson type III Distribution	139..01	143.23	148.25	151.16	158.78	162.32	171.31
Percentage difference	2.78%	5.45%	7.19%	11.4%	10.93%	12.83%	11.42%

4.17 Comparison between the expected rainfall magnitude for Gumbel distribution and Log Pearson with their percentage difference for Benin city

Return period	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
Gumbel distribution	124.25	134.34	144.14	156.51	165.79	174.80	183.89
Log Pearson type III Distribution	121.64	128.62	130.26	142.80	149.02	156.43	162.12
Percentage difference	2.12%	4.35%	10.11%	9.71%	10.69%	11.09%	12.58%

4.18 Comparison between the expected rainfall magnitude for Gumbel distribution and Log Pearson with their percentage difference for Calabar.

Return period	2yrs	5yrs	10yrs	25yrs	50yrs	100yrs	200yrs
Gumbel distribution	109.94	117.66	125.15	134.60	141.69	148.59	155.53
Log Pearson type III Distribution	109.07	110.56	119.11	123.90	128.76	132.43	140.98
Percentage difference	0.79%	6.22%	4.95%	8.27%	9.56%	11.50%	9.81%

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMEDATIONS

5.1 Conclusion

The annual maximum rainfall data in Warri, Benin City and Calabar varies in magnitude and space, the magnitude of the annual maximum peak flood for Warri ranges from 61.4 to 182.4, for Benin city ranges from 52 to 164.3 and for Calabar it ranges from 66 to 216 m^3/s between the year 1964 and 2013.

The rainfall data was plotted for Warri, Benin city and Calabar against their hydrological years as seen from the hydrograph in Fig 4.1. However, two probability distribution and three plotting positions were fitted to the annual maximum discharges of the river in Warri, Benin city and Calabar. The performances of the two probability distributions were compared.

However, Gumbel distribution model and Log Pearson type III was used to perform the flood frequency analysis on the annual maximum series for rainfall in Warri, Benin city and Calabar.

The return period of 2yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs, and 200yrs gave the expected rainfall data of 142.93, 151.25, 159.32, 169.51, 177.15; 184.58 and 192.074mm for Warri respectively. While the return period of 2yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs, and 200yrs gave the expected rainfall data of 124.25, 134.34, 144.14, 156.51,165.79, 174.80 and 183.89mm for Benin respectively. While the return period of 2yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs, and 200yrs gave the expected rainfall data of 109.944, 117.66, 125.15, 134.60, 141.69, 148.59 and 155.53mm for Calabar respectively for Gumbel.

The return period of 2yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs and 200yrs gave the expected rainfall data of 140.01, 143.23, 148.25, 151.16, 158.72, 162.32 and 171.31mm for Warri respectively. While the return period of 2yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs, and 200yrs gave the expected rainfall data of 121.64, 128.62, 130.26, 142.80, 149.02, 156.43, and 162.12mm for Benin respectively. While the return period of 2yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs, and 200yrs gave the expected flood of 109.07, 110.56, 119.11, 123.90, 128.76, 132.43 and 140.98mm for Calabar respectively for log Pearson type III.

The result obtained shows that the rainfall data satisfied both Gumbel distribution and Log Pearson type III distribution method for Warri, Benin city and Calabar. However Gumbel was found to be the best model.

For the percentage difference of seven return period between Gumbel distribution and log Pearson for Warri, Benin city and Calabar for 2yrs, 5yrs, 10yrs, 25yrs, 50yrs, 100yrs and 200yrs are 2.78%, 5.45%, 7.19%, 11.4%, 10.93%,12.83% and 11.42% where 100yrs gave the highest percent for Warri. 2.12%, 4.35%, 10.11%, 9.71%, 10.69%, 11.09% and 12.585 where 200yrs gave the highest percent in Benin city.0.79%, 6.22%, 4.95%, 8.27%, 9.56%, 11.50% and 9.81% where 100yrs gave the highest percent for Calabar.

5.2 Recommendations

This study should be carried out in order to make adequate comparison between the various probability distribution which are used to fit in different hydrological data such as rainfall data, flood discharge etc. And also using a combination of stream gauge, historical and paleoflood records to extend extreme rainfall records has proven to be useful in improving flood frequency analysis. Also the standard of the data recording and storage facilities should be improved to enable accurate data.

REFERENCES

Abbett, Robert W., American Civil Engineering Practice, John Wiley & Sons, 1956

Agnone JC (ed.) (1995) Raging Forces: Earth in Upheaval. National Geographic Society.

Ann. Math Statist, 12(2), 163-190 Haddad, Aziz, K., Rahman, A., Weinmann, P.B. and Ishak, EH. (2009). A Probabilistic Model for Estimation of Large Floods in Ungauged Catchments.

Application to South-east Australia. In Proc, 31" Hydrology and Water Resources Symp.. Newcastle, Australia. HRU (1972) Design Flood Determination in South Africa Report No. 1/72, Hydrological

Barry JM (1997) Rising Tide: The Great Mississippi Flood of 1927 and How It Changed America. Simon and Schuster.

Boston, MA: American Meteorological Society.

Brown, Richard; Chanson, Hubert; McIntosh, Dave; Madhani, Jay (2011). Turbulent Velocity and Suspended Sediment Concentration Measurements in an Urban Environment of the Brisbane River Flood Plain at Gardens Point on 12–13 January 2011. Hydraulic Model Report No. CH83/11. p. 120. ISBN 978-1-74272-027-2.

Cembel, E. (1941). The return period of flood flows

Chanson, H., Brown, R., McIntosh, D. (26 June 2014). "Human body stability in floodwaters: The 2011 flood in Brisbane CBD". In L. Toombes (ed.). Hydraulic structures and society - Engineering challenges and extremes (PDF). Brisbane, Australia: Proceedings of the 5th IAHR International Symposium on Hydraulic Structures (ISHS2014). pp. 1–9.

Cluckie ID and Collier CG (eds) (1991) Hydrological Applications of Weather Radar. Ellis Horwood.

Dingman L (1994) Physical Hydrology. Upper Saddle River, NJ: Prentice-Hall.

Ground-water flooding in glacial terrain of southern Puget Sound, Washington". Fact Sheet.

Glossary of Meteorology (June 2000) Flood Archived 2007-08-24 at the Wayback Machine, Retrieved on 2009-01-09

Gumbel, EJ. (1941). The return period of flood flows. Ann. Math. Statist, 12(2), 163-190.

Hirabayashi, Yukiko; Mahendran, Roobavannan; Koirala, Sujan; Konoshima, Lisako; Yamazaki, Dai; Watanabe, Satoshi; Kim, Hyungjun; Kanae, Shinjiro (September 2013). "Global flood risk under climate change". Nature Climate Change. 3 (9): 816–821.

Hill CE (ed.) (1986) Nature on the Rampage: Our Violent Earth. National Geographic Society.

How climate change is making record-breaking floods the new normal". United Nations Environmental Program. 3 March 2020.

Hjalmarson, Hjalmar W. (December 1984). "Flash Flood in Tanque Verde Creek, Tucson, Arizona". Journal of Hydraulic Engineering. 110 (12): 1841–1852.

Houghton-Carr, 1999 Flood Estimation Handbook, Volume4 Restatement of theFlood Studies Report Rainfall-Runoff method. Institute of Hydrology, Wallingford, Oxfordshire, UK, 288 pp.

Hualou, L. (2011). Disaster Prevention and Management: A Geographical Perspective. Disaster Advances 4(1) January 2011

Lorenz EN (1993) The Essence of Chaos. Seattle: University of Washington Press.

Ludlam F (1980) Clouds and Storms. University Park, PA:

Pennsylvania State University Press.

Pruppacher HR and Klett JD (1997) Microphysics of Clouds and Precipitation, 2nd edn. Dordrecht: Kluwer Academic Press.

Ray P (ed.) (1986) Mesoscale Meteorology and Forecasting.

Research Unit, Department of Civil Engineering, University of the Witwatersrand, Johannesburg

Sarewitz D, Pielke RA Jr and Byerly R (eds) (2000) Prediction: Decision-Making and the Future of Nature.

Simon, Andrew L., Basic Hydraulics, John Wiley & Sons, 1981

Singh , B., Rajurohit , D., Vasishth, A. and Singh ,A.(2012), Probability analysis for estimation of annual one day maximum rainfall of Jhalarapatan area of Rajasthan , India Plant Arch 12(2),1093 - 1100.

APPENDIX

For Warri

Mean =2.0246

$\sum (\log_{10} Q - \log_{10} \bar{Q})$ = -0.01364

Variance =0.00275

Standard deviation = 0.0524

g=$\frac{50(-0.01364)}{(50-1)(50-2)(0.0524)^{3}}$ = -2.01

For 2 years return period

K 2yrs = 0.307

K 5yrs =0.777

K 10yrs = 0.895

K 25yrs = 0.959

K 50 yrs = 0.980

K 100yrs = 0.990

K 200yrs = 0.995

$Y_T = \bar{Y} + Ks_x$

Y 2yrs = 2.0246±0.307(0.0524)=2.0653

Y 5yrs = 2.0653

Y 10yrs = 2.0715

Y 25yrs = 2.0749

Y 50yrs =2.0760

Y 100yrs = 2.0765

Y 200yrs = 2.0767

For discharge for the respective return period can therefore be obtained using the formula be low

Q_T =In log Y_T

Q 2yrs = In log $2.0407 = 140.01mm$

Q 5yrs = In log $2.0653 = 143.23mm$

Q 10yrs = In log $2.0715 = 148.25mm$

Q 25yrs = In log $2.0749 = 151.16mm$

Q 50yrs = In log $2.0760 = 158.72mm$

Q 100yrs =In log $2.0765 = 162.32mm$

Q 200yrs = In log $2.0767 = 171.31$

For Benin

Mean =1.8609

$\sum (\log_{10} Q - \log_{10} \bar{Q})$ = 0.02080

Variance =0.0055

Standard deviation = 0.07415

g=$\frac{50(0.02080)}{(50-1)(50-2)(0.07415)^3}$= -1.085

For 2 years return period

K 2yrs = -0.164

K 5yrs =0.758

K 10yrs = 1.340

K 25yrs = 2.043

K 50 yrs = 2.542

K 100yrs = 3.022

K 200yrs = 3.489

$Y_T = \bar{Y} + Ksx$

Y 2yrs = 1.8609±0.164(0.07415) =1.8730

Y 5yrs = 1.9171

Y 10yrs = 1.9603

Y 25yrs = 2.0123

Y 50yrs =2.0493

Y 100yrs = 2.0849

Y 200yrs =2.1110

For discharge for the respective return period can therefore be obtained using the formula be low

Q_T =In log Y_T

Q 2yrs = In log $1.8730 = 121.64mm$

Q 5yrs = 128.62

Q 10yrs = 130.26

Q 25yrs = 142.80

Q 50yrs = 149.02

Q 100yrs = 156.43

Q 200yrs = 162.12

For Calabar

Mean =2.0246

$\sum (\log_{10} Q - \log_{10} \bar{Q}) = 0.012386$

Variance =0.00051

Standard deviation = 0.02257

$g = \frac{50(0.012386)}{(50-1)(50-2)(0.02257)^{3}} = 0.011$

For 2 years return period

K 2yrs = 0.000

K 5yrs =0.842

K 10yrs = 1.282

K 25yrs = 1.751

K 50yrs = 2.054

K 100yrs = 2.326

K 200yrs = 2.576

$Y_T = \bar{Y} + Ksx$

Y 2yrs = 2.0246±0.000(0.02257) =0.0457

Y 5yrs = 2.0436

Y 10yrs = 2.0535

Y 25yrs = 2.0641

Y 50yrs =2.0710

Y 100yrs = 2.0771

Y 200yrs =2.0827

For discharge for the respective return period can therefore be obtained using the formula be low

Q_T =In $\log Y_T$

Q 2yrs = In $\log 0.0457 = 109.07mm$

Q 5yrs = 110.56

Q 10yrs = 119.11

Q 25yrs = 123.90

Q 50yrs = 128.76

Q 100yrs = 132.43

Q 200yrs = 140.98

Gumbel warri

Mean =121.9

Variance =155.76

Standard(sx) =$\sqrt{155.76}$ =12.48

Where n = 50 yrs

y_n= 0.5465 σn = 1.1607

Y_T = $-(0.834+2.303\log(\frac{T}{T-1})$

For 2yrs Y_T = $-(0.834+2.303\log(\frac{2}{2-1})$ = 0.3665

For 5yrs = 1.4999

For 10yrs =2.2504

For 25yrs =3.1985

For 50yr =3.9091

For 100yrs = 4.6000

For 200yrs=5.2958

$Q_T = Q + S_x\ (\frac{Y_T - Y_n}{\sigma})$

For 2yrs Q_T= 121.9 + 12.48(-0.1550)=142.93 m^3/s

5yrs = 151.25 m^3/s

10yrs = 159.32 m^3/s

25yrs = 169.51 m^3/s

50yrs = 177.15 m^3/s

100yrs = 184.58 m^3/s

200yrs = 192.07 m^3/s

For Benin

Mean = 108.15

Variance =134.16

n = 47 years

Standard deviation = $\sqrt{134.16}$ =11.58

$Q_T = Q + S_x (\frac{Y_T - Y_n}{\sigma})$

For 2yrs = 108.15 + 11.58(-0.1550)=124.25 m^3/s

5yrs = 134.34 m^3/s

10yrs = 144.14 m^3/s

25yrs = 156.51 m^3/s

50yrs = 165.79 m^3/s

100yrs = 174.80 m^3/s

200yrs = 183.89 m^3/s

For Calabar

Mean = 141

Variance =229.59

Standard deviation $=\sqrt{229.59} = 15.15$

n= 48years

$Q_T = Q + S_x \left(\frac{Y_T - Y_n}{\sigma}\right)$

For 2yrs $Q_T = 141 + 15.15(-0.1550) = 109.44$ m^3/s

5yrs = 117.66 m^3/s

10yrs = 125.15 m^3/s

25yrs = 134.60 m^3/s

50yrs = 141.69 m^3/s

100yrs = 148.59 m^3/s

200yrs = 155.53m^3/s