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Determinants of Flooding and Strategies for Mitigation: Two-Year Case Study of Benin City

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Abstract: Recent flood disasters in Benin City, Nigeria have claimed a number of lives, damaged property, and threatened the overall livelihood of residents. The economic burden of such events has forced a vast reallocation of monetary resources for clean-up and recovery, as well as forcibly altered and suspended internal trade via devastated transportation routes. Secondary trends include inflation and migration concerns. As a result, the aim has been to prioritize mitigation by examining easily read, rapidly accessible flood hazard maps, as well as assess and identify areas within the city prone to flooding. We used a number of data sources and conducted a questionnaire surveying three of the local government areas of Benin City over a two-year period. Findings indicate excessive unsustainable land use and land cover change and a flat and high water table area with close proximity to the Atlantic Ocean make the city susceptible to flood risk. Heavy rainfall and drainage system blockage are leading causes of flooding which have destroyed property and houses—two major side effects. A number of mitigation and disaster risk reduction measures were, hereafter, recommended to reduce flooding occurrence in Benin City or lessen its effects on inhabitants.

Keywords: flooding; mitigation; heavy rainfall; disaster risk reduction; Benin City

1. Introduction

Urban flooding is a main impact of meteorological and climatic change. It is considered a major and serious environmental problem confronting municipal authorities in developing countries. It is a critical environmental problem and major hazard which continuously affects the effective functioning of urban environments, especially in the areas of infrastructure and service provision, which are germane to sustainable livelihood. When severe flooding occurs in areas occupied by humans, it causes loss of human life and property and serious disruption to the activities of large urban and rural communities [1]. The economy is also severely affected by flooding as businesses may lose stock and patronage. Also, disruption of utilities and transport infrastructure can be adversely affected in a wider area. Flooding is therefore a universal reality that cuts across every sphere of human society. The negative effect of climatic events and unsustainable anthropogenic activities, which manifested in a wave of flooding across Nigeria in recent times, is capable of derailing the process of the actualization of the United Nations' 17 Sustainable Development Goals (SDGs) since it poses a major threat to the progress already made in eradicating extreme poverty and disease. Recorded damage caused by urban flood is on the rise due to intensified extreme events, and this accentuates the need for consistent studies of flood characteristics specific to impacts in local areas, such that appropriate disaster risk reduction (DRR) strategies can be implemented effectively and in a timely manner. For decades, the consequences of floods on the physical environment and the economic and social well-being of the inhabitants of an area have been recognized as massive. Kolawole et al. [2] assert that flooding affects more people on an annual basis than any other form of natural disaster. Association between flooding and population displacement is well established in the literature. However, more revealing is the fact that moving displaced persons into a new territory may cause local conflict or fuel existing ones [3]. For example, empirical research in the Ganges Basin of northern India associated flooding with an average increase of 13.1% in the occurrence of diarrhea within flood-ravaged areas [4], thus elevating flood risk as a serious enough hazard associated with civil as well as health-oriented challenges.

A sound definition of flooding is the overflowing or eruption of a great body of water over land not usually submerged. It is the inundation of any area which is not normally covered with water, through a temporary rise in the level of a river, lake, or sea, and when excess precipitation exceeds natural infiltration, evaporation, and possible runoff [5]. It is the most common of all environmental hazards and regularly claims more than 20,000 lives per year and adversely affects approximately 75 million people worldwide [6–8]. Generally, environmental problems such as pollution from fuel exploration and ozone depletion have been addressed mostly in developed nations and urban centers. However, flooding, mostly induced by climatic hazardous events, especially in developing countries, is still a major risk. Flooding is one of the natural disasters ravaging the African continent and Nigerian society. A variety of climatic and non-climatic processes influence flood processes, resulting in river floods, flash floods, urban floods, sewer floods, glacial lake outburst floods, and coastal floods. These flood-producing processes include intense and/or long-lasting precipitation, snow melt via increased temperature and dam break, and reduced conveyance due to jams or landslides or by storm [4]. Population growth has also been found to indirectly intensify flooding [9,10].

Flooding has caused significant damage worldwide. In 2004, the International Federation of Red Cross and Red Crescent Societies showed that during the 10 years from 1993 to 2002, flood disasters affected an estimated 140 million people globally per year on average, more than all other natural or technological disasters put together [11]. There have been flood disasters in various parts of Nigeria, as virtually all states have witnessed flooding at one time or another. However, this paper focuses on the challenges and prospects of flooding in Nigerian cities, using Benin City in southern Nigeria as a case study. Benin City is vulnerable to climatic impacts, particularly flooding, due to its topology, climate, vegetation, soils, economic structure, population size, and settlement patterns. This triangulation effort combines empirical field results with other secondary data. It investigates how floods can be effectively controlled, eliminated, or even avoided to avert its impact on human activities, through examination of flooding and socioeconomic activities in Benin City. This paper is an extension of Cirella and Iyalomhe's [12] research that examined a flooding conceptual review of best practices in Nigeria; it focalizes on the nature and case study causes of flooding within Benin City and provides feasible and sustainable solutions to DRR and flood management city-wide. To achieve this, the objectives of the case study, among others, are to: (1) examine the factors responsible for flooding, (2) identify flood-prone areas, (3) assess the major impacts of flooding, and (4) establish feasible control and management measures of flood hazards.

2. Data and Methods

2.1. Study Area

2.1.1. Latitudinal and Longitudinal Location

Benin City serves as the principal administrative and socioeconomic center for Edo State, Nigeria. Benin City is a humid, tropical, urban settlement, which comprises three major local government areas (LGAs), namely: Oredo, Egor, and Ikpoba Okha. Benin City is a narrowed, key-shaped, north-to-south strip of land in West Africa. The area is about 1125 km^2 and situated on fairly flat land, about 8.5 km above sea level. It is located between latitude 6°44′ N and 6°21′ N and longitude 5°35′ E and 5°44′ E (Figure 1).

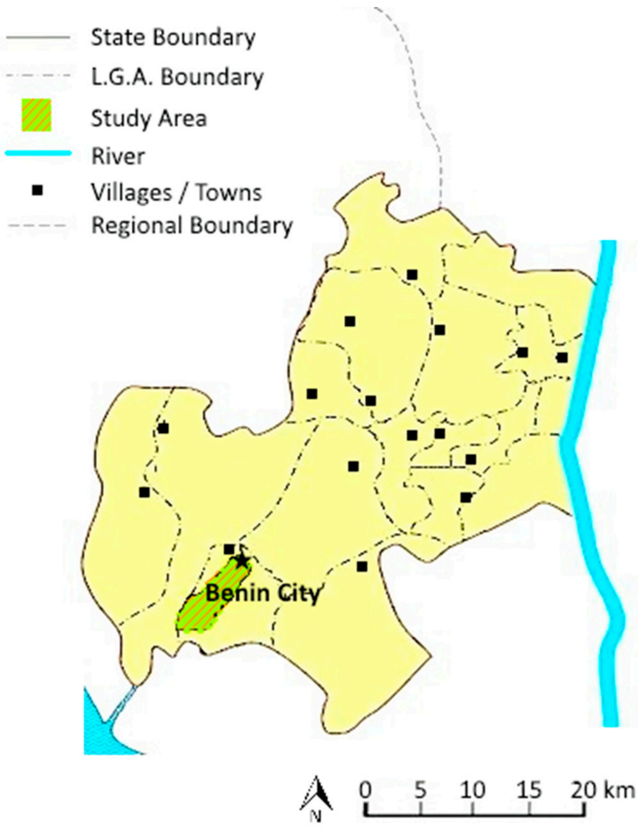

Figure 1. Map of Edo State [13].

2.1.2. Climate

Benin City's climate is hot and humid. The rainy season is from April to November while the dry season is from December to March. Temperature in Benin City is very high with an average daily temperature of about 28 °C in the dry season and about 24 °C in the wet season. The study area has a low temperature range. Benin City and its environs experience intense rainfall especially in the rainy or wet season. Rainfall is present all year, with an annual total of 2000–2300 mm, and monthly average of about 180 mm. This intense rainfall is induced by excessive evapotranspiration in the urban area due to prevalent high temperature. Relative humidity in the study area is also high, reaching about 80% in the wet season and 70% in the dry season [14–16].

2.1.3. Vegetation and Soil Type

The vegetation to the north of Benin City is mainly savannah where the palm oil grows in the wild. On higher altitudes, the soil is gravelly, becoming sandy towards the Orle Valley. The eastern plateau is made up of diverse vegetation, savannah in the north and forest in the south. Where deforestation has occurred, elephant grass and secondary growth take over. The soil is clayey or of porous red sand. Oil palm and rubber grow reasonably well. The Benin lowlands, initially covered with vast rain forest, have been mostly displaced by rubber plantations. The riverine communities in the south have mainly mangrove swamp vegetation [17].

Soil type ranges from low productive sand in the southeast to fertile clayey soil in the northwest, and is generally the red-yellow kind of ferralsols. Variations in Akoko Edo consist of shallow, stony, reddish clay at the feet of inselbergs in the higher section, lateritic clay and fine-grained to sandy soils, while in the upper slope, lateritic tablelands and ferruginous soil on the crystalline acid rocks are on the basement complex. In Orle Valley, the soil is lateritic, gravelly sand, while on the Esan Plateau, the soil is either clayey sand or porous red sand soil type in the Benin lowland—these soils range from loose, poorly productive sand in the southwest to fertile, clayey soil in the northeast close to the Niger, the Osse, and the Benin River that are alluvial and hydromorphic [18]. As a result, the pedological complexity of the area's soil genesis constitutes factual basis for flood concern via its pedogenic processes and soil patterns. This concern relates to an inability to absorb water and increase runoff. Edo State is in a distinctive tropical bioclimatic zone, with two distinct climatic seasons (i.e., rainy and dry) and its pedogenic (i.e., soil-forming) processes—past and present—show signs of high degree of flood risk.

2.1.4. Geology, Relief, and Drainage

The distinct relief regions in Edo State include: Northern Plateau, Orle Valley, Esan Plateau, Benin lowlands, and swamp forests. There are six types of physical features which constitute the landscape of Edo State. In Benin City, lowlands are found in a sandy coastal plain and alluvium clay with some hills in the east. Slopes are filled in the southwest direction. Rivers Osse, Orhionmwon, and Ikpoba drain the area. With the exception of the River Osse that has a wide flood plain, the other rivers are characterized by steeply incised valleys in their upper courses; they become broad as they enter River Ethiope in Delta State [17,18]. The Northern Plateau ranges from 183 to 305 m of basement rock with occasional granite peaks rising above 610 m. Its southern portion is mainly sandstone. The Afemai Hills rise to a height of 672 m, making it the highest elevation in the state. The Orle Valley was formed by an east–west river which cut into the sandstone between the Northern Plateau and the Esan Plateau. The Rivers Owan and Orle drain the Plateau to the west and east, respectively. The Esan Plateau is a continuation of the sandstone of the Northern Plateau and ranges from 213 to 305 m. The north and south fall steeply to the Orle and Niger valleys, while the south and west are gradual gradients to the Benin lowlands.

2.1.5. Socioeconomic Setting

Agriculture is the mainstay of the state's economy. Edo's inhabitants are mainly farmers, producing cash and food crops such as rubber, oil (i.e., palm, cocoa, yam, cassava, maize, rice, and plantain), sugar cane, cashew, palm oil derivative products, groundnut, soya bean, tomatoes, cotton, and tobacco. Fruits like pineapples, coconuts, oranges, and avocados, as well as green leafy vegetables, all grow abundantly state-wide. Trading is also a common activity within the state, as most traders buy and sells food crops, textiles materials, and products (e.g., cosmetics), while in the riverine areas of the south, fishing is a key sector. Benin City's inhabitants are numerous in formal sectors as well as informally engaged in brass casting, wood carving, and blacksmith forging. Major markets located within Benin City include Oba, New Benin, Oliha, Uselu, Agbado, and Edaiken [17,19]. It is also a place known for its cultural integrity spanning from the time of the Ogiso dynasty (i.e., the first dynasty) to present-day Oba.

2.2. Data Sources

In order to provide data for the analysis of flooding in Benin City, data was collected from field studies and secondary sources. The study collected primary data through questionnaires, field observation, and interviews made over a two-year period (i.e., between February 2017 and January 2019). Sources of secondary data comprised academic books, journals, public media (e.g., magazines), and annual rainfall data collected from the archives of the Nigerian Meteorological Agency (NIMET), Airport Station, Benin City, Nigerian Institute for Oil Palm Research, and Agro-Metrological Station, Benin City. The mean annual rainfalls of Benin City were computed from the minimum and maximum temperature data. The rainfall data consists of data collected for the 19-year period from 2000 to 2018 covering daily, monthly, and annual rainfall. Variance (σ^2) was used as one of the key statistical methods when looking at annual rainfall volatility; see Equation (1).

$$\sigma^2 = \frac{\sum(x-\mu)^2}{N} \tag{1}$$

where x is the initial annual rainfall value; μ is the mean annual rainfall value; N is the total number of years.

For the 19-year period, the annual rainfall's standard deviation (σ) was then calculated by taking the square root of the variance yields and expressing how much spread existed from the annual mean values; see Equation (2).

$$\sigma = \sqrt{\sigma^2} \quad (2)$$

Data was also collected from academic books, unpublished manuscripts, academic journals, and library research. This was supplemented by face-to-face expert interviews with representatives from the Ministry of Environment and Sustainability, Benin City, in order to access first-hand data on previous flooding events and how they were handled. The questionnaires were designed in an open-ended format to extract information on the land use pattern, and on how respondents perceived and experienced causes of flooding, nature of drainage in the study area, sanitation and sewage disposal, the most flood-prone months, and flood risk areas, as well as other effects of flooding on the people. The flood-affected locations were monitored, and almost all the people that were included as respondents had lived in flood-prone areas for about 10 years and more. The respondents were additionally confronted with a population density map of the study area to help relate the occurrence of flooding to human activities and/or human migration from rural areas to urban centers. A flood risk map of the study area was developed to reveal the areas that were prone to flooding.

2.3. Method of Sample Selection

Primary data needed for the research was acquired by a sample survey in Benin City. In view of the enormous area liable to flood, the three main LGAs that make up the study area were selected: Oredo, Egor, and Ikpoba Okha. Scientifically, 1050 questionnaires were randomly distributed among the study populations, and distributed with 350 in each of the three LGAs. A probability simple random sampling technique was used, in which fieldwork personnel chose persons and households at random with no specific bias. An equal chance (i.e., probability) of selecting a respondent from the population was conducted with the exception of asking and confirming if respondents were over the age of 18. Respondents were later distributed based on occupation where questionnaires were proportionally distributed as shown in Table 1. Also shown in Table 1 is a response analysis where 930 (88.8%) of the questionnaires were retrieved while 120 (11.2%) were not retrieved.

Table 1. Population of the study area as well as respondents' distribution according to occupation and response analysis from the surveyed field questionnaires.

LGAs	Population [1]	Civil Servants	Traders	Transporters	Farmers	Other	Total
Oredo	**374,515**	50	100	100	50	50	**350**
Egor	**340,287**	50	100	100	50	50	**350**
Ikpoba Okha	**372,080**	50	100	100	50	50	**350**
Total	**1,086,882**	**150**	**300**	**300**	**150**	**150**	**1050**
Unreturned questionnaires		0	20	70	30	0	**120**
Total returned questionnaires		150	280	230	120	150	**930**

[1] National Population Commission (NPC) 2006; Source: Researchers' fieldwork, 2019.

Additionally, in support of DRR measures, respondents were distributed in a number of flood-related datasets: (1) whether they lived through or experienced flood (i.e., flood occurrence), (2) drainage system information and infrastructure mitigation, (3) government efforts to control flood, and (4) community awareness regarding the city's flood measures and capacity to deal with such events.

3. Results

3.1. Causes of Flooding in Benin City and Mitigation Measures

The respondents were able to identify the causes of flooding in Benin City. They gave factors suspected as responsible for several floods in the area as well as measures adopted to stop or check the flood menace area-wide. Respondents also revealed that measures put in place to mitigate flooding were grossly inadequate and, at most times, ineffective. Table 2 indicates that among the respondents who were also residents of Benin City, heavy rainfall (i.e., 40%) and blockage of drainages (i.e., 31%) were perceived as major causes of flooding, most especially in Oredo, Egor, and Ikpoba Okha. Poor urban planning and land use (i.e., 18%) and as well as building on flood plains (i.e., 11%) were perceived among the respondents to be other causes of flooding in Benin City. This corroborates the finding that poorly executed urban renewal projects induced by reckless buildings in unapproved places are one of the banes of flooding in urban cities throughout Nigeria [20].

Table 2. Causes of floods in Benin City.

Causes of Floods	Oredo	Egor	Ikpoba Okha	Total	%
Heavy rainfall	130	120	120	**370**	**40**
Blockage of waterways	100	70	120	**290**	**31**
Building on flood plains	40	30	30	**100**	**11**
Poor planning/land use	60	60	50	**170**	**18**
Total	**330**	**280**	**320**	**930**	**100**

Source: Researchers' fieldwork, 2019.

Moreover, most Nigerian capital cities are not environment-friendly, as found in other research, and Benin City is not exempt. Adekola and Ogundipe [10] used five research-proven criteria (i.e., (1) effective and efficient waste management board, (2) having a non-moribund Ministry of Environment, (3) embracing effective horticulture and greening of the environment, (4) effective and efficient transport management agency, and (5) having a central and well-managed motor park) to assess which Nigeria capital cities are environment-friendly. Shockingly and sadly, only 4 out of 36 state capital cities had all five criteria as of 2017 and Edo State was conspicuously missing, meaning some of the above criteria or all are missing. It is, therefore, not surprising if such a city is more susceptible to seasonal flooding.

3.2. Rainfall Data and Analysis

Rainfall data was calculated using descriptive statistics, specifically mean, standard deviation, and variance. In addition, frequency distribution was used to enhance analysis of data acquired. As a result, for a 19-year period (i.e., 2000–2012) the mean annual rainfall came to 1914.27 mm per year with a variance of 68,922.93 and a standard deviation of 262.53 mm per year (Table 3).

3.3. Occupational Distribution of Residents of Flood-Prone Areas

The first section of the questionnaire aimed at acquiring information on individual occupation groups within the flood-prone areas; that is, four key occupations were targeted and all other occupations were labeled as "Other" (Figure 2).

The highest occupational group was found to be traders, having 30%, then transporters with 25%, followed by civil servants and other (i.e., mostly students) with 16% each, and, lastly, farmers at 13%.

Table 3. Rainfall analysis of the study area.

Year	Annual Rainfall (mm) (x)	Mean Difference (mm) ($x - \mu$)	Squared Difference $(x - \mu)^2$
2000	1816.3	−97.97	9598.84
2001	1709.5	−204.77	41,932.26
2002	2135.8	221.53	49,073.91
2003	1703.0	−211.27	44,636.57
2004	1928.8	14.53	211.01
2005	1595.0	−319.27	101,935.68
2006	1972.9	58.63	3437.05
2007	2036.5	122.23	14,939.27
2008	1891.7	−22.57	509.57
2009	1792.0	−122.27	14,950.85
2010	1814.3	−99.97	9994.74
2011	2087.3	173.03	29,938.11
2012	2369.8	455.53	207,504.23
2013	2251.2	336.93	113,519.35
2014	1734.8	−179.47	32,210.80
2015	1674.0	−240.27	57,731.44
2016	1701.6	−212.67	45,230.09
2017	1589.3	−324.97	105,607.89
2018	2567.4	653.13	426,573.99
$N = 19$	$\mu = 1914.27$		$\sigma^2 = 68{,}922.93$ $\sigma = 262.53$

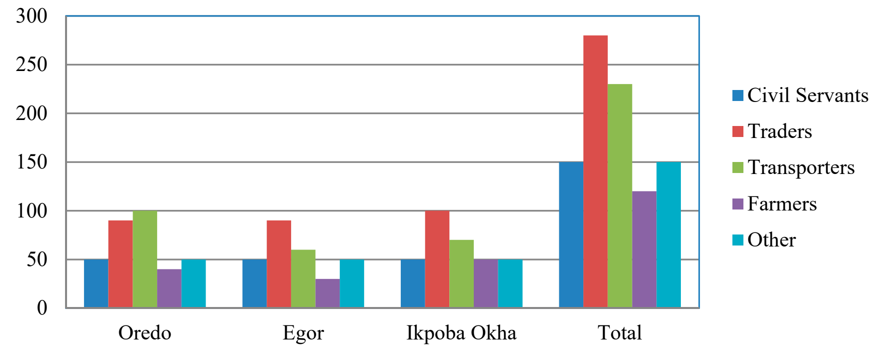

Figure 2. Different occupational groups within the study area.

3.4. Flood Occurrence

Respondents that lived through or experienced a flood occurrence over the past 19 years responded as follows: 95% affirmed the occurrence of flood in Benin City, while 5% did not (Figure 3). Relative to respondents living through a flood occurrence, the year with the highest duration of flood occurrences was found to be 2012, in which over 2.1 million people were displaced nation-wide.

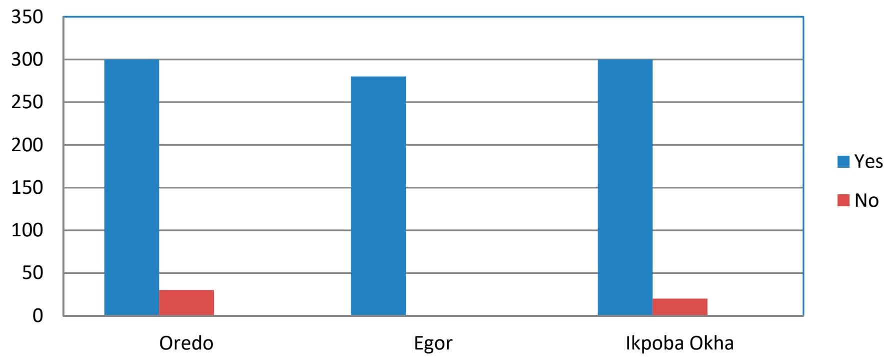

Figure 3. Respondents that experienced flood occurrence in the previous 19-year period.

Loss, damage, and hazard caused by flooding in Benin City has been devastating to the area. Destruction of property and houses has taken a major toll on the economy and infrastructure of its inhabitants (Figure 4).

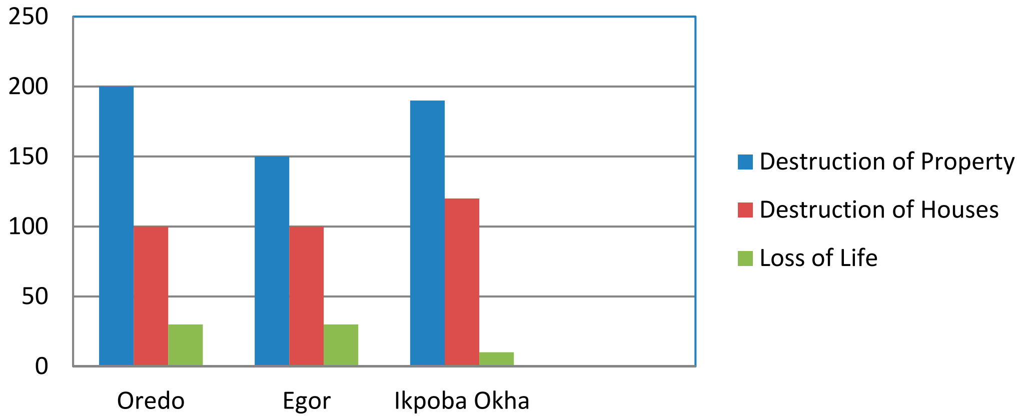

Figure 4. Flood loss, hazard, and damage in Benin City in the previous 19-year period.

As a result of flood, a number of inconveniences have been experienced. From the collected questionnaire data, the highest inconvenience experienced was the abandonment of houses (38%), followed by psychological fear (26%), the relocation of property (20%), and abandonment and relocation (16%) (Table 4). This reveals how hazardous flood occurrences were experienced by the respondents during their lifetime and the importance of DRR research.

Table 4. Inconveniences caused by flooding to Benin City residents.

Flood Inconveniences	Oredo	Egor	Ikpoba Okha	Total	%
Relocation of property	70	70	50	**190**	**20**
Abandonment of houses	110	90	150	**350**	**38**
Psychological fear	100	60	80	**240**	**26**
Abandonment and relocation	50	60	40	**150**	**16**
Total	**330**	**280**	**320**	**930**	**100**

Source: Researchers' fieldwork, 2019.

3.5. Drainage System Information

In general, the level of drainage cleanliness within the three LGAs indicates that about 90% of the respondents affirmed the drainage system is littered with dirt and not properly cleared for the free flow of flood water. Only 10% of the respondents had the opinion that the drainage system was clean. Despite the fact that studies in Germany and in other developed countries [21,22] demonstrate flood-induced damage correlates with a higher propensity of lack of environmental concern or know-how, the attitude of Benin City's residents must be taken into account. Inhabitants continue to pour refuse into drainage lines during heavy downpour which will continue to impede upon the overall drainage flow. As a result, respondents stated the inadequacy of the drainage system as the most frequent reason for flooding (i.e., 62% versus 38% stating it as sufficient). At length, 20% of respondents stated the drains were often cleaned, versus 40% stating they were rarely cleaned and 40% never cleaned.

3.6. Government Control and Community Awareness

In retrospect of government efforts to control flood, results indicate a low-engaging and dejecting local authority. Our findings specify greater efforts are needed if better regulation, control, and management are to be resolved. Consequently, public opinion remained relatively low with 59% of respondents claiming that the government had not worked or constructed any infrastructural measures in regard to flood control. However, though 41% did believe the government has done something, the community at large was still very uninformed about the perceived flood control measures (Table 5).

Table 5. Perceived flood control measures by the local government.

Flood Control Measures	Oredo	Egor	Ikpoba Okha	Total	%
Desilting of drainages	50	20	20	**90**	**10**
Drainage networks	130	90	90	**310**	**33**
Creation of canals	0	30	20	**50**	**5**
None	150	140	190	**480**	**52**
Total	**330**	**280**	**320**	**930**	**100**

Source: Researchers' fieldwork, 2019.

As a result, residents of Benin City have had to endure a lack of information and awareness regarding the city's flood measures and capacity to deal with such events. Results confirm that about 58% of the information acquired from residents was from their own know-how versus government involvement. The highest source of flooding information was obtained through public media (i.e., 57%), while other sources included personal experiences (i.e., 28%) and the NIMET (i.e., 14%). Finally, the suggested flood control measures to be used by the government indicate a reoccurring theme of securing the drainage system and its enlargement (Table 6). On a widened scale, the results indicate a commonality (i.e., linkage between approaches) that has emerged throughout the literature on comparable themes (e.g., Protective Action Decision Model [23], Hyogo Framework for Action [24], and Sendai Framework for Disaster Risk Reduction [25]).

Table 6. Suggested flood control measures by respondents.

Suggested Control Measures	Oredo	Egor	Ikpoba Okha	Total	%
Creation of drainage networks	170	170	170	**510**	**55**
Raised foundation	0	40	0	**40**	**4**
Sand bags	0	0	30	**30**	**3**
Proper land use planning	100	40	70	**210**	**23**
Flood insurance	60	30	50	**140**	**15**
Total	**330**	**280**	**320**	**930**	**100**

Source: Researchers' fieldwork, 2019.

4. Discussion

In Benin City, based on the collected data, the overall findings reveal that during the 19-year period (i.e., 2000–2018), heavy rainfall was the highest cause of flooding (i.e., 40%) followed by blockage of drainages (i.e., 31%). Evidently, rainfall affects most parts of Benin City; the effects are mostly felt in Oredo and Ikpoba Okha where improper waste disposal accentuates the impact of heavy rainfall and worsens flood situations. Flooding in Benin City is also influenced by the regional soil texture, as well as the flat and table land nature of the area which has high water tables due to its proximity to the Atlantic Ocean. These flood-prone areas are characterized by paved or tarred surfaces, blocked drainage systems, improper waste disposal, slums, and uncontrolled development as well as poor planning. Examples of these areas are: Teachers' House of Siluko Road, Uwelu Road by Ogida Primary School, Ekenwan Road, Uselu Lagos Road by Tom Line Building, Five Junction and Adolor Junction along New Lagos Road, Upper Mission Road, and Forestry Road.

In addition, the study reveals one of the major causes of flooding in Benin City is overpopulation characterized by unpreparedness. As the population of Benin City continually increases, its carrying capacity has begun to reach exceedingly difficult levels. One key result of this change is improper waste disposal, as stated in this study. Increasing population causes development to gradually expand and augment the urbanization process; this augmentation, due to the increased human activity associated with population growth, causes an unprecedented change in land use and vegetation cover. Population growth and urbanization have led to land use changes as the population continuously struggles for survival. Agricultural land use has been encroached by industrial and commercial land uses, causing more natural changes in the soil surfaces and quality, to be paved or tarred thereby impeding infiltration of rainwater and promoting the occurrence of flooding. About 80% of the entire landscape of Benin City is prone to flooding especially in densely populated areas of the three LGAs where industries, markets, and low-income residence reside. Benin City remains the commercial and industrial nerve of Edo State. Benin City is consistently experiencing fast growth and expansion as well as development of new areas (e.g., Benin and Greater Benin) both in the core of the city and its periphery—especially in Oredo. Similar evidence has been found elsewhere; for example, rapid economic growth in conjunction with unplanned expansion of suburban and coastal settlements in the south of the state lack capacity and experience increased vulnerability due to the high concentration of inhabitants [26]. Interestingly to some degree, wealthier zones have contributed in developing adjacent poorer ones, and consequently have assisted in flood-readiness, prevention, and mitigation. Apart from population intensity and urbanization, other causes of floods in Benin City include: intense rainfall, building in flood-prone areas, poor planning, and maintenance of available drainage facilities (e.g., government reluctance to implement the World Bank's proposals for flood control in the country and Edo State in particular). Cutting down trees and digging up the vegetation cover increase soil erosion, thus augmenting flooding city-wide. As a result, cultivation decreases water retention soil capacity and increases runoff. Vast areas of land along rivers, streams, or the ocean have a high water table and thus make soil saturation very fast throughout the Benin City area.

Psychological fear is another major inconvenience associated with flood occurrences. No matter the degree of inconvenience, certain steps can be made to increase the level of preparedness within flood-prone areas. Empirical evidence in France, Namibia, and Zambia found that sociodemographic characteristics such as education level, marital status, access to and size of land, risk perception, and sense of community affect flood preparedness [27,28]. The onus now lies on policy makers in Edo State to raise the banner of progress among its residents in the light of socioeconomic rank so they can be better prepared for future flood occurrence.

Flood-prone communities the world over now use different approaches to manage individual situations from time to time. For instance, Bhattacharjee and Behera [29] found that those residing around the Rhine River use structural building measures, deployment of flood barriers, and purchase of insurance as measures to control and minimize the level of flood damage. In addition, empirical evidence from India shows that forest cover and tree planting have been effective in limiting the extent of flood damage [30]. In Benin City, however, respondents of the questionnaire opined that the best control measures were the creation and maintenance of a sound drainage system, proper land use planning, and flood insurance for affected victims (i.e., in the form of compensation). Other control measures stressed by respondents include a raised foundation (4%) in Oredo and use of sand bags (3%) in Ikpoba Okha. Suggestions such as provision of incinerators and trash cans would also reduce the blockage of drains in an effort to control flooding to a reasonable extent. In consequence of the land use image map of Benin City, it is observable that the cementification and urban sprawl dominate the city's landscape and further landscape architectural planning and design should be immediately implemented (Figure 5). We believe this will help with reducing flood risk and introduce an educational element to the community at large.

There is a multifaceted relationship between DRR and poverty. The research on which the article is based was done at a household level throughout three main LGAs of Benin City, a developing part of the city strongly dependent on agriculture and prone to flood-related disasters. Of the 1050 questionnaires that were randomly distributed about the causes of flooding, mitigation measures, occupational distribution, flood occurrence, drainage, government control, educational awareness, and socioeconomic status, simple analytical correlation as well as our own qualitative fieldwork denote flooding had the highest impact on poor households. An examination of the relationship between socioeconomic factors (i.e., occupation and income) and the damage caused by the flood disasters, specifically in 2012, appears to significantly correlate relative flood loss and occupation type. This socioeconomic linkage would suggest an absolute necessity for DRR measures since it implies that households that depend specifically on agriculture are the most susceptible to economic damage. Consequently, since an important component of the paper is the DRR recommendations (i.e., stated in the conclusion), the relationship between flooding and human settlement indicates a positive correlation between disaster damage, poverty, and vulnerability. The subject matter is, hence, critical to the livelihood and survival of impoverished people. We believe, from this case study, enhanced DRR measures add value to the already growing amount of DRR literature and support African-centric [31–34] as well as other developing countries' [35–37] struggle with natural disasters [38,39]. Moreover, research synergistic with the United Nations' 17 SDGs that examine many disasters from around the world would advance understanding. In socioeconomics terms, the study could be broadened to include other indicators of poverty, such as gender, movement in and out of poverty, infant and child mortality rates, differences between male and female mortality rates, life expectancy, disability rates, and access to safe tap water for drinking.

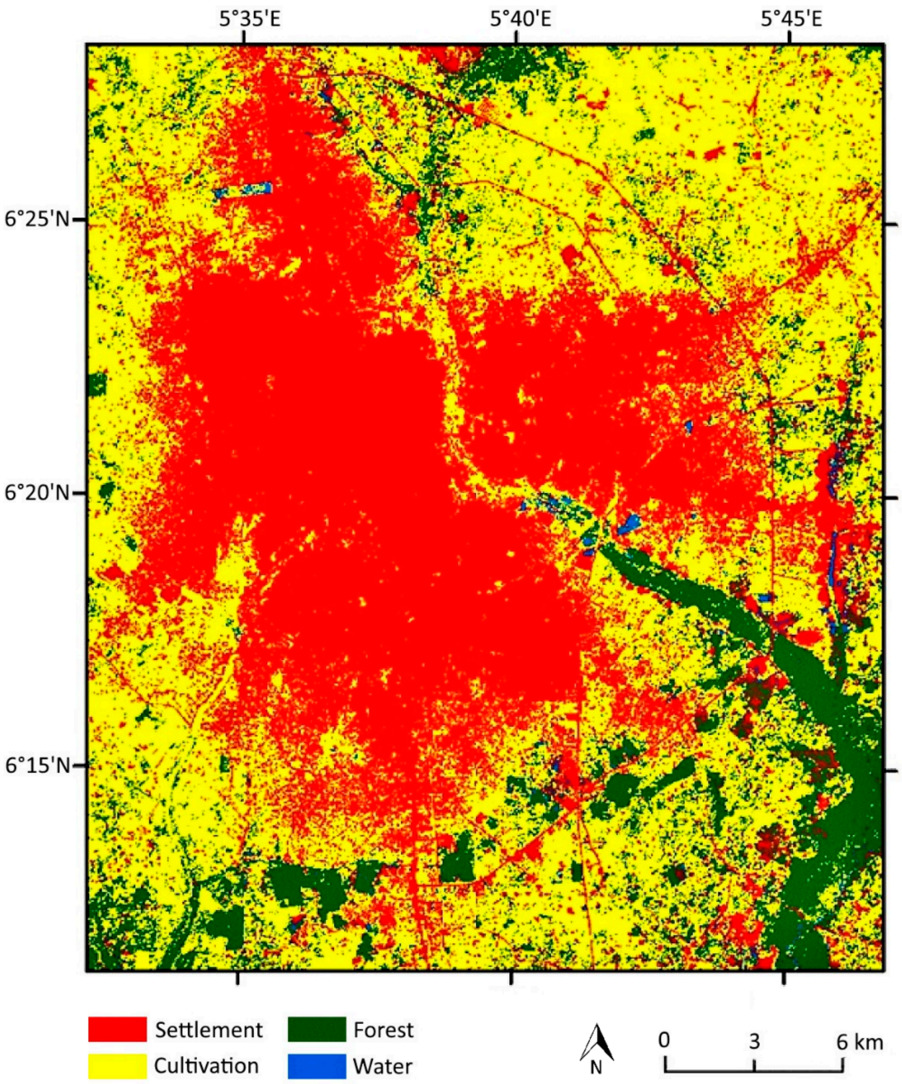

Figure 5. Land use image map of Benin City.

Finally, although storm-induced coastal flooding is not a common phenomenon in Edo State, some areas of Benin City are close to the Gulf of Guinea that is linked to the Atlantic Ocean and, generally, are below 8.5 m above sea level; hence, raised levies and a realignment is needed to prevent any coastal-induced flooding much in the same way it has helped in La Faute-sur-mer, France [40].

5. Conclusions

In this study, three flood-prone areas were studied, namely the LGAs of Oredo, Egor, and Ikpoba Okha. However, rainfall and the unprepared attitude of the populace remain the most suspected cause of flooding due to the subequatorial climatic location of Edo State, and Benin City in particular. The population of the study area has suffered from multiple losses, with destruction of property the highest. Although Benin City has a robust intracity road network, it seemingly does not adequately or properly channel flood drainage. Government reluctance to issue efficient measures to manage flooding further accentuates the risks and hazards of flood events. Data presented and analysis revealed that the impacts of flooding on both the human and natural environment are enormous. As a result, economic burden of such events has involuntarily reallocated monetary resources for clean-up and recovery, as well as forcibly altered and interrupted internal trade via devastated transportation routes. Secondary trends throughout the country include inflation and migration concerns. The following key DRR recommendations arise from the results found.

First, there is the need for the government to be more active in curbing the issue of flooding. This can only be achieved when it begins to focus more on land use planning, development control, zoning, and other legislative and policy-oriented practices. Such best practices will properly prevent and mitigate flood occurrence, rather than just involve itself in provision of relief materials for flood victims as experienced in recent times. Second, mitigating flooding is not the work of government alone. Studies have found that community action groups working with government and NGOs can help to ameliorate flooding in low-capital and flood-prone communities [41,42]. Thus, increased public awareness of the potential hazard of floods would help to properly inform developers and urban residents. An emergency warning system designed for flood plain occupants that alarmed them before a flood occurrence will help reduce flood damage and losses. Government agencies, authorities, planners, environmentalists, practitioners of the built environment, international organizations, and individuals must work in synergy to evolve a comprehensive approach that would emphasize more the means of reducing flood damages and sensitize residents of flood-prone areas to the awareness and culture of living in a flood-risk environment. This is important since empirical evidence has emerged that perception can influence attitude and, as a result, action toward mitigation. A study in Bangladesh indicated that people who correctly perceived the danger of flooding cooperated better with government mitigation strategies than those who did not [43]. Third, the construction of an underground and open surface water channeling system to empty flood water into the receiving Benin City River is needed. This step correlates with a properly built and managed drainage system as it would reduce the amount of runoff generated given the large levels of cementification city-wide. Fourth, there is the need to reinforce the practical application of flood-risk mapping and digital surveillance. Town planners should use such maps to consistently guide them to help in site inspection and planned approval for construction of new buildings. These flood-risk maps will help to determine areas which should be avoided due to flood-prone areas. For example, flood-prone areas can be used for development of agriculture (e.g., livestock and rice cultivation) as well as for recreational purposes. Fifth, deforestation should be controlled using stringent policies and regulations state-wide; this will especially curb flooding throughout Benin City. Since effective control of flooding is a combinative effort as opined by Perez-Molina et al. [9], controlled deforestation should be linked with protection of wetlands, and the like, throughout the state. Sixth, land use planning and development control are inevitable tools for controlling urban development. In a rapidly urbanizing area like Benin City, proper land use policies, regulations, building, and development by-laws are very necessary to check the excesses of developers and to monitor the nature of urban development. Finally, flood forecasting has to be well developed with standard modern technologies of predicting the occurrence of flood. This pre-occurrence knowledge will help to assess expected damage, which is likely to help local residents prepare and explore plausible mitigation strategies in a similar way to what northern Ghana and Italy have done [44,45]. This will also be supplemented by the construction of flood frequency curves to determine the frequency rate of floods in certain areas. The recommended procedures would definitely put a limit to the effect of flooding in Benin City and place it at the national, as well as international, forefront for strategies for flood mitigation.

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