Building Construction, Road Works and Waste Management: Impact of Anthropogenic Actions on Flooding in Yenagoa, Nigeria

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Abstract: Floods are generally seen as natural occurrences with other underlying causal factors. These factors are both natural and anthropogenic in nature and often induce or exacerbate flood episodes in the environment. As it were, while some of these factors stem from natural ecological cycles, others are engendered by accumulated anthropogenic actions or inactions. This study aims to examine three independent documents comprising of two technical reports commissioned by the Bayelsa State government in Yenagoa and contiguous neighborhoods and narratives from a PhD flood research with a view to understanding the nature and dynamics of anthropogenic actions causing flooding in Bayelsa State. The objectives include; a systematic review of the government commissioned technical reports on floods in Yenagoa and other related documents; identify and highlight both natural and anthropogenic causes of flooding in the study area; recommend an appropriate course of action. The study adopted direct personal observation, photography and secondary data analysis to obtain data. Findings from the combination of these documents highlight some of the deliberate human actions and/or inactions taken by both Government and private developers regarding incidents of flooding within the Yenagoa Metropolis. Based on the document's review, three key anthropogenic actions were identified; building construction and other physical development activities, waste management and drainage systems and public infrastructure development. Specific recommendations such as the adoption of a holistic approach towards harmonized flood data management framework, effective implementation of such policies to tackle these identified challenges, undertake EIA, hydrologic and hydrographic studies, as well as base line studies before embarking on any developmental projects, desilting of clogged drainage culverts and proper alignment of road projects to reduce incursion and subsequent impediment of free flow of runoffs were made.

Keywords: Flooding; Yenagoa; Anthropogenic actions; Building Construction; Road Creation; Solid Waste.

1. INTRODUCTION

Flooding is a multifaceted natural occurrence within the environment, and its impact encompasses connection among social systems, people and the natural environment because of the physical underlying destructions seen after every flood episode [1]. Over the years, it has become a common knowledge that flooding has been linked to the consequences of climate change globally. This paper examines the connection between people and naturally occurring floods by investigating some of the actions and/or inactions of people that often results in either inducement or exacerbation of flooding, which are referred to as anthropogenic actions. These actions make communities in the global south vulnerable to the vagaries of increased flooding episodes because; they are manifestations of deliberate or ignorant human choices which have over the years incapacitated cities leading to a complete makeover of ecological and environmental processes [2]. For [3], floods are natural occurrences associated with damages and loses that represent the consequences of human actions. Some of these actions may not be deliberate, such as changes in human behavior and evolving natural circumstances, which could result in increased flood vulnerability in most environments [4]. Floods in urban areas are not always caused by excessive runoff, rather, it might also be the consequence of unintended and unplanned patterns of land use which often turn useful precipitation into floods [5]. In effect, anthropogenic actions whether deliberate or not could be attributed to the predominant changes in landscapes that engender flood disaster in vulnerable locations [6]. Some of the widespread human actions taken in Bayelsa State over time and their consequences as it relates to increase in floods, as captured in three-key reports over the years, would be highlighted. It is an outcome of both private and Government sponsored actions ranging from seemingly minor activities undertaken by private home developers to major earth-distorting government organized projects.

Several studies have established that anthropogenic actions such as land reclamation, river and flood path diversion in vulnerable localities, changes in the landform and distortion of the natural environment over the years have engendered changes in the intensity and frequency of floods [7-9]. Other studies have analyzed actions relating to civil works, construction, geological works and other forms of development that have contributed to flooding. For instance, [10] identified how human-induced activities such as building on floodplains distort the flow dynamics of

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runoffs. Furthermore, [11] linked rising and more frequent floods to inappropriate human activity such as deforestation, land reclamation and improper construction of levees on the Yangtze River. Agriculture-related activities of local farmers and communities contribute in increasing the chances of flooding in most rural enclaves because they do not apply best practices in rural land use, thereby becoming prone to flood associated disasters [12].

In Nigeria, studies have linked the 2011 floods in Ibadan to twelve anthropogenic actions listed under four themes which include: hydrological actions, waste management actions, institutional actions and awareness [13]. There is an identified nexus between anthropogenic activities such as agricultural activities, oil and gas exploration and exploitation and continuous inundation in the Orashi region in Rivers State. This has led to incremental depletion in the vegetation over the years [14]. With the numerous anthropogenic activities, flood susceptibility level in the region is very high because its coastal elevation lies between 4m and 7m above mean sea level, which has significantly impacted on continual eustacy [15]. The nature of the terrain engenders tidal surges because of the rising sea levels and sometimes after intense precipitation, the low-lying coastal fringes submerge leading to flooding that could be as high as 3.2m in some locations depending on the height [16].

2. STUDY LOCATION

Bayelsa State is in the Niger Delta area, which lies in the southern part of Nigeria and is a mixture of tropical rain forests and mangrove swamps. It has a total land area of 9,059km$^{2.}$ The capital city Yenagoa is one of eight Local government areas that make up its administrative structure of the state. It has a climatic disposition of being tropical as it lies just above the Equator with an annual mean temperature range of 23.9°C – 29.5°C. The mean maximum temperature rarely exceeds 35°C. Relative humidity is high and it increases as progression is made towards the coast. The terrain is scarred by a network of tributaries, creeks and rivers, depositing their load into the Atlantic Ocean. There are ten channels from which the waters of the River Niger are emptied into the Atlantic Ocean and eight of these runs through Bayelsa State.

Yenagoa being the capital of Bayelsa State is in the North-East region of the State. This region is crisscrossed by the estuaries, creeks, rivulets of the Nun and Sagbama Rivers. These bodies of water in combination with the characteristic heavy rainfall in the region cause annual flooding and subsequent erosion. The major drainage outflow channels within the Yenagoa Capital City are the Ekole Creek, Epie Creek, Kolo Creek and Azikoro Creek. The Epie creek serves as both an inflow and outflow channel based on the season. It runs south-westward and has 59 other connecting creeks and rivulets running off it, all of which empty into the Capital City Territory. Other subsidiary creeks within the Capital city include Igbogene Creek, Akenfa Creek, Agudama Creek, Edepie Creek, Amarata Creeks 1 and 11, Onopa Creek, Otuasega Creek, and Elebele Creek amongst others [17]. The annual rainfall in Yenagoa Capital Territory is estimated to be about 2,845mm, with two peaks in July and October, respectively, at which time flooding is expected to occur.

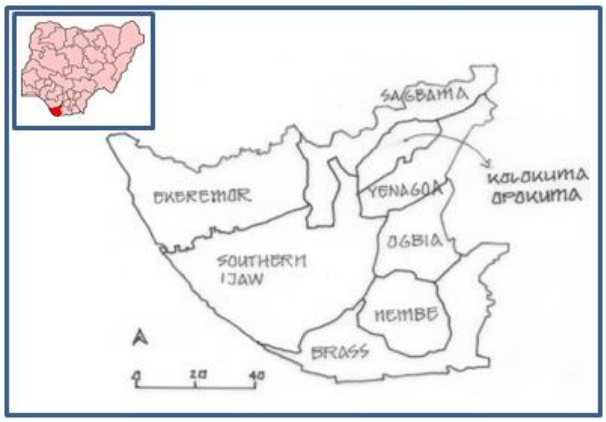

Figure 1: Map of Bayelsa State, showing 8 local government areas.

3. METHODOLOGY

This is a passive observational study based on the secondary data obtained from systematic literature review of relevant articles, official Government gazettes and policy documents that were obtained and analyzed for the study. Such secondary data include two government commissioned reports; outcome of physical site inspection of water channel locations in Bayelsa State and interaction with key stakeholders of community development institutions by the Infrastructure Advisory Committee (BSIAC) and the Post Flood Management Committee (PFMC), while the second report looks at the hydrological and hydrographic survey commissioned by the State government during the 2012 floods, to obtain benchmarks and draw up a flood vulnerability map of the capital city and its environs, and a PhD thesis on the diverse plausible causes of flooding in Yenagoa and environs. The study also adopted the use

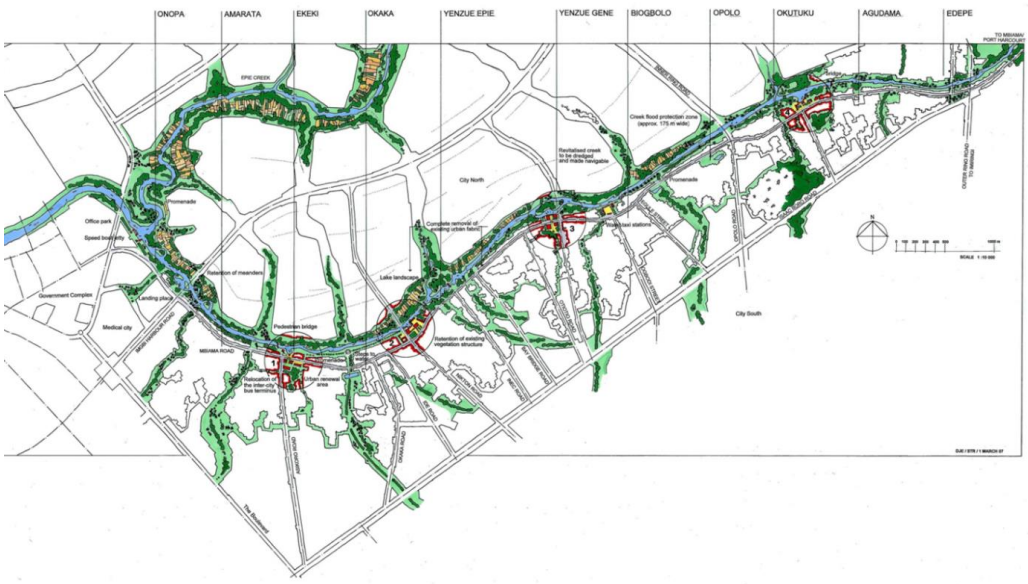

Figure 2: Epie creek and its tributaries in Yenagoa City Territory - Courtesy (Albert Speer and Partners, 2006).

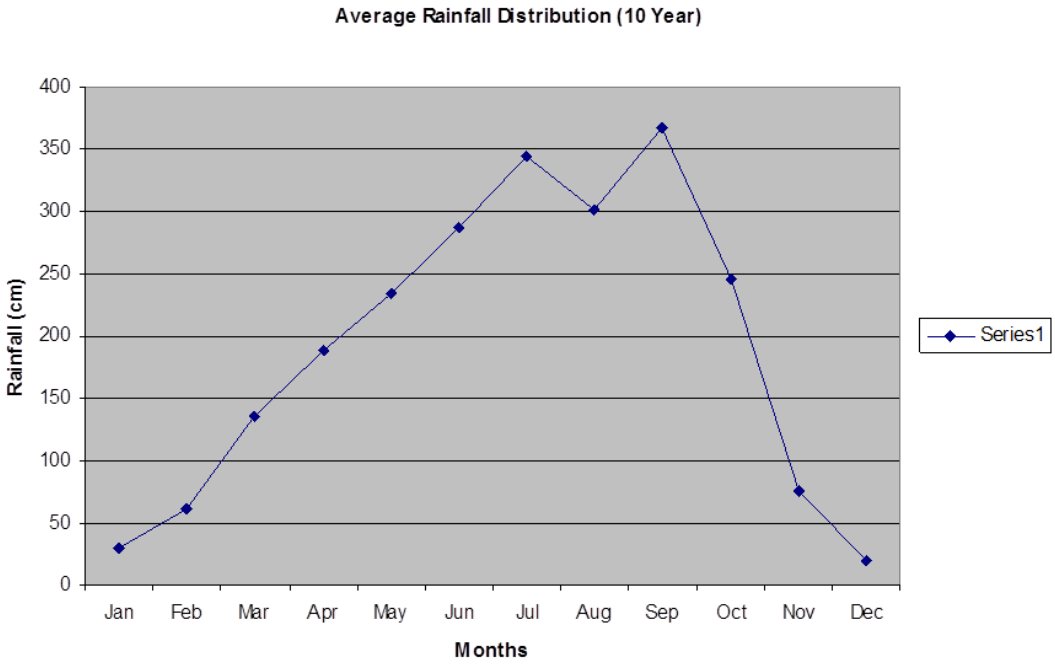

Figure 3: Average rainfall distribution for Bayelsa State (Ebakpa 2018).

of photographic imagery to highlight anthropogenic actions causing flooding in Yenagoa.

Anthropogenic Actions in Yenagoa, Bayelsa State

Challenges of flooding in Bayelsa state are both global and local. The global challenge is inextricably tied to climate change and its contribution to rising sea levels and increased differentials in weather patterns. While the local challenges are the products of low terrain levels, high rainfall intensities, high tidal levels and dam failures from the up streams of the River Niger and its tributaries. In the local communities, high floods are associated with the littoral characteristics of communities and consequent overflow of the riverbanks. This usually occurs from the banks of the communities, other creeks and streams from the back,

while in the capital city, it is caused by the inflow and outflow characteristics of natural drains and strands of urbanisation activities [17]. Urbanisation activities in Yenagoa are varied and this study intends to examine these activities that fall as anthropogenic actions. In the [17] report, it was observed that majority of flooding in Yenagoa is accentuated by sedimentation and urbanisation activities such as construction of buildings, creation of roads, and ineffective waste management systems.

Construction of buildings is an anthropogenic action that causes flood especially when floodplains are being developed and buildings constructed within river setbacks and vulnerable hazard prone environment. Besides, other widespread identified anthropogenic activities in Bayelsa State involve ancillary construction industry related services such as logging for furniture and building, land reclamation activities, such as sand filling, and dredging of the seabed. The reports that form the subject of analysis in this study have included those developments as part of anthropogenic actions in the form of urbanisation activities that exacerbate flooding in the region.

Douglas *et al*. [3] observed that many of the culverts have been in existence for more than 20 years and have not been maintained by any of the government agencies. Lack of regular maintenance of this hydraulic conveyance infrastructure predisposes the culverts to blockage from debris and urban wastes that effectively reduces their size, increasing the frequency of flooding in urban areas.

Building Construction – Deforestation, Reclamation and Floodplain Development

Building construction as an anthropogenic cause of flooding is still an area in contention, studies have shown that forests provide natural protection from floods (the rising of water bodies and their overflowing onto normally dry land) [18-22]. There is also specific study linking deforestation and increased severity of floods around the world [23]. Other studies have provided strands of evidence that forest loss makes landscapes more vulnerable to flooding [20,24]. Systematic clearing of rainforests, wetlands and mangrove swamps for residential and other developments, reduces the capacity of the land for floodwater storage and exposes the area to direct consequences of rainfall resulting in heavy run-off due to reduction of interception [24].

With the vast expanse of rainforests, wetlands and mangrove swamps in Bayelsa State, deforestation, reclamation, dredging and building construction activities on floodplains are some of the most common evidential anthropogenic activities undertaken indiscriminately by private developers as well as the Government. In Bayelsa State, the development of floodplains has become synonymous with deforestation, reclamation and sometimes dredging activities contiguous to floodplains development. [2] states that land reclamation is achieved through destruction of mangrove and wetlands and filling-in of swamps and floodplains. The material for filling-in is achieved primarily by dredging. The PFMC report also draws attention to the unguarded sand dredging at Onuebum and Otuegwe II communities on the outskirts of Yenagoa, which have exacerbated flooding in the communities. Their recommendations were that for there to be an effective control of the unguarded sand dredging works at Onuebum and Otuogwe II communities, a study (simulation) is required to establish safety margins.

Figure 4: Mangrove swamp cleared for development (Source: Brisibe 2014).

Figure 5: Site being reclaimed by sand filling. (Source: Brisibe 2014).

Besides outrightly building on floodplains, which should be prohibited, another palpable anthropogenic action that has been identified in Bayelsa involves the hydrological modifications of creeks and river channels. This is repeatedly done through diversion and land reclamation by filling small river courses with sand to gain additional land space to build. [13] also observed that in Ibadan, natural courses of rivers and streams have been diverted using man-made structures. The diversion of flow has caused unnecessary artificial meandering of rivers. In some cases where the rivers courses have not been diverted, their width have been greatly reduced by sand filling. During flood seasons, these river channels are unable to accommodate the volume of storm water flowing through them and tend to spill over into adjacent lands and inundate them [13].

After the 2012 flood episode in Bayelsa State, the State Government set up a team of surveyors and town planners headed by the Surveyor-General of the state and a combination of experts in hydrological, hydrographic, and topographical research to commission a base line study in 2013. The aim was to understand the terrain of the State with respect to floodplains, troughs and crests, to create a flood vulnerability map identifying areas at different levels of flood risk in the State capital, and to create benchmarks and establish datum points of reference. Results of this survey were expected to enable residents and government of Bayelsa State to have access to information regarding the nature of landed properties before acquiring such for development or sale, and to have benchmarks and datum reference points from which flood levels can be obtained and building floor heights established during construction within the mapped areas. A 3D digital elevation model of the surveyed landform was expected to be developed from the data obtained, and from which natural flood drainage channels would be established that would aid the design and development of artificial drainage system that would accommodate extra runoff. This has been anticipated with the increase in frequency and duration of intense rainfall and its associated challenges. The survey was also intended to furnish the Government and people of the State with information about already existing properties on flood plains and those along riverbanks designated as setbacks that are anticipated to increase the chances of flooding. Such information would enable them to increase the flood resilience capacity of their buildings or have ample time to evacuate the area in the likely event of a flood.

Unfortunately, the survey commenced in early 2013, but it was not completed because as the project was underway, the base monitor equipment failed with only a limited percentage of the data collected. Seven years on and after two major flood episodes in 2017 and again in 2019, the survey is yet to resume and be completed as expected. The data for the already concluded area is yet to be published, up till now parcels of land are still being purchased and sold off. Most of the dealers and speculators alike are completely oblivious of what properties fall within any of the designated flood vulnerable zones.

But for the areas where the survey was completed, available data indicates that the scape floodplains were dotted with either fully developed or partly developed residential buildings. One of the most fully developed floodplains in the area falls within the Igbogene community (Personal communication with the Surveyor-General of Bayelsa State, 25th April 2020). The most obvious developments on designated flood plains are those along the entire length of the Epie creek on the opposite side of the waterway. Buildings along this creek are constructed with little or no setbacks from the waterway and as such suffered different levels or damage due to different levels of inundation during the 2017 and 2019 floods in Bayelsa (see Figures **6** & **7**).

A similar scenario was observed in Ibadan after the 2011 floods where approved setbacks for major rivers ranging from 15m – 45m, before buildings and roads can be constructed, were breached. Such violation of planning rules and building regulations were some of the significant contributors to the high casualty and flood damage incurred during the 2011 flood event [13].

Figure 6: A flooded area within the Igbogene floodplain (Source: Brisibe 2014).

Figure 7: Flooded Okarki community (Source: Ibama 2019).

Waste Management and Drainage Systems

An inner-city study on slums in Yenagoa was conducted and part of the findings linked anthropogenic activities such as solid waste disposal and poor drainage facilities to increased flooding in Yenagoa amongst other things [25]. Three inner city slums were used as case studies; these were the Yenagoa central slum, the Edepie slum and the Yenezue-Gene slum. Indications emerged that a cumulative 94% of total households in all three study areas use environmentally unfriendly methods like packing solid waste into open containers as well as dumping of solid waste either behind buildings, in both open and closed drainages, along the roadside and into seasonal streams. These activities have invariable consequences such as that have exacerbated frequent flooding within the inner-city areas of Yenagoa.

Findings indicate that although waste collection centres exist in these areas, they are not properly distributed for ease of access and proximity to all residents in terms of planning. Implicitly, most residents are tempted to use unhealthy methods of solid waste management that put their lives at risk and clog the already overburdened and poorly constructed drainage systems within the city. A distribution of existing drains in the study area showed that about 9% of the houses were along roads with blocked covered drainage systems; 7% were along roads with blocked open drainage systems; while 84% of the houses were either on roads without drainage systems or not on access roads at all [25].

Distribution of Drainage System by Community:

0% – Covered drainage system that is flowing

0% – Open drainage system that is flowing

9% – Covered drainage system that is not flowing (blocked with solid wastes)

7% – Open drainage system that is not flowing (blocked with solid wastes)

84% –No drainage system

Without proper drainage systems, excess run-off from rainwater floods the neighborhood, mix with domestic effluent from kitchen and bath places usually located close to the latrines and run along open earth gutters and natural drains to other areas in the neighborhood. Sometimes it runs along and across footpaths and communal grounds.

Figure 8: Natural drainage system blocked by solid waste at Obelle Community in Yenagoa (Source: Ebakpa 2018).

Figure 9: Backwater channel blocked by solid waste (Source: Ebakpa 2018).

4. ROAD CREATION ACTIVITIES

After the 2012 floods, the Bayelsa State government set up an Infrastructure Advisory Committee (BSIAC) and a Post Flood Management Committee (PFMC).

The aim was to assess the level of damage to buildings and infrastructure and advice on control and mitigation measures in the event of any future extreme floods. Based on the official report by the Bayelsa State Infrastructure Advisory Committee (BSIAC) and Post Flood Management Committee PFMC, certain degree of human fatalities and displacement of persons and communities were recorded. Some communities were either fully or partially inundated with flood waters to heights ranging from 0.80m to 2.5m especially at the back swamps. It was also observed that most of the flooding resulted from overflow of nearby rivers, creeks, streams and other natural/artificial canals. Some of the informed conclusions deduced by the PFMC were that the trend of construction within Yenagoa allowed for diversion, entry and retention of flood waters in both natural and built up areas in the city and its environs. Their report indicated that among other things, some road construction activities heralding the creation of Bayelsa State have created inner dyke circles, which have aggravated flooding episodes in Yenagoa Capital City Territory.

Those road networks are:

- DSP Alamieyesiegha Road, which runs north-easterly to meet the BPL Road spur at the plantation.
- The new Express Road, which runs northwesterly from Yenagoa-Mbiama Road at Stewed to join DSP Alamieyesiegha Road at Km 10.
- The strip of land between DSP Alamieyesiegha Road and Yenagoa-Mbiama Road form *North Polder*.
- A road spurring from Yenagoa-Mbiama at Amarata to Swali.
- Series of other road networks on the north-western section of Y-CCT crisscross and impede the flow of water in natural watercourses. The strip of land bounded by the New Express Road on the north, BPL main access road and its spur on the east and south, respectively, and DSP Alamieyesiegha Road form a *Central Polder*.
- Also identified is the *East Polder*, which is the strip of land bounded by BPL Road on the west, Kolo Creek Road on the east, section of Yenagoa-Mbiama Road between Opolo and Etegwe on the north and the spur from Kolo Creek Road on the south. Without proper and functional drainage system, these polders are water trap areas

The recent flooding menace on the Y-CCT is primarily caused by these recent road network developments.

Figure 10: Unhealthy Interaction between Recent Road Network and Existing Drainage Culvert (D-02 at Agbura Axis) (Source: NPFC 2013).

Figure 11: Completely Silted/Blocked Armco Culvert on Drain D-02 Alignment at Agbura (Source: NPFC 2013).

- Acquisition of right-of-ways on our drainage lines routes

5. GOVERNMENT POLICIES CONTROLLING ANTHROPOGENIC ACTIONS

The official gazette of May 2011 of the Federal Republic of Nigeria has a section on National Environmental Regulations and a sub-section on Flood and soil erosion control. Part of the flood control regulations address issues that amount to anthropogenic actions such as building on floodplains and other high-risk flood areas, where it states that:

a. Water Resources Master Plan (FMWR, 2013)

b. Action plan for Erosion and Flood Control (FME, 2005b)

c. Technical Guidelines on Soil Erosion, Flood and Coastal Zone Management (FME, 2005b)

- The siting of facilities and major structures on identified high-risk flood areas are prohibited. But if buildings are to be in any of such areas vulnerable to flood hazards, special building and zoning permits are required.

- Still concerning flood hazard areas, the regulations also state that certain locations will be designated as special flood hazard areas where intrusive developments such as dredging, reclamation or sand filling, excavating and mining etc will be prohibited

The flood control regulations also state that:

- Infrastructural development and construction involving water diversions shall not terminate drainage system into any adjoining or downstream settlement or built-up area. In addition, all infrastructural development shall incorporate appropriate flood control measures such as surface and sub-surface drainage facilities, dams, flood walls, planting of trees, shrubs and grasses.

The action of greening is meant to discourage creation of impervious layers using concrete as ground covers over large areas. This anthropogenic action does not allow for natural seepage of water into the groundwater table but increases the amount of surface run-off and because of that, flooding ensues.

The regulations also state that:

- Any form of water diversion or encroachment into an existing stream channel will require obtaining a permit.

If all these regulations could have been enforced in the different States of the Federation that are rated as high-risk flood zones, it would stem anthropogenic actions that exacerbate flooding to a large extent. Although this policy document has some regulations that attempt to address the issues of flood control, it apparently leaves the implementation and enforcement of these control and mitigation measures to the various States of the Federation to be handled on case-specific basis. This was indicated in number 4 of the regulations which states that “applicants are to comply with zoning and building regulations of particular States and Local Governments in which development is to take place”. This is because although in Nigeria the Federal Government establishes Acts, State Governments can also enact laws and byelaws based on their geographical peculiarities as they see fit. As such, it absolves the Federal Government of the responsibility of ensuring the implementation of these regulations and relinquishes the onus on to the States. This is not a problem but what constitutes the problem is that these regulations, acts or laws are only in place *de jure* and not adopted as *de facto* regulations. This means that most State authorities have yet to adopt these regulations much less implement them.

6. DISCUSSIONS

The ineptitude and losses experienced during the 2012 flooding episode in Nigeria, in general, and the 2019 floods in Bayelsa State specifically, were eye-opener to both the government and the governed. This calls for the urgent need to reconsider the flood management strategies adopted in Nigeria and the State to advance the knowledge of the causal dynamics. With increased awareness of climate change, majority of the populace now assume that increased frequency and duration of rainfall is the major cause of floods. Agbola *et al*. [13] suggest that 95% of vulnerable population perceive that intense precipitation is the main causal factor of flooding. However, in the case of Yenagoa where annual floods are menacingly phenomenal, increased awareness regarding anthropogenic actions among the Government and vulnerable populace need to be done so that they can be made aware of such causal dynamics for floods in the city. The consequences of carrying out what was considered purely infrastructural projects in Bayelsa State were never taken into consideration until seven years ago when the BSIAC and the PFMC carried out a post-flood analysis and mitigation study. The study became an eye-opener to the anthropogenic effects of road construction when done without proper hydrological analysis, hydrographic and topographic studies as well as Environmental Impact Assessment studies. Unfortunately, it has remained an archival decoration since no reactive actions have been taken to correct identified defective projects that were mentioned earlier, nor proactive actions taken to forestall further vulnerable anthropogenic construction projects.

There are documents that indicate flood management policies in Nigeria with defined plan of actions and objectives as discussed in this paper; they have become outdated and left as archival decorations as evident in the 2012 and 2019 flood episodes in the country and in Yenagoa due to non-implementation and absolute lack of periodic review of these policies [26]. Incidences of overlap was evident among line agencies such as: National Emergency Management Agency (NEMA), Federal Ministry of Environment, State Emergency Management Agency (SEMA), and the Local Emergency Management Agency (LEMA) concerning the flooding as a result of poorly defined and assigned roles of each agency. Unnecessary overlap function among line agencies stalled the effective implementation of the various policies during any flooding and other related disasters. Such have been the case over the years as evinced in the frequency of flooding episodes in those areas with incremental devastating menace on humans and the environment alike with little or no respite in sight from relevant agency. Further disjointed synchronization of the flood disaster management policies has led to a paucity of reliable data and statistics regarding flood disaster, which has caused poor handling and management flood data over the years.

7. CONCLUSION

The frequency of flooding in Bayelsa State after the 2012 flood episode has necessitated the need for a flood vulnerability map. The map, as expected, will help to inform the populace of areas identified as high-risk flood zones and further expected to guide them in future land acquisition as well as preparation against imminent floods in cases where properties have already been developed there. Although the initially commissioned hydrological, hydrographic and topographic studies were truncated in 2013, it has become imperative to recommence and logically conclude those studies to save live and properties.

Based on the findings of the three reports, indications emerged that besides natural factors like sedimentation and the resultant overflow of the banks of Epie Creek, other actions and inactions like lack of maintenance of the natural channels by government, poor/lack of holistic engineering design consideration, especially of roads within the capital city, indiscriminate erection of buildings and ineffective waste management systems have all contributed to increased flooding in the city. While these inactions can be addressed, the actions, some of which are done with the best of intentions, must be re-evaluated and identified faults corrected, to serve as flood mitigation strategies instead of causative actions.

8. RECOMMENDATIONS

In view of the myriad of issues bedeviling flood disaster management and the understanding of flood causality in Bayelsa State and Nigeria at large, this study makes certain recommendations after careful analysis of the reports.

As a precursor, there is a need for the adoption of a holistic approach towards harmonized flood data management framework that will improve inter-agency data and knowledge sharing to enhance mitigation and management of flood-related disasters in Yenagoa and Nigeria as a whole.

Diligently undertake EIA, hydrologic and hydrographic studies, as well as base line studies before embarking on any developmental projects such as road construction, dredging, reclamation and building construction project in high-risk flood zones in Bayelsa State as this cannot be overemphasized.

Drainage studies and Masterplan also need to be undertaken and reviewed regularly for new projects and to upgrade existing outdated drains and culverts. Furthermore, institutional restructuring is inevitable especially in parastatals responsible for waste management in Bayelsa State to enable effective waste collection and disposal. This will however go together with renewed public enlightenment on approved waste disposal methods, a new system to ensure compliance enforcement as well as consequences for defaulters. In the opinion of [25], eliminating or minimizing anthropogenic action to the barest minimum will greatly enhance the flow of surface water in drains and natural channels to reduce the menace of rising flood waters.

Further recommendations for the study include

- Removal of all abandoned culverts acting as retaining wall to enable free flow of water
- Production of a detailed drainage report and flood control system to cover the entire state.
- Immediate reconstruction of existing inappropriate culverts taking into consideration their sizes, horizontal and vertical alignments.

- Provision of a functional waste management system to discourage indiscriminate discharge of refuse into drainage channels.
- Putting in place of a legislation to protect the encroachment and blockage of all-natural channels.
- Provision of essential data such as base line studies, hydrographic studies, topographic data, hydrologic analysis, and drainage studies among others, to set benchmarks for all infrastructure-based development in the Capital City.
- All the major creeks (Azikoro Creek, Kolo Creek and Epie Creek) should be dredged and made navigable at all seasons.
- All the drainage channels should be cleared and opened-up.
- CCDA to define and acquire the rights-of-way of major drains.
- CCDA to produce bi-annual status report of the drainage condition of natural channels within the city.
- Delineation and acquisition of right-of-way for the major rivers and creeks.

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