FLOOD MANAGEMENT STRATEGIES : A GLOBAL PERSPECTIVE

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ABSRACT
The review centered on flood management strategies in Nigeria, and globally given the spate of flood in Nigeria and other parts of the world The terrain of coastal town in Nigeria as well as their vulnerability to flood were briefly described, The various strategies for managing floods such as flood plain management, , flood modeling, , use of Goegraphi information system, Global positioning system, structural approach, hydro plate, geomorphologic approach, flood risk mapping, HEC-RAS, historic approach etc were discussed It was concluded that floods cannot entirely be prevented, floods also have benefits that can be harnessed, Floods have caused colossal damages in many Nigerian towns and cities..Enactment of strict land use and management laws should be enacted and well enforced to mitigate flods caused by human activities. Government and donor agencies should help fund research in flood prevention and management..Early and adequate preparations flood occurrence were recommended
Keywords Flood , Management, Strategies Environment, Nigeria

1.0 INTRODUCTION

Floods are an inevitable natural disasters that cannot be completely prevented or stopped, being a natural event continually induced by human activities, lifestyle and interferences. The negative impact of flood can be reduced through effective management covering all flood management timelines of preparedness, mitigation, evacuation, adaptive and recovery measures.

Proper understanding and continuous monitoring of the geography (watershed) and climate of an area, the history of flood, causes and incidences, risk and vulnerability of the people to flood disaster, existing management, control and coping strategy of the people are very vital for proper preparation and sustainable management of disaster particularly flood (Onuigbo 2017, Ismail and Opaluwa, 2013). Geographic information system (GIS) and Remote Sensing offers a synoptic view of the spatial distribution and dynamics of hydrological phenomena such as flood and erosion. They are used to measure and monitor the extent of flooded areas, provide a quantifiable estimate of the land area and infrastructure affected by flood (Onuigbo, 2017)

There's however need to move from the traditional strategy of running away from flood to confronting and living with the flood, while maximizing and harnessing its advantages while also reducing maximally its negative impacts by reducing damages from severe flood (Ocheja *et al.,* 2014)

Many researchers have opined that climate is changing and causing a lot of variability in rainfall characteristics, temperature, river and sea level rise, and rise in flood and other disasters occurrences around the world causing colossal damages to the environment and properties, impoverishing the people, causing injuries and deaths. (Oc holi, 2014; Okoye, 2009; Suleiman *et al* .,2019) Usually, the rains are heavier during the months of June and July and with the opening of Cameroon's Lagdodam, the Kainji dam, and the Shiroro dam, the Niger valley is usually flooded causing a lot of damage to humans, properties and constant economic losses. Floods have become a recent decimal in Nigeria, occurring every year, therefore there is the need to review the existing flood management strategies ,while trying to fashion out new methods or techniques, these techniques can be employed by town planning agencies, emergency management agencies , development agencies /organisations for enacting strict land use and management acts, mitigation strategies , rescue and rehabilitation

2.0 LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 Concept of Flood

Flood is an overflow or backwash of water that submerges a land that is usually dry and saturated that occurs in different categories and extent. Flood is a natural hazard like drought and desertification which occurs as a result of an extreme hydrological (run off from heavy precipitation) event (Nwafor, 2006). The term flood as also defined by Sada and Odemerh (1988) represents high rate of water discharge which often lead to inundation of land adjacent to stream often caused by intense or prolong rainfall. Zbigniew, *et al* ,(2013), however went further to describe flooding as overflowing of the normal confines of a stream or other body of water or accumulation of water over areas that are not normally submerged. These then meansa flow of water over areas which are habitually dry which may result from storm surge, melting of glacier, snow melt or heavy rainfall. It is a temporary covering by water of land normally not covered by water. A condition of flood also occur when the discharge of a river cannot be accommodated within the limits of its normal channel, water thus spreads over adjoining low-lying grounds on which farmlands or urban structures including residential areas may occupy (Abashiya *et al.*, 2017, Strahler and Strahler, 2003).This include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and include floods from sewerage systems.

Floods are the most common natural disasters and their incidence and negative impact are on the increase worldwide (Paul, *et a*l 2010). Flood can strike anywhere without warning, and is generally a temporary condition of partial or complete inundation of normally dry areas from overflow of inland or tidal waters or from unusual and rapid accumulation or runoff (Akintoye, *et al*, 2016).

The terms floods, flood hazard, and flood risk cover a broad range of phenomena. The terms such as flood risk and flood losses are essentially our interpretation of the negative economic losses and social consequences of natural events.

Flood Vulnerability: Vulnerability refers to the degree of fragility of a natural or socio-economic community or a system (natural or socio-economic) towards natural hazards. It is a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of the impact and the consequences of natural hazards. Vulnerability is determined by the potential of a natural hazard, the resulting risk and the potential to react to and/or to withstand it, i.e. adaptability, adaptive capacity and/or coping capacity.

Flood Damage: The amount of destruction or harm, either in health, financial, environmental function and others as a consequence of an occurred hazard is referred to as damage. flood

Flood extent: Flood extent is the amount of space, degree or distance to which the flood gets to such as length, area, volume, or scope and the extent of the damage caused by the flood.

Flood plain maps: This indicates the geographical areas, which could be covered by a flood according to one or several probabilities: floods with a very low probability or extreme events scenarios; floods with a medium probability (likely return period >= 100yrs); floods with a high probability.

2.2.1.1 Types of Flood

Several types of floods occur but based on the geomorphology of a location, only a few may be experienced in that particular location. The following are the classifications of flood generally but encompasses several flood sub types (United Nations, 2012), the following are the types of flooding:

A. Pluvial (Surface) Flooding

When heavy rainfall produces a flooding event exclusive of an overflowing water body, it is referred to as pluvial flooding (World Meteorological Organization, 2013). The most common type of pluvial flooding is urban drainage. In undeveloped locations, nature provides the drainage system but once an area is built up, it becomes necessary to find ways and means of eliminating excess water which cannot infiltrate the ground due to impervious surfaces. The idea of urban drainage is the use of a closed passage system to contain and dispose of excess surface runoff water after rainfall. This philosophy implies that no matter how heavy the rainfall or how long it last, the drainage system should be able to contain and get rid of the runoff (WMO, 2013).

This system works very well in developed countries where all the drains are enclosed and there are gullies under every street constructed to collect water from road surfaces. The only concern is the prevention of downstream flooding and this is done through the regulating and controlling of the runoff water known as storm water management (United Nations, 2012). In developing countries such as Nigeria, most of the urban cities have open drains which make it very easy for rubbish and waste to get inside the drains and choke them. As these drains are choked, any amount of rainfall lasting any duration results in some form of flooding with heavy downpours resulting in floods whose aftermath is the loss of life and property.

B. Riverine Flooding

Riverine flooding occurs as a consequence of runoff water exceeding the capacity of channels, either natural or man-made, and overflowing to adjacent low lying areas (WMO, 2013). Riverine flooding dynamics vary with terrain. Runoff in mountainous regions may occur minutes after heavy rainfall but in flat and low lying areas, water may cover the land for days or weeks. There are two different types of riverine flooding and these are overbank flooding and flash flooding. Overbank flooding: This occurs when the volume of water in a river or stream increases and exceeds its capacity and overflows onto adjacent floodplains due to surface water runoff after a heavy downpour, the spill of a dam, melting of snow or ice jams (WMO, 2013). This is the second most common flood (heavy downpour) event in Nigeria. Flash flood is a fast and dangerous flow of high water into a usually dry area, or a swift rise in a stream or river above a predetermined flood level. It is characterized by a high velocity, intense gush of water that ensues in an existing river channel with little or no notice.

Flash floods are more dangerous and destructive to life and property than overbank flooding because of the speed with which flooding occurs and large amounts of debris carried with the flow (WMO, 2013).

C. Groundwater Flooding (Ground Failure)

The onslaught of some floods is from below ground. As the water table rises to the surface due to prolonged periods of rainfall, it can wash away portions of the topsoil. This can cause an array of ground failures which includes sinking soil (subsidence) and liquefaction; a development in which water-soaked silt loses stability and acts like a liquid (WMO, 2013). Subsidence and liquefaction may lead to mud floods and mudflows. Mud flood implies a flood in which the water conveys, about as much as fifty percent (50%) by volume, heavy masses of silt which may include coarse debris (WMO, 2013). Mud flow refers to a flood which is made up of mud and water, the make-up of the mud is a flowing mass of soft wet unconsolidated earth and fine grained debris.

D. Coastal Flooding

Coastal flooding is caused by the combination of heavy storms or other extreme weather conditions together with high tides which causes sea levels to rise above normal and force sea water on to land (WMO, 2013). The causal agents for coastal flooding are storm surges and earthquakes. A storm surge is the rise in sea water above normal tide levels due mainly to low atmospheric pressure and wind action over a long expanse of open water. When there is a storm or hurricane, suction is created by the low pressure inside the eye of the storm and this creates a dome of water. If the storm is near land, strong winds in the storm push the dome on to land as a surge. Underwater earthquakes, caused by the movement of tectonic plates, offset large extents of the ocean floor. The abrupt vertical shift over such large extents displaces large amounts of water, generating long-range and destructive waves known as tsunami (WMO, 2013). Each type of flooding type and its resulting hazard can be modeled by the different methodologies for flood hazard mapping but some methods are better suited to some forms of flooding depending on the objective and purpose of the map and the availability of data.

Flood may be classified according to the following;

1. According to Duration of Flooding;

(a) Slow-Onset Flooding: Slow-Onset Floods usually last for a relatively longer period; it may last for one or more weeks, or even months. As this kind of flood last for a long period, it can lead to lose of stock, damage to agricultural products, roads and rail links.

(b) **Rapid-Onset Flooding**: Rapid-Onset Floods last for a relatively shorter period; they usually last for one or two days only. Although this kind of flood lasts for a shorter period, it can cause more damages and pose a greater risk to life and property as people usually have less time to take preventative action during rapid-onset floods.

(c) **Flash Flooding**: Flash Floods may occur within minutes or a few hours after heavy rainfall, tropical storm, failure of dams or levees or releases of ice jams. And it causes the greatest damages to society.

2. According to Location

(a) Coastal Flooding: Coastal Floods usually occur along coastal areas. When there are hurricanes and tropical storms which will produce heavy rains, or giant tidal waves created by volcanoes or earthquakes, ocean water may be driven onto the coastal areas and cause coastal floods.

(b) Arroyos Flooding: Arroyo is river which is normally dry. When there are storms approaching these areas, fast-moving River will normally form along the gully and cause damages.

(c) River Flooding: This is the most common type of flooding. When the actual amount of river flow is larger than the amount that the channel can hold, river will overflow its banks and flood the areas alongside the river. And this may cause by reasons like snow melt or heavy spring rain.

(d) Urban Flooding: The urban area is paved with roads etc and the discharge of heavy rain can‘t absorbed into the ground due to drainage constraints leads to flooding of streets, underpasses, low lying areas and storm drains.

2.2.1.2 Causes of Flooding

Flood results from lots of conditions working individually and interdependently. These conditions are essentially natural and anthropogenic. Natural causes of flooding are generally a result of heavy rain and downpour. Anthropogenic causes of flooding are enhanced by human activities (Whitworth Malcolm, Malcolm, and Brian, 2015; Giuseppeand Felix 2018). Floods only become a hazard when they interrupt human activities, mostly built-infrastructure along floodplains and coastlines, farming commercial activities, movements etc. Essentially, flood hazards create socioeconomic loses and socio-psychological conditions of stress. Major causes of flooding are linked to human interaction with the environment (e.g., urbanization and agricultural activity). As urbanization increases, natural surfaces are replaced by buildings, paved roads and concrete surfaces, which do not readily allow water to infiltrate into the ground. The effect consequently is that a large proportion of rainwater, which normally should infiltrate into soil or be intercepted by plants, is immediately converted into surface runoff. The construction of dams and other water control structures is a bid to harness available water resources. However, the failure of these structures, occasionally as they may be, has also resulted in floods (e.g., the collapse of the Bagauda Dam near Kano in 1988).

The encroachment of buildings on floodplains through towns and cities and poor waste management causes blockage of existing drainages facilitating flooding. In addition, poor city planning and management, alongside natural rain-induced causes, can be injurious to urban setting. Six general causes of flooding have been identified in Nigeria, they include: heavy rainfall (tropical climate combined with a relating wet season); soil nature (poor infiltration of rainwater flow and soil percolation); deforestation (increased removal of forest and vegetation, particularly within lowlands, flood plans and valley beds; Musa *et al*., 2016); climate change (increase in rainfall, raise in water volume of seas and rivers as a result of increased temperature and ice melting- the flood disaster of 2012 and indirect aggravation of flood patterns in flood prone areas (Nkwunonwo, Whitworth, Baily, 2016); poor waste disposal (causing blockage of drainage channels especially in urban centers); and poor land use policy planning and management (improper sitting of buildings, structures, road and drainage construction

2.1.2.4 FLOOD IMPACTS

Effects of flooding

Flooding affects every section of the environment, people, economy and systems in any city where it occurs; some of these impacts are summarized below:

2.2.3.1 Economic effects

1. Causes destruction to Public buildings, Public utility works, housing and house –hold assets.

2. Results in loss of earnings in industry and trade

3. Causes loss of earnings to petty shopkeepers and workers

4. Leads to loss of employment to daily earners

5. Leads to loss of revenue due to Road, Railway Transportation Interruption

6. Causes a hike in prices of essential commodities.

7. After flooding, government and nongovernmental organizations has to put in a lot of resources to aid affected people e.g., police force, fire control, and aid workers purposely for restoration of flood affected structures, persons, live-stock etc. Flooding usually causes great economic loss to the states, individuals and to the society generally.

2.2.3.2 Environmental Effects

Flood results to imbalance of eco-system of the area it occurs. Causes damage to the surroundings environment, forests, ridges, wild-life, zoo, urban community-trees, water bodies, shrubs, grass, and fruits/vegetables. Flooding also results in loss of biodiversity, some wildlife migrate to other areas or even die due to change and disruption of habitats.

2.2.3.3 Effect on Traffic

Flooding results in the damage and collapse of roads, collapse of bridges which further leads to traffic congestion limiting the day-to-day activities of the people.

2.2.3.4 Effect on Human Beings

1. Human lives: Every year floods incidence calm hundreds and thousands of lives around the world. A good number of persons are left homeless and forced to move to camps leaving their ancestral homes culture and investments.

2. Psychological impact: Persons of all ages left with various impacts from flooding incidence usually suffer psychologically as a result of the aftermath effect ie been stranded without homes, loss of businesses, loss of properties, loss of means of livelihood, diseases etc. this psychological impact may last for a whole life time.

3. Disease: Flooding usually is accompanied with infectious diseases like, fever, pneumonic plagues, dysentery, common cold, cholera, diarrhea, typhoid, worm infections etc. The chances of food poisoning is also increased as flood water may flow into stored food and ingested without proper cooking and also due to interrupted power supply which may cause spoilage of stored food in the refrigerator.

4. Public Inconveniences: The people in affected areas are faced with a lot of inconveniences due to several destructions to public utilities i.e roads, schools, hospitals, offices etc. Flooding cause's impairment to transportation and communication system which leaves the people stranded e.g. school children, college students, office goers, vegetable, milk venders etc. There is difficulty in making basic and essential commodities reach the common persons as a result of the miss functionality of the system. This results either to hike in prices of commodities and starvation of the poor common persons.

2.2.4 Benefits of Flooding

Generally flood is seen as been only destructive to man, his properties, his economic activities and his environment. While in the actual sense flood is accompanied with a lot of benefits such as ground water recharge, increase soil fertility by providing nutrients in which it is deficient. Flood waters provide much needed water resources in arid and semi-arid regions particularly where precipitation events can be very unevenly distributed throughout the year. Ecosystem maintenance around the river corridors is a function of flooding and a key factor in maintaining floodplain biodiversity. Flooding adds a lot of nutrients to lakes and rivers which leads to improved fisheries for a reasonable number of years, and also because of the suitability of the floodplain for spawning, flooding makes it easier. Fishes also make use of flood waters to reach new habitats. Like wise Birds also profit from the boost in production caused by flooding like fishes.

Periodic flooding was and is crucial to the well-being of ancient town and cities along the Tigris-Euphrates Rivers, the Nile River, the Indus River, the Ganges and the Yellow River, and Lokoja among others. The viability for hydrological based renewable sources of energy is higher in flood

3.0 METHODOLOGY

Literature materials on floods, and flood management strategies were sourced from Journals, Conference proceedings , book, bulletins etc , they were then discussed and reviewed

4.0 DISCUSSION

4.1 Flood Management

The huge losses sustained from flood throughout the world have stimulated actions to deal with flood problems as a priority issue. Both structural and non-structural measures have been undertaken to tackle the problem (Khanna,*et al* 2008)

4.1.1 Structural Flood Management

It was initially believed that the way to reduce flood damage was to manage the rivers through structural measures and moderate the floods. Structural measures as the name implies involve the construction of structures like dams, embankments, drainage channel etc. However after spending hug amount of money on flood management works, it was realised that this approach was not effective. The reason is not farfetched; as anyone living by the river is at risk of its flooding when flood occurs which the structure cannot contain. Individuals suffer more damage than what they would have suffered had the structure not been built in the first place. Besides, there are various difficulties in the construction of flood management structure (like financial constraints). Due to which it is not possible to protect all flood prone areas from floods of all magnitudes.

It was thus, learnt that we should not try to mitigate flood damages by only keeping the water away from the people. This also made the people realized the important of flood plains. Flood plain is the land adjoining the river which it occupies during floods and can be used for dry season farming. The study and use of flood plain in this manner is called "flood plain management" and the reduction of flood damage in this manner is called the "non-structural" approach (khanna,*et al* 2008).

2.2.4.2. Non-structural

An increasing attention is now being laid on the non-structural measures. The important non structural measures are therefore, described below;

A. Floodplain Management

A flood plain is an area of land that is prone to flooding. People realize it is prone to flooding because it has flooded in the past due to a river or stream overflowing its banks. A flood plain usually is a flat area with areas of higher elevation on both sides. Flood plains can be very small or very large. Small flood plains sometimes are part of a valley. Houses that are built in small flood plains often require more insurance coverage because damage due to flooding is more likely to occur there than in higher elevations. large flood plains can almost take up entire countries.

In Vietnam's Mekong River delta, the flood plain of the Hau and Tien rivers covers more than 12,000 square kilometers (7,450 miles). Flood plains usually are very fertile agricultural areas. Floods carry sediment rich in nutrients and are spread over a wide flood plain area. Flood plains are flat with relatively few rocks to no rocks or other large obstacles that may prevent farming. The flood plains of the Nile River have been Egypt's center of agriculture for thousands of years. Floods are usually seasonal and can be predicted months ahead of time. The ability to develop agriculture, the transportation allowed by rivers, and the normally stable flood season make flood plains ideal locations to develop urban areas (Agada and Nirupama, 2015).

Flood protection infrastructure generally comprises river banks protections, the floodplain zoning, planned urbanization, restoration of abundant channels, dredging of rivers and streams, increased elevations of roads and village platforms, building of efficient storm sewer systems, establishment of buffer zones along rivers, conservation tillage, controlled runoff near construction sites, adjustment of life-style and crop patterns, good governance, and improvement in flood warning/preparedness systems (Kasnon, *et al.*, 2014).

A floodplain is a low-lying region that borders a river, a creek, a lake, an ocean, a coast or an alluvial mountain formation. The area generally lies above the high-water mark and is dry except in times of flooding. Floodplains are often described in terms of certain geographical and topographical designations. They can also be categorized by the yearly statistical odds of flood occurrence.

i. Riverine Floodplains: Riverine floodplains are usually defined as wide, flat areas that lie adjacent to a river, creek, lake or coastline. Riverine flooding can inundate the plain for days or weeks. The water covering a riverine floodplain is generally shallow, but it can rise if rains continue to fill river channel hundreds of miles upstream.

ii. Mountainous Floodplains: Mountainous floodplains are frequently located within ranges characterized by steep river valleys or a peak that has eroded into an alluvial land. Floods in these areas are often of the "flash" variety, occurring with little warning. Mountainous floodplains may be decimated by walls of debris-filled water which possess incredible force but are of short duration.

iii. Estuarine Floodplains: Estuarine floodplains are the areas lying between the mouth of a river and an ocean. Bays, harbours, sounds, inlets and marshlands are estuaries. Estuarine floodplains are usually submerged when tides suddenly rise and a storm surge takes place, as in the case of hurricanes or cyclones.

iv. Periodic Floodplains: Periodic floodplains are categorized by names such as "100-year" floodplain. The statistical reference does not mean that a gigantic flood will happen every 100 years. It instead refers to the idea that there is a one in 100 chance, in any given year that a specific land area will be covered by a certain amount of water. Periodic floodplains may rarely experience flooding, but when they do, the results can be catastrophic.

v. Coastal Floodplains: Coastal floodplains are the areas bordering an ocean or large lake. These areas generally are afflicted with rising waters stemming from storm surges or hurricanes and are not protected by an estuary. Loss of life can be extreme when a coastal floodplain experiences a natural disaster, as was the case with the Indian Ocean earthquake and tsunami that crippled Thailand in 2004.

In the management of flood disasters, flood hazard/risk mapping is one of the vital steps undertaken to prepare for and mitigate the effects of a flooding event. Some of the other vital steps may include vulnerability analysis, climate forecasting, flood plain management and enforcement of standards and codes (United Nations, 2012).The operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works and floodplain management regulations.

Floodplain Management Regulations: Zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (covering, for example, floodplains, grading and erosion control), and other regulations to control future development in floodplains and to correct inappropriate development already in floodplains (Floodplain Management Association, 2005). Effective floodplain management requires a sound understanding of the physical, biological, geological and chemical processes that impact flood hazards. It is equally important to understand the social processes involved in human interaction with the floodplain (Dunbar *et al.*, 1995). Floodplains are rich and fertile lands located downstream in the watershed. They attract human settlements as they are flat and spacious for cities, have rich fertile soil for agriculture and provide good access to the river for waste disposal and transport methods. Many major cities are located on floodplains for these "ideal "conditions.

The past few decades have seen an increase in human migration to cities. This has resulted in overcrowding, placing stresses on services, resources and natural resources resulting in increasing vulnerability and flood risk. Floodplain management is a multi-sectoral and multi-stakeholder process that must be based on planning. The national government plays a role in promoting the concept of floodplain management as part of an integrated watershed management (IWM) approach. There should be suitable legal backing to uphold the law and stand up to large private companies, agricultural workers, tourist companies and anyone who may be opposed to management activities because of their personal interests in the area.

Floodplain management is aimed at reducing vulnerability to flooding and the losses that occur. It does so by enabling the best use of the floodplain to minimize risk while considering the need for economic development, agriculture and human recreation. It is essential for planning new developments, treating existing risk and also residual risk (risk that remains after mitigation strategies have been applied). The way in which the floodplain is managed depends on its characteristics and the nature of the human settlements. Ideally, the solution would be to keep people away from the floodplain, but in most occasions, development has already occurred and a suitable risk reduction strategy must be employed. As well as addressing flood risk in terms of location, floodplain management also includes addressing other related risks such as health risks associated with the discharge of industrial, agricultural and untreated sewage waste into waterways. The tools that are applied to implement floodplain management include land use planning, zoning and zoning regulation, building codes, and urban and rural planning, policy and legislations. The supporting mechanisms include:

a. Pilot programs.
b. Institutional arrangements and capacity to enforce and uphold the legislation.
c. Developing the capacities of local staff which are to enforce the law.
d. Training staff to use appropriate tools such as GIS.

e. Monitoring and evaluating the effectiveness and feed back to the management process.

Asrat (2015) assess urban flood response planning and resilience in Calgary and Toronto. The case study examined flood response planning, tools, and the barriers experienced. The interview questions generally covered five theme areas: resilience planning, uncertainty and forecasting, tools that work well, tools that didn‘t work well, and barriers. Each of these themes brings together several related points addressed in the interview protocol.

B. Flood Plain Regulations and Enforcement of Standard Codes

Nigeria, like many other developing nations, is experiencing rapid rates of urbanization. This has led to increased land fragmentation and the indiscriminate building of structures often in places which are within the natural courses of streams and rivers. Consequently, storm waters from roofs and paved surfaces have no natural channels to follow. The solid waste disposal habits of Nigerian urban dwellers are relatively poor; people dump their refuse into nearby streams or otherwise prevent the natural flow of rain water. These features according to Akin (2009), coupled with changes in the rainfall regime often result in extensive flooding in the urban environment.

Standards and codes for flood-prone areas should be enforced to help minimize the impact of flood events. Enforcement procedures should be simple enough to aid the implementation of penalties with regards to non-compliance to the standards and codes. Regular emergency response drills should be undertaken to ensure that flood prevention measures still work (WMO, 2013).

Obinna (2016) examined the impact of incidents of flooding in Nigeria with a view to ascertain the level of implementation of government policy on mitigating the effect of this natural disaster in 2012. This is against the backdrop that the study of government policy response in Nigeria has become integral to extant development debate among scholars, policy makers and development practitioners. The focus has shifted from reactive to proactive measures in addressing incidents of natural disasters. It explained the policies of government towards addressing the problem of flooding in Nigeria, as well as the strategies implemented. The study focused on three (3) Niger Delta states: Rivers, Bayelsa and Delta. It examined the activities of federal and state agencies in the respective states. Agencies examined included the States Ministries of Environment, the States Emergency Management Agencies, and the National Emergency Management Agency (NEMA) in the South-South Zone. It was observed that these Ministries and Agencies made frantic efforts to achieve the mandates for which they were established, but were constrained due to some external factors, particularly funding and lack of trained manpower and personnel.

C. Flood Forecasting

Based on identified changes in the patterns of ocean and atmospheric circulation, the magnitude of a storm can be forecasted and this information can help in emergency response preparedness. This information can be used to reduce the severity of flooding when it occurs by creating awareness, increasing flood storage and management of fresh water (United Nations, 2012).

D. Flood plain zoning

Flood plain zoning is the process of classification of areas liable to floods of different frequencies in the vicinity of a river. These areas are then marked on large scale maps along side with close contour intervals and displayed at public places for wide publicity. Very little work in this field has been done in India while this requires greater attention in our country because of its high population density. Flood hazard zone mapping can be used as a means of non-structural flood control planning of the flood plain and for making policy decision to regulate the flood plain development activities. Using historic satellite data combined with hydrological and close contour data, a flood hazard zone map can be prepared for flood prone basins (Khanna, Agrawal and Pravin, 2008).

2.2.3.1.1 Historic Approach

Pertinent information to delineate flood regions may be gathered from old maps, photographs, satellite images, written reports, or any other document. The historic approach is generally used for broad purpose flood assessments maps and initial flood assessment maps. This approach affords data on areas noted to have been inundated in the past by flood waters. The data to be derived from maps and satellite images can be in the form of dates on which flood events occur, the specific location of the affected areas and the extent of damage to human lives, property and infrastructure. Data from written reports make available information about the causes for the floods, the areas affected and the magnitude of the flood. Photographs help to compare current physical conditions of a location with the conditions existing when the reports were written. The disadvantage of the historic approach is that for a particular flood event, there may not be enough information or data covering the whole event and hence resulting flood maps are incomplete (WMO, 2013).

Wagemaker and Jemba (2015) generated a flood map for Uganda based on extreme weather events recorded in local newspapers, to aid in the disaster preparedness in flood prone Uganda. Newspaper repositories of the Daily Monitor and the New Vision, both national newspapers, were used as a data source. A database of 3726 news articles between 2001 and 2015 from the two newspapers were used. Using similar features as a base, sentences were clustered and interpreted into four classes:

1. Current flood event
2. Past event or flood warning
3. Mixed and
4. Unrelated.

The results yielded a total of 1173 of news articles with flood sentences and geographical reference. These articles were then used to generate a flood map for interested districts.

Boudou *et al.*,(2016) assessed the temporal evolution of flood vulnerability of two French cities, Besançon and Moissac, through mapping of land use from historical information. The aim of the research was to focus on the two cities that were significantly flooded in the past and to understand how their vulnerability to flooding had changed up to the present day. An initial total of 176 major floods in France since 1770 were selected based on the following considerations: diversity of flood types, strong flood hazard or spatial extent and important socio-economic impacts. The 176 floods were evaluated and cut down to focus on 9 based on three main features; flood intensity, flood severity and spatial extent of damage. Historical land use data was analyzed to allow the mapping of land use and occupation within the areas affected by the selected floods, both in past and present contexts, to provide an insight of the complexity of flood risk evolution at a local scale.

2.2.3.1.2 Geomorphologic Approach

This approach involves the interpretation of distinct marks left in the landscape by past Floods and flows. The interpretation can be used to derive flood extents and other parameters such as magnitude of flood can be derived to a certain degree. This approach can also be used for broad purpose flood assessments maps and initial flood assessment maps but it is frequently used for validation during the stage of detailed mapping. Geomorphologic approach is most advantageous when there is the need to determine the effect of erosion and deposition in the flood plain but the method is rather restraining because it is mostly applied over small areas such as river basins and streams and it is time demanding, in that, it requires data over a long stretch of time of how the landscape has changed with past floods and flows; that is, geological time scale (WMO, 2013).

Fernandez-Lavado *et al.*,(2007), developed a hazard map for flash-floods in the municipality of Jucuaran, El Salvador by mapping the geomorphologic evidence such as alluvial fans, preferential stream channels, erosion and sedimentation. The geomorphologic effects caused by hurricane Mitch in 1998 were regarded as a reference event. The process for developing the hazard map involved three complementary techniques; vertical aerial photo-interpretation of the river basins; Fieldwork and eyewitness reports; and Community workshop. Evidence from aerial photographs were corroborated from local people during fieldwork and the community workshop was used to obtain a historical perspective and specific information about the reference event (Hurricane Mitch) to complement eyewitness reports obtained during field work.

2.2.3.1.3 Modeling Approach

Flood Modelling

Sunil *et al.*, (2014) defined flood modelling as one of the engineering tools which provide accurate information on the flood profile with the rainfall, runoff, and catchment characteristics, and return period as the parameters that govern the flood. Brych, *et al*., (2012), have attempted the hydraulic modelling using soft computing tools. Also Yi Xinog (2011) have used different parameters as variables and found that hydraulic modelling is an effective tool for the mitigation measures. However, this study will utilize GIS and HEC-RAS software for modelling which is believed to be more effective and accurate in flood analysis as the tools are commonly used and have been employed by researchers for conducting various types of studies including building flood forecasting and flood inundation models (Whiteaker *et al.,* 2006), analyzing different flood control alternatives, addressing social impacts of small dam removals (Wyrick *et al.,* 2009) and developing a flood early warning system.

GIS software together with remote sensing (Microwave and optical Satellite images), hydrological and hydraulic data can be used to simulate floods of different magnitudes. The modeling approach is generally used for detailed flood assessment. To accurately determine and model flood prone areas for an entire series of flood events (for 20 or 30 or 100 years), mathematical applications are essentially required. The modeling approach employs geographic data such as topography, land use and land cover, bathymetry; Hydrological/hydraulic data such as river discharge, rainfall, peak discharge, water velocity and elevation; soil geology, etcetera, to develop flood hazard maps. Currently there is a number of software which can model flood plains in one and two dimensions and generate maps (Sayers *et al.,* 2013). Given that the modeling approach uses satellite imagery together with software and given the synoptic nature of satellite imagery, the modeling approach has the advantage that it can be applied over a large area in a comparatively short period of time. It enables direct observations of flood events and prediction of flood events and its behavior. The disadvantage for optical satellite imagery is that it requires cloud-free conditions, acquired only during daytime, and is unable to penetrate flooded areas under canopies formed by trees. Microwave satellite imagery does not have this problem (Sayers *et al.,* 2013).

Understanding the level and degree of susceptibility of exposures to flood hazards helps in effective flood risk analysis. Although the meaning and the concepts of vulnerability is being contested by researchers, it remains an essential element in analyzing risk and also providing adaptation measures against disaster (Birkmann, 2013).

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Hierarchical Process (AHP) was adopted to assign weights to various contributory factors such as elevation, land use, rivers and roads to determine the most vulnerable zones within the area; these were integrated using re-classification and overlay analysis in GIS to determine the flood affected areas.

Nwilo *et al.,*(2012) assessed the physical vulnerability of some communities in Adamawa State, Northern part of Nigeria by modelling the flood inundation level using Remote Sensing and Cellular Automaton Evolutionary Slope and River (CAESAR) software. The output of the model shows the water heights and possible settlements at risk within the flood prone areas of the inundation.

2.2.3 Flood Models.

2.2.3.1 The Hydroplate Model

The hydroplate theory has the advantage of explaining great devastation in the first 40 days. This theory for the catastrophic formation of the sedimentary layers during the Flood has been proposed by Walter Brown (former Chief of Science and Technological Studies at the Air War College, and Associate Professor at the U.S. Air Academy) (FEPA, 2006).

The main proposal for the origin of the Flood waters is massive destruction in the first 40 days of the Flood. (We agree with the European Flood proponents that the initial devastation was exceedingly great, but we dispute that there remains no evidence of the *mabbul* and its effects on creatures in the geological record.) The Brown hypothesis is that the Earth's crust was fractured (maybe by an impact), releasing vast subterranean waters (the "fountains of the great deep') under great pressure into the atmosphere, perhaps as high as 30 km. Brown's model essentially deals with water, but in the following continental drift phase includes volcanic activity as a result of the fast tectonic movement caused by the denying rupture in the Earth's crust (Brown, 1996). Thus, he states:

"In some regions, the high temperatures and pressures formed metamorphic rock. Where this heat was intense, rock melted. This high pressure magma squirted up locks, producing other metamorphic rocks. Sometimes it escaped to the earth's surface producing volcanic activity and "floods" of lava outpourings such as we see on the Columbia and Deccan Plateaus. This was the beginning of the earth's volcano activity." Brown (1996) further stated that, Shift of masses upon the earth creates stress and ruptures in and just beneath the earth's crust. This was especially severe under the Pacific Ocean, since the major continental plates all moved toward the Pacific. The portions of the plates that buckled downward were pressed into the earth's mantle. This produced the ocean trenches and the region called the "ring of fire" in and around the Pacific Ocean. The sharp increase in pressure under the floor of the Pacific caused ruptures and an outpouring of lava which formed submarine volcanoes called seamounts (Brown, 1996).

2.2.3.2 The Vapour Canopy Model

The vapour canopy model of the Flood is the one that has held greatest sway in scientific creationism since serious research began in the 1960s. The book *The Genesis Flood* by Whitcomb and Morris, (1996) first published in1961 and Whitcomb's later in *The World that Perished* (1996) explains this view. The vapour canopy theory is that the Earth's atmosphere was surrounded by a water vapour blanket that collapsed at the onset of the Flood. Dillow has extensively explored this concept theoretically. This model has led the field for a number of years, but has difficulties in accounting for the large amount of catastrophic upheaval in the

Earth at the beginning and through the Flood year (Mclntosh *et al* , 2000).
Catastrophie upheaval is evident, for instance, at the Old Red Sandstone rock formation from Loch Ness to the Orkneys in Scotland where an area 2500m deep and 160km across, contains countless fish, buried in contorted and contracted positions, as though in convulsion. There is all the evidence of catastrophic burial by processes (it would seem) off greater power than that provided by the vapour canopy theory. Although there may be some substance in these objections to the vapour canopy proposal, it should be noted that this model of the Flood, though it predicts late drowning of creatures by rising floodwaters, should not be regarded as tranquil. Indeed in this model, the rising waters would be extremely turbulent, and involve vast surging tidal waves. Nevertheless it is still difficult to explain the major fossil strata by this method (Robinson, 1996).
Consequently some, such as Garner, Garton, Tyler, and Robinson, object, not to the vapour canopy model of the Flood, but also (more fundamentally) to the premise that the Flood caused most of the fossils (Whitcomb and Morris, 1996). Their objection arises from their belief that the geological column represents a real time sequence (though on a fast time-scale of the one-year Flood followed by many post-Flood disasters). Because there is evidence deep in this geological column that many animals were alive on land, and yet are buried above waterborne sediments, they propose that most of the geological column was deposited after the Flood.
Thus, they propose that the Flood removed all trace of land air-breathing creatures and that most of the fossils found on the Earth were buried by post-Flood catastrophes. Known as the "European Flood model', we have sought to show in a companion article that Biblically, this is greatly straining the straightforward meaning of Genesis 6:9. Here we seek to show that to regard the geological column as a true chronological record is at best a questionable assumption. We agree with Froede that there needs to be a complete rethink of how to interpret the geological layering so evident in the rocks. Wood morappe rightly points out that the way the supposed ten periods are assigned can be quite subjective (Robinson, 1996).

2.2.3.3 Hazus-MH Flood Model

Hazus model is one of the scientific models of flood that has wide application; the model allows planners and other practitioners to carry out a variety of flood hazard analysis (FEPA, 2006). Input entails two modules that carry out basic analytical processes: flood hazard analysis and flood loss estimation analysis. The flood hazard analysis module uses characteristics, such as frequency, discharge, and ground elevation to estimate flood depth, flood elevation, and flow velocity. The flood loss estimation module calculates physical damage and economic loss from and analysis. Among the newly included features includes; A new coastal storm surge modeling capability integrating two industry standard models (SLOSH and SWAN), which now allows Hazus to predict the physical and economic impacts of hurricane scenarios on coastal flood regions. In addition to estimating the separate impacts of coastal flooding and high winds, the coastal surge scenario methodology also estimates the con general building stock in a manner that avoids double counting of flood and wind losses. Riverine Velocity has been added to the Flood module as a What-if in both Hazard and Analysis. Flood Shelter analysis has been optimized to run faster for large regions. The 200-year Return Period has been removed and a 25-year Return Period has been added to the Suite of Return Periods in the Flood module. The Flood module has implemented the modified WAFIS, adding the significant wave height transects analysis in the following areas:

i. Level 1 Coastal Flood Hazard;
ii. Coastal Surge Model Near shore analysis
iii. Coastal Surge Model Deep shore analysis; and
iv. Coastal Surge Model no SWAN grid.
v. An HPR extract utility has been added that allows users to extract specific tables and data from exported Hazus study regions (FEMA, 2006).

In achieving a good result the following components are important for flood modelling

Steady and Unsteady Flow

Flow in an open channel is steady, if the depth, discharge, and mean velocity of flow at a particular location does not change with time, or if it can be assumed constant during the time period under consideration. Flow in an open channel is unsteady if the depth, discharge and velocity of flow at some point changes with time. A time factor is taken into account explicitly in the case of unsteady flow analysis, while steady flow analysis neglect time factors altogether. This component of the HEC-RAS modelling system is capable of simulating one-dimensional unsteady flow through a full network of open channels. The unsteady flow component was developed primarily for subcritical flow regime calculations.
The steady flow regime types may be Sub critical flow, Supercritical Flow and Critical (Mixed) type. The effect of gravity upon the state of flow is defined by a ratio of inertial force to gravitational force as the dimensionless Froude Number (USACE, HEC-RAS River Analysis System User's Manual Version 4.1, 2010a).

$$F=V/\sqrt{(gL)} \qquad (i)$$

where, F = Froude number (dimensionless)
V = mean channel flow velocity (m/s)
g = acceleration due to gravity (m/s2),
L = characteristic length (m).

In open channel flow, the characteristic length is often taken as the hydraulic depth D, which is defined as the cross sectional area channel normal to the direction of flow divided by the width of the free surface. The flow is classified as subcritical, critical or supercritical, depending on the Froude number. When the Froude number is less than 1, the effect of gravitational force is less than the inertial force and the state of flow is referred to as subcritical flow. When inertial and the gravitational forces are equal, the Froude number is equal to unity, state of flow is controlled by channel characteristics at both the upstream and downstream end of the river reach. The flow is said to be at the critical stage. When the inertial forces exceed the gravitational force, the Froude number is greater than 1, and the flow is referred to as supercritical flow. In the case of supercritical flow, the flow is governed by the upstream end of the river reach (USACE, HEC-RAS River Analysis System User's Manual Version 4.1, 2010a).

Boundary condition

Boundary condition is required in order to perform the calculation. For sub-critical flow, only the downstream boundary condition is required and for super-critical flow, only the upstream boundary condition is required. Both upstream and downstream boundary conditions are required to perform some mixed flow regime calculations (NOAA, HEC-RAS River Analysis System User's Manual 2002). There are four types of boundary condition:

Known water surface profile

For this boundary condition, the user must enter a known water surface for each of their profiles to be calculated.

Critical depth

When this type of boundary condition is selected, the user is not required to enter any of the further information. The program will calculate the critical depth of the profile and uses that as the boundary condition.

Normal depth

For this kind of boundary condition, the user is required to enter the energy slope that will be used in calculating normal depth. Based on the user entered slope, normal depth will be calculated for each profile. If the energy slope is unknown, the user could approximate it by entering either the slope of the water surface or the slope of the channel.

Rating curve

When this type of the boundary condition is selected, a pop up window appear allowing the user to enter an elevation versus flow rating curve. The critical depth boundary condition has been used for this project because system itself calculates the boundary condition in this type. Rest of the methods requires additional inputs that cost more time and money..

2.2.3.2 Geographical Information System (GIS) Application in Flood Vulnerability and Risk Mapping

For years, floodplain management studies have been expensive and unwieldy, with much of the analysis performed by hand using paper maps. Today, new technologies, such as GIS, GPS, and remote sensing are floodplain managers to create accurate and current floodplain maps with improved efficiency and speed at a reasonable cost. Accurate floodplain maps are the key to better floodplain management for developing floodplain models and maps. Accurate and current floodplain maps can be the most valuable tools for avoiding severe social and economic losses from floods. Accurately updated floodplain maps also improve public safety. Early identification of flood-prone properties during emergencies allows public safety organizations to establish warning and evacuation priorities. Armed with definitive information, government agencies can initiate corrective and remedial efforts before disaster strikes (Chapman and Canaan, 2001).

According to ESRI, Geographic Information System (GIS) allows us visualize, question, analyze, and interpret data to understand relationships, patterns, and trends about location as well as essential to understanding what is happening and what will happen in a geographic space (Paterson, 2012). GIS is ideally suited for various flood plain management activities such as, base mapping, topographic mapping, and post-disaster verification of mapped floodplain extents and depths. For example, GIS was used to develop a River Management Plan for the Santa Clara River in Southern California. A GIS overlay process was used to further plan efforts and identify conflicting uses along the river and areas for enhancing stakeholder objectives. 1 inch = 400 ft (1 cm = 122 m) scale base map was created to show topography, plan metric features, and parcels. Attribute data were entered into a separate database and later linked to the appropriate map location. Six layers were created for flood protection related work: 100-year floodplain, 100-year flood way, 25-year interim line, existing facilities, proposed facilities, and flood deposition. The lessons learned from this mapping project indicate that GIS is useful in capturing and communicating a vast amount of information about the study area and the river. While the use of GIS and the process to gather and record data were not without problems, the overall value of GIS was found to overweigh those challenges (Sheydayi, 1999).

Clement (2013) applied geographic information systems (GIS) in mapping flood vulnerable areas in

Makurdi town. The study draws its relevance from the importance of a GIS database in tackling flood related problems as well as create a map of flood risk zones in Makurdi town, results of the analysis shows that Makurdi town is generally susceptible to flooding and very little has been done in steering away development from 'highly susceptible' areas. It recommends that there is need for town planners to steer development away from areas of high risk or vulnerable areas to low risk areas.

2.2.5.1 GIS with Hydraulic/Hydrological Approach

Ologunorisa (2004) assessed flood vulnerability zones in the Niger Delta region by using a hydrological technique based on some quantifiable physical features of flooding, observed frequency of flood incidence, elevation and vulnerability factors (social-economic). 18 settlements were randomly selected across three ecological zones in the region and rated based on the parameters stated. Three flood risk zones emerged from the analysis and these were the severe flood risk zones, moderate flood risk zones and low flood risk zones.

2.2.5.2 GIS with Remote Sensing Approach

Adjei-Darko (2017) generated an efficient and cost-effective flood hazard map for the Northern region of Ghana and Atonsu, a suburb of Kumasi in the Ashanti region by using level 1b ASTER imagery to generate contours and elevation. He also generated a topographic map covering the study area at a scale of 1:50000 and a land cover map. He then combined the generated maps and demographic data in a GIS environment, to create a district level map indicating flood hazard prone areas for each district.

Kusi-Appiah (2012), used land cover data obtained from a classified ASTER image, contour generated from DEM, geometric data extracted from the DEM, topographic map and field measurements collected together with HEC-RAS model to calculate floodplain elevations and determine floodway encroachments along the Susan River in the Ashanti region of Ghana. The coalesced geometric data together with the topographic maps were used to generate a flood hazard map that covered an area of approximately 2.93 km² and the analysis indicated a flood depth of 4.02m as the maximum water level. This high depth of water occurred along the main channel and spreads gradually to the floodplains.

2.2.5.3 HEC-RAS

HEC-RAS (River Analysis System) is an integrated system that comprise of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphical and tabular output, and reporting facilities of software, designed for interactive use in a multi-tasking environment (Kurniawan,*et al* 2020).

2.2.5. 4 GIS and HEC-RAS

Geographic Information Systems (GIS) are successfully used to visualize the extent of flooding and also to analyze the flood maps to produce flood damage estimation maps and flood risk map. The GIS must be used together with a hydraulic method to estimate flood profile with a given return period. After 1970, Hydrologic Engineering Centers- River Analysis System (HEC-RAS) software developed by United States Army Corps of Engineers (USACE) is widely used in Europe and America (Demir and Kisi, 2016).

Mapping and prediction of flood hazards are important aspect of flood risk assessment. Flood nature, intensity and frequency of occurrence are better understood through mapping and simulating of both the already occurred and potential flood hazards. They are essentially useful for assessment of the level of risk (knowing the affected people and properties), providing early warning in case of future reoccurrence and hydraulic design, especially for potential flood management and disaster risk reduction. Although little researches have been conducted in this area based on the existing literatures, some Nigerian scholars have however conducted researches on the flood mapping in Nigeria, with most of them using remote sensing data aided by the Geographic Information Systems (GIS).

Various GIS-based models have been used in flood simulation, including the use of specialized GIS software like SOBEK (Sunil*et al.*, 2014), HEC-RAS (Rivera *et al*., 2007; Samarasinghe *et al*., 2010), MIKE II, LISFLOOD, one-dimensional two-dimensional (1D2D) hydraulic (Koivumäki *et al*., 2010) and TUFLOW (Evans, *et al*., 2007) to mention just a few. Previously, most studies tended to use topographic maps in delineating flood extent (e.g. Evans *et al*., 2007; Forte *et al*., 2005; Ishaya *et al*., 2009) with additional data such as vegetation, digital elevation model (DEM), drainage network and satellite images.

t development debate among scholars, policy makers and development practitioners. The focus has shifted from reactive to proactive measures in addressing incidents of natural disasters. It explained the policies of government towards addressing the problem of flooding in Nigeria, as well as the strategies implemented. The study focused on three (3) Niger Delta states: Rivers, Bayelsa and Delta. It examined the activities of federal and state agencies in the respective states. Agencies examined included the States Ministries of Environment, the States Emergency Management Agencies, and the National Emergency Management Agency (NEMA) in the South-South Zone. It was observed that these

Ministries and Agencies made frantic efforts to achieve the mandates for which they were established, but were constrained due to some external factors, particularly funding and lack of trained manpower and personnel.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Flooding issues is fast becoming a serious environmental problem in the country and globally as it cannot be completely stopped. Proper and sustainable flood management strategy is most desired for a healthy environment .The traditional flood management strategy is ineffective in flood management

5.2 Recommendations

The integrated flood management strategy should be employed in mitigating floods in Nigeria

Government should assist by funding research in flood and erosion management and control

Public enlightenment on safe and sustainable land use and management.

Strict enforcements of land use and management laws.

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