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The August 2011 Flood in Ibadan, Nigeria: Anthropogenic Causes and Consequences

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Abstract Determining when and where flood strikes can be a daunting task. Apart from heavy and prolonged rainfalls and river overflows, there are anthropogenic causal factors of flooding. These anthropogenic factors are significantly variable and exacerbate floods, but may be difficult to measure. This study aims to unravel some of the anthropogenic factors, particularly with respect to their contributions to the flood in Ibadan City on 26 August 2011. Data were collected through structured questionnaire and key informant interviews. The August 2011 Ibadan flood was perhaps the worst in the history of this ancient city. Twelve anthropogenic factors are broadly identified as having contributed to the flood and the flood had five major consequences. Some policy implications that can help prevent future flood occurrence are outlined.

Keywords floodplain management, Ibadan, Nigeria, urban flooding, waste management

1 Introduction

Natural disasters are on the increase globally and their impacts affect the physical, economic, social, geographical, psychological, and cultural spheres of human endeavor. Flood is one of the most common natural disasters, irrespective of the state of human development and natural conditions. Flooding has remained the second deadliest of all weather-related hazards in the United States, and has been detrimental in many other societies in most parts of the world, because of the large numbers of fatalities and the costly damages to properties and human lives (Ashley and Ashley 2008). Flooding arises from structural failures, heavy rainfalls, and a host of human-induced factors. Floods depend on rainfall amounts and rates, topography, land use, soil type, and antecedent moisture conditions (Funk 2006).

The city of Ibadan, Nigeria has a history of flood disasters—the most recent occurred on 26 August 2011. Floods are a common occurrence in the city and have been officially recorded since 1951. But records on urban floods in Ibadan are patchy and characterized by incomplete information. Table 1 shows that more floods were recorded in the 1980s than in the 1960s and 1970s. Most of the recorded floods occurred in August, a period between the first rainfall peak and the rainfall break. The heaviest rain on record that caused flood in the city occurred in 1980 when the city recorded 274 mm of rainfall during a single flood episode. The second heaviest recorded rainfall was 258 mm in 1963. The amount of rain that fell on 26 August 2011 was 187.5 mm, and was the third heaviest recorded. It started at 16:40 in the afternoon, continuing in intense torrents until 20:00 in the evening, with intermittent drizzling until 23:00 late at night, accompanied by wind speeds as high as 65 km h^{-1} (Oyo State Government 2011). The rainfall was most intense in a 70-minute period between 18:10 and 19:20 when 75 percent or 140.63 mm of the rain fell. This translated to an average rainfall intensity of 127.84 mm h^{-1} (National Water Resources Institute 2011). An accurate assessment of the havoc created by floods in Ibadan over the years is difficult to obtain because of the paucity of official data. A number of official estimates have been made. The losses from the flood disaster of August 1980 were estimated at over ₦300 million (Nigerian naira, or USD 1.92 million), while over 500 lives were lost (Akintola 1994). The estimated amount to fix the culverts and bridges damaged by the 2011 flood is ₦2.1 billion (Oyo State Government 2011).

Despite the fact that the rainfall of 26 August 2011 was not the highest in the recorded history of the city, the monetary value of damages to property that resulted from the event were by far the highest. As Ward (1978) observed, floods are unique events and similar flood-generating conditions may result in different flood outcomes. Understanding the perceived causes and consequences of the 26 August 2011 flood motivated the present study. Pertinent questions addressed include: (1) What were the perceived causes of the flood? (2) What factors influenced the perceived causes? (3) What were the institutional challenges that contributed to the flood? (4) What were the consequences of the flood? The perception of the causes of urban flood informs local response and adjustment strategies. It will also reveal people's knowledge of the causes of the flood, and what needs to be done to ameliorate flood hazards.

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Table 1. Rainfall induced floods in the city of Ibadan, Nigeria, between 1951 and 2011

Date	Rainfall (mm)	Estimated Damage to Properties (naira)	Estimated Loss of Lives
9–10 July 1951	161	Unknown	Unknown
16–17 June 1955	173	Unknown	Unknown
16–17 August 1960	178	Tens of thousands of naira	Unknown
27–28 August 1963	258	Tens of thousands of naira	At least 2 persons
14 May 1969	137	Tens of thousands of naira	At least 2 persons
1973 (undated)*	Unknown	More than 100,000	3
20 April 1978	126	Over 2,000,000	At least 2 persons
31 August 1980	274	More than 300,000,000	More than 500 with over 50,000 displaced
1982 (undated)*	Unknown	Unknown	Unknown
1984 (undated)*	Unknown	Unknown	Unknown
April 1986 (undated)*	Unknown	Unknown	Unknown
June/July 1987 (undated)*	Unknown	Unknown	Unknown
April 1997 (undated)*	151	Unknown	Unknown
26 August 2011	187.5	Over 30 billion	Over 100

Note: USD 1 = ₦156.
Sources: Nigeria Environmental Study Action / Team (NEST 1991, 107), and National Water Resources Institute (2011, 10). *: Akintola and Ikwuyatum 2012, 199.

2 Study Area

Ibadan, one of the oldest cities in Africa, is the capital of Oyo State, Nigeria, and has eleven local government areas (LGAs). By 1856, the population was estimated at 60,000, rising to over 200,000 in 1890, to over 238,000 in 1921, and more than 386,000 in 1931 (Mabogunje 1962). The 1991 census in Nigeria put the population of the city at 1.22 million with a density of 475 persons km^{-2}. Ibadan's population was 2.55 million according to the 2006 estimate by the National Population Commission. The population was projected to increase at 3.2 percent annually, to 2.89 million people by 2010 (Oyo State Government 2011).

The study sites include four localities in the Ibadan metropolitan area: Apete (Ido Local Government Area), Moniya (Akinyele Local Government Area), Bodija (Ibadan North Local Government Area), and Odo-Ona (Oluyole Local Government Area) (Figure 1). These localities are characterized by a mixture of traditional, transitional, and modern housing and culture, representative of the contemporary changes taking place in most cities in Africa. The population of Apete, Moniya, Bodija, and Odo-Ona in 1991 was 2464, 14,923, 27,447, and 25,044, respectively. There has not been any update on the population of these communities because the National Population Commission is yet to release the breakdown of the 2006 census by localities.

The study area is characterized by a typical West African monsoon climate with distinct rainy and dry seasons, and is drained mainly by the Ona and Ogunpa Rivers and their tributaries. The floods in the city over the years were often the result of prolonged rainfall that led to inundation of streams and river channels. The floods are sustained by dense networks of rivers and streams in the urban and peri-urban neighborhoods.

3 Methodology

The four localities in Ibadan (Apete, Moniya, Bodija, and Odo-Ona) were selected for the study because the impact of the August 2011 flood was very severe in these areas (Oyo State Government 2011). A structured questionnaire that addressed the perceived causes and consequences of the flood was designed and administered in the selected localities using a systematic random sampling method. The questionnaire was administered to household heads at each of the selected sites, a total of 600 questionnaires in the four localities, 150 questionnaires in each. The questionnaire administration was undertaken over the course of a week by research assistants, postgraduate students of the University of Ibadan, each of whom was assigned to a locality. The use of the questionnaire permitted the assessment of the divergent opinions of the people on factors that caused the flood as well as its consequences. Information was also gathered from community and opinion leaders in the communities. Apart from the primary data used in the analysis and discussions, secondary data were obtained from the report of the Task Force on Flood Prevention and Management inaugurated in September 2011 by the Oyo State government (Oyo State Government 2011). Topographical sheets covering the study area were obtained from the Office of the Surveyor General, Oyo State, and spot heights to delineate the topography were obtained from Shuttle Radar Topographical Mapping (SRTM) data. The questionnaires were analyzed using frequency, cross tabulation, percentage, and chi-square techniques. The study findings are presented and discussed in two parts: the perceived causes of the flood, and the consequences of the flood in Ibadan City.

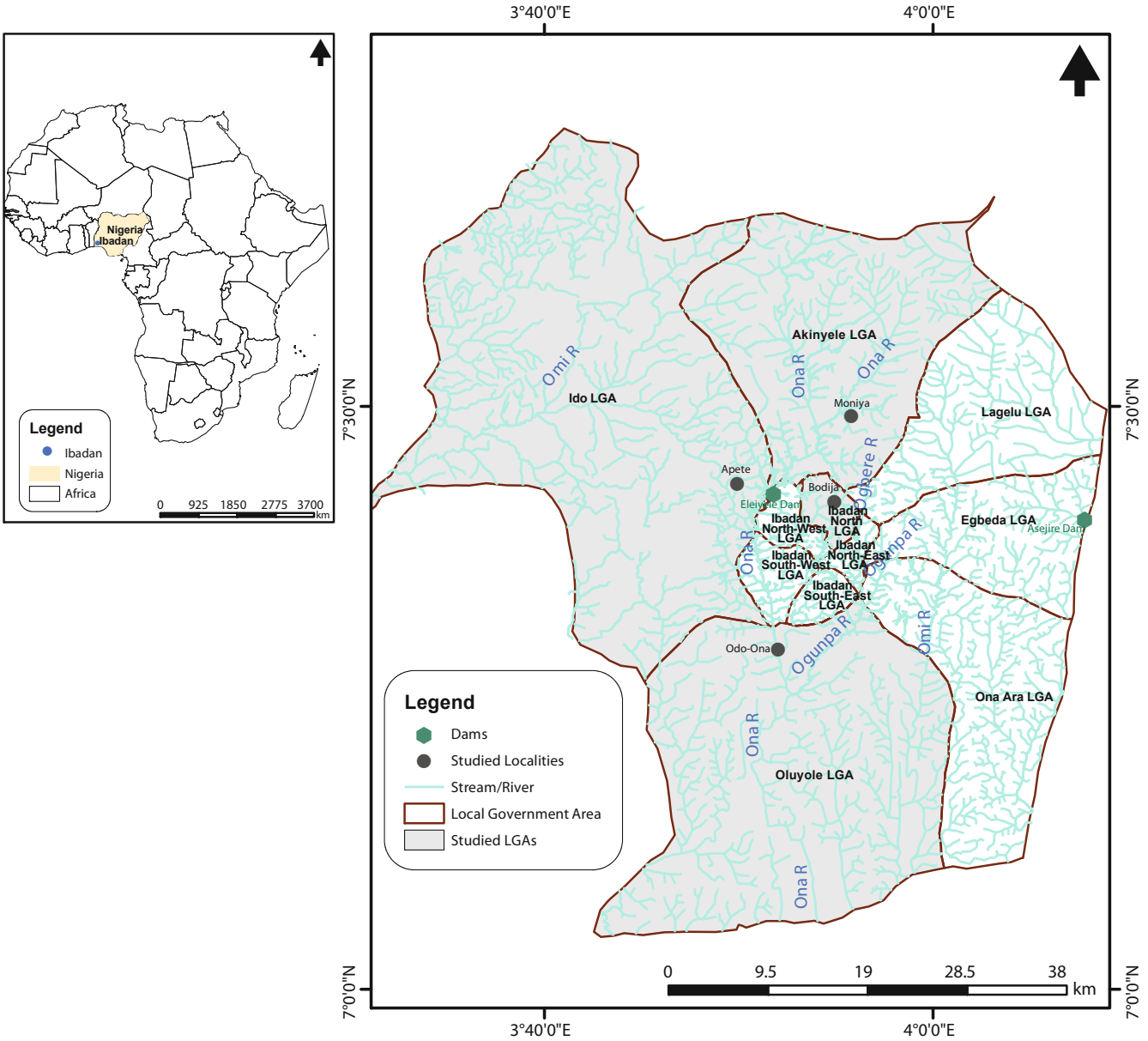

Figure 1. Map of the Ibadan metropolitan area, Nigeria, showing the studied localities
Source: Administrative map provided by the Office of Surveyor General, Oyo State, Nigeria, 2011; drainage network extracted from Google image; and contours derived from Shuttle Radar Topographical Mapping (SRTM) data.

4 Perceived Causes of the Flood

The perceived causes of the August 2011 flood are discussed under four main themes: (1) hydrological factors; (2) waste management factors; (3) institutional factors; and (4) awareness factors. Hydrological factors are those related to water and they include prolonged heavy rainfall, dam breaking, blockage of culverts and drainage channels, and growth of vegetation in channels. Waste management factors are related to the way the waste management practices of the inhabitants affect the free flow of water in drainage channels. Institutional factors are those that reveal the weakness of existing government administrative structures in city planning and development control with respect to physical developments (housing, schools, religious centers, and commercial enterprises) encroaching into setback of rivers/streams, deforestation of sanctuary forest, alteration of river channels, and increased impervious surfaces. The awareness factor relates to the role of the media in the dissemination of flood related information.

Table 2. Perceived anthropogenic causes of the 26 August 2011 flood in Ibadan, Nigeria

Factors	Agree		Disagree		Don't Know	
	Count	Percent	Count	Percent	Count	Percent
Building close to riverbanks	533	89	46	8	21	4
Changing course of rivers by development	496	83	15	3	89	15
Inadequate housing development monitoring	183	31	344	57	73	12
Ignorance	418	70	66	11	116	19
Lack of early warning information	315	53	153	26	132	22
Riverbed sedimentation	141	24	27	5	432	72
River channels covered by weeds	312	52	218	36	70	12
Dam breaking	58	10	87	15	455	76
Heavy rainfall	567	95	33	6	0	0
Dumping refuse in drainage channels	444	74	80	13	76	13
Deforestation	234	39	56	9	310	52
Increased impervious surfaces	53	9	332	55	215	36

Source: 2011 fieldwork by the authors; questionnaires administered to 600 respondents in Apete, Moniya, Bodija, and Odo-Ona in the Ibadan metropolitan area.

4.1 Hydrological Factors

Like many previous floods, the August 2011 flood came during the August break period, a time when the city ordinarily should not experience rainfall of such magnitude. Ologunorisa and Adejumo (2005) noted that the most important causes of floods were heavy, prolonged rainfalls and river overflows. Floods are natural phenomena, but damage and losses are the consequences of human action and inaction (Douglas et al. 2009). The results of the questionnaire survey (Table 2) revealed that 95 percent of the respondents attributed the flood to the heavy rainfall, which lasted for several hours (Oyo State Government 2011), caused havoc in most parts of the city, inhibited transportation, and damaged electricity infrastructure. This view was widely expressed by all respondents from the four localities surveyed and hence there was no significant local variation in the perception of the rain that fell on 26 August 2011 as the major cause of flood in the four residential localities ($X^2 = 24.522$, $P \geq 0.05$). It was widely agreed that the rain was very heavy and this led to the flood. Available data from the International Institute of Tropical Agriculture (IITA) (National Water Resources Institute 2011, 10) shows that 187.5 mm of rain fell on the day of the event alone. This figure represented the highest daily rainfall amount for the month as well as for the year.

Thakur et al. (2011) identified climate change, rainfall intensity, duration, and frequency, topography, degree of land cover, and nature of soils as some of the physical factors that predisposed locations to flood disasters. Climate change may alter storm occurrence and intensity and lead to local changes in urban areas (due to alterations of the urban land surface and water pathways, compounded by such activities as construction, paving, soil compaction, and removal of vegetation). Blockage of drains and the diversion of natural flows combine to produce increased local runoff and higher flood frequency, magnitude, and duration in cities. Characteristically, rainstorms in the tropics are highly localized, intense, and of short duration, covering less than 10 km^2 and usually lasting for an hour or less (Gupta and Ahmad 1999). This results in high spatial variability in rainfall, which makes precise forecasting difficult and poses problems for delivering reliable flood warnings.

The Eleiyele Dam located within the upper catchment of the Ona River in Ibadan North government area was badly affected by the flood. The stilling basin and the downstream walls were damaged, while the waterworks, station transformer, pump house, and control panels at the dam were all completely submerged. The damage resulted from heavy stormwater and exacerbated the flood in the downstream neighborhoods of the dam, as observed by 10 percent of the respondents. However, 15 percent of the respondents disagreed that the damaged dam caused the flood, which they attributed to the rain and other environmental and behavioral attributes of the people (Table 2). The downstream neighborhoods and areas along some of the rivers serving as natural outlets for the Eleyele Dam water were most severely hit compared to other areas where floodwater was only from local rainfall. The sudden rush of water washed away dozens of people and properties along its path. The damage to the stilling basin and wing wall of the spillway channel of the Eleiyele Dam may be referred to as a secondary cause of the flood. The dam has an installed capacity of 27,000 m^3 d^{-1} and it is one of the major sources of drinking water for the city of Ibadan, together with the Asejire Dam located in the Egbeda LGA (installed capacity of 82,000 m^3 d^{-1}) and Osegere Water Scheme (near Asejire Dam in the Egbeda LGA (13,500 m^3 d^{-1}). The Eleiyele Dam would have helped to retain some of the floodwater from upstream areas if the dam's water retention capacity was not reduced due to siltation. The dam filled with water to capacity had its spillway channel damaged under the water pressure. The water released from the pressured burst worsened the flood in the city.

Blockage of bridges, culverts, and drainage channels due to high sediment yield from construction activities and several earth roads in the city is another factor that has been

identified as responsible for flooding in Ibadan. Twenty-four percent of the respondents agreed that river sedimentation was a cause of the 2011 flooding, 5 percent disagreed, and 72 percent did not know. Stream channels in urban areas get filled quickly after heavy rains and the floodwater often passes through small culverts. These were initially adequate to manage the water volume but no longer are, because of increased urbanization and expanding areas of impervious surfaces that now produce runoff that exceeds the capacity of the culverts. 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 (Douglas et al. 2009). The stream channels themselves may contain so much municipal solid wastes and fecal waste in cellophane bags that their channels are smaller than they were two decades ago. A majority (74%) of the respondents agreed that dumping of solid wastes in drainage channels and river beds was one of the causes of the August 2011 flood, while 13 percent disagreed and another 13 percent indicated that they were not sure that dumping of solid wastes in drainage and stream/river channels could lead to flooding (Table 2). The highest percentage of respondents that perceived culvert blockage as a problem was in Apete (46%), followed by respondents from Bodija (36%), Moniya (21%), and Odo-Ona (14%). Significant variation in the data (X^2 = 6.341, $P \leq 0.05$) indicates that the perception of the contribution of blocked culverts to the severity of the flood varied among the four sampled localities. This variation could be due to the local perception of flood predisposing factor in each locality coupled with the collapse and subsequent washing away of some bridges and culverts in these localities.

The absence of river/stream management policies, with particular regard to the maintenance of the river/stream channels and the waste disposal behavior of the city residents, may be largely responsible for the blockage and constriction of drainage channels and stream/river beds. The only river in Ibadan that has been channelized is the Ogunpa River. The channelization has involved dredging and the construction of concrete embankments to ensure that the channel can carry more floodwater. The project started in 1982 and completed the lower and middle sections of the river. Construction work stopped in 2005 and left the upper section of the river untouched.

Vegetation growth on the banks of some of the rivers and streams was another factor identified as contributing to the recent flooding in the city. Some of the river channels were covered with weeds nourished by the composted household organic wastes dumped into the water, inhibiting the free flow of floodwaters. This condition becomes aggravated when the river loads include different types of household wastes that act as drags on the riverbed. The vegetation reduced the depth and width of rivers and stormwater was forced to backflow on to the adjoining lands bordering the rivers. The awareness of the role of weeds, particularly those that grew along the river channels, in precipitating flooding was high, as indicated by 52 percent of the respondents (Table 2). The highest percentage of respondents that perceived vegetation growth on river banks as a problem was in Moniya (36%), followed by respondents from Bodija and Odo-Ona (both 22%), and Apete (20%). Significant variation in the data (X^2 = 5.8371, $P \leq 0.05$) indicates that the perception of the contribution of vegetation growth to the severity of the flood varied among the four sampled localities. The possible reasons may be the level of experience of the respondents and the varying amount of vegetation growth in the water courses in the different localities. Vegetation encroachments have been noticed in many segments of the Ogbere, Ona, and Ogunpa rivers. Apart from the rivers and streams, the weeds encroach deeper into the Eleiyele Dam and reservoir, where about 15 percent of the surface area was covered with weeds, including water hyacinth especially in the north-eastern and eastern segments of the dam site.

4.2 Waste Management Factor

The percentage of the respondents who indicated that dumping of refuse in rivers and drainage channels could have been responsible for the 2011 flooding was 74 percent (Table 2). Dumping of refuse impeded the free flow of water. The practice of dumping wastes in drainage and river channels is common in the city areas (Onibokun and Kumuyi 1999; Olaseha and Sridhar 2004) where there are no provisions for waste bins by the government and people have been unable to organize private refuse collectors, either because of lack of communal cohesion or because such services are not affordable. Typical waste streams in river channels are largely made up of degradable (leaves, tree cuttings, leftover food) and non-degradable (rags, plastics, nylons and iron, furniture, utensils, bottles, and so on) materials. This refuse is often deposited in anticipation of rains believing that they will wash them from gutters into streams and rivers. It is common to see wastes in drains and gutters (both open and covered), where they can accumulate and impede the flow of water, which then flows onto the adjoining road. The practice of disposing waste into water channels is more common in the rainy seasons than in the dry seasons. In dry seasons, wastes are allowed to dry before they are burnt in an open space. The seasonal variation in waste management adopted at the household level has serious implications for the severity of flooding. Thirteen percent of the respondents indicated that dumping of refuse did not affect flooding and 13 percent claimed ignorance of the role of waste management practices on flooding. No significant variation exists in the perception of indiscriminate disposal of wastes as one of the contributing factors to floods in the studied residential localities (X^2 = 21.646, $P \geq 0.05$). The practice of waste disposal in water channels needs to be discouraged to reduce the incidence of flooding. These waste materials acted as catalysts for the

August 2011 flooding: they blocked the drainage channels of most rivers and led to the swelling floodwaters overflowing the banks. City residents' priority was to remove wastes from their immediate household environments by dumping them into water channels, as if doing this is the ideal and healthy way of managing waste. The residents only end up creating more problems because even if the waste dumped is washed downstream, when the degradable part is decomposed, it will facilitate the growth of vegetation in water course which will combine with the non-degradable part to further constrict the flow of water and contaminate the rivers/streams.

4.3 Institutional Factors

The weakness of existing institutional frameworks for the monitoring and management of the urban environment may also have contributed to the flooding. Manifestations of the weak institutional frameworks are reflected in many detrimental activities taking place in the city. Building construction on river floodplains, indiscriminate waste disposal, and illegal parking of vehicles at unauthorized locations are common in the city. In some instances, building approvals were granted without a clear understanding of the nature of the environment and the impacts of the construction on the overall environmental quality of the locality. Such constructions both obstruct the free flow of water and are at risk of being flooded. There were 26,553 buildings within the approved statutory setbacks of rivers/streams in the eleven LGAs of the metropolitan area of Ibadan in 2011 (Oyo State Government 2011). Yet, most of the property owners claimed they had approved building plans. Judging by the quality of most of the properties that violated setback regulation, it is clear that affluent residents were the culprits in peri-urban neighborhoods and low-income residents were the culprits in the inner city. Monetary inducements, poverty, greed, inadequate awareness, and undue political influence were some of the reasons for the violations. Table 2 shows that 31 percent of the respondents believed that flooding in the city is linked to this problem. A greater percentage (57%) however could not link flooding with poor urban management and 12 percent stated that they did not know whether it contributed to the flooding. The largest number of respondents who indicated institutional weakness as a factor in flooding came from Bodija (34%), followed by Apete (29%), Odo-Ona (19%), and Moniya (18%). There was a significant difference in the identification of this factor across the different communities ($X^2 = 7.191$, $P \leq 0.05$). The variations could have been influenced by the socioeconomic characteristics of the residents. Strong policies are needed that restrict physical developments within the ecologically sensitive areas. Such policies would curtail the number of injuries and fatalities from flood disasters.

Allocation of blame between the affected property owners and the officials of the Local Planning Authorities (LPAs) in the eleven LGAs exacerbated the poor environmental management. While the property owners claimed ignorance of the effects of constructing buildings close to river setbacks, they strongly believed that the planning officers, including those at the Ministry of Physical Planning and Urban Development (MPPUD), should have informed them before granting plan approvals. The planning officials argued that many developers willfully violated government planning and building regulations, especially the statutory setbacks, and many others either altered approved plans or built without approval. The city planners further claimed that inadequate tools and personnel who would ensure real-time monitoring were the major hindrance to their effective monitoring of physical development activities in their areas of jurisdiction. Wahab (2011) observed that the planning authorities and the MPPUD were grossly understaffed to be effective in their development control activities. He stated that while in 2011 the eleven LPAs had a total of 203 personnel (65 professional town planners, 97 technical, and 41 administrative staff) the MPPUD had 49 personnel (17 professional, 12 technical, and 20 administrative staff) monitoring development in the Government Reservation Areas and Estates throughout the 33 LGAs of Oyo State. The August 2011 flood exposed the weaknesses of the existing flood prevention system as well as the weaknesses of the various local planning agencies entrusted with the responsibilities of managing disaster risks. Ignorance of the physical and environmental conditions of the different residential neighborhoods, particularly concerning flood risk potential, was identified as one flood risk factor in the city of Ibadan. The percentage of respondents who indicated that ignorance was a contributing factor was 70 percent (Table 2). A factor identified by the respondents for the low level of awareness on flooding was the absence of data and information from government and other agencies on the flooding potential of some of the rivers as well as the flood vulnerability of the different residential and commercial zones in the city. A flood vulnerability map of the city was not available to guide urban development and assist people in their preparedness for flood. By 2011, Ibadan still had no development (master) plan to guide and direct its growth (Wahab 2011), which explains the sprawling nature of the city. Although a high illiteracy rate was thought a contributing factor to vulnerability to flood, lack of up-to-date information rather than literacy might largely be responsible for the severe flood problems in Ibadan, because the 2011 flood affected both the literate and illiterate population. The available statistics from the Nigeria Demographic and Health Survey (NDHS) show that 84.5 percent of people in the flooded areas of Ibadan had formal education and 15.5 percent did not (National Population Commission 2009). Apart from inadequate data and information from the government, other reasons for flood vulnerability include low personal assessment of flood danger, faith in technological solutions, and the reliance on government for flood management. It is of paramount importance to educate people on the risks of living in the floodplains, and on the wide range of non-technological alternatives that could offer some measure of protection (McPherson and Saarinen 1977).

Table 3. Approved setbacks for major rivers in the Ibadan metropolitan area, Nigeria

No.	River Name	Setback (m)
1	Odo-Ona Elewe	15
2	Adamo	15
3	Alalubosa	15
4	Sango	15
5	Others	15
6	Oluyole	15.5
7	Kudeti	30.5
8	Orogun	30.5
9	Onire	30.5
10	Gbaremu	30.5
11	Alaro	30.5
12	Ogbere	30.5
13	Gege	30.5
14	Ogunpa	45
15	Odo-Ona	45
16	Ona-Ara	45.7

Source: Oyo State of Nigeria 2005.

Rapid urbanization, population growth, internal migration, and poverty have led to increasing development of sensitive ecosystems especially in developing countries (Douglas et al. 2009). Today, there are noticeable building developments within the setback limits of most rivers and streams that traverse the city of Ibadan. The Oyo State government's 2005 gazetted setbacks, which range from 15 m to 30 m and 45 m for sixteen streams and rivers in the metropolitan area of Ibadan, are shown in Table 3. Despite the existence of this document, there are still various ongoing construction activities within these zones. These gazetted setbacks were issued in response to the flood that ravaged the city in 1980. Since then, the setbacks have not been reviewed, particularly in line with the changing climatic regimes locally as well as the dynamics or changing status of the water bodies and increasing urbanization. Residents in properties located within these setbacks are particularly vulnerable to flooding because of the closeness of their properties to rivers and streams. The percentage of residents that agreed that building within river and stream setback zones could predispose residents of such properties to flood was 89 percent, 8 percent disagreed, and 4 percent were not sure (Table 2). The largest number of respondents who indicated that building within a floodplain could precipitate flooding was in Bodija, followed by Odo-Ona, Moniya, and Apete. There was no significant variation ($X^2 = 28.849$, $P \geq 0.05$) in the perception of this factor in the four localities studied. Most of the respondents believed that this factor is important in exposure to flood risk. Some of the reasons for the development of floodplains and riverbanks include ignorance, poverty, inheritance, and scarcity of land for development. Greater encroachments were noticeable within the traditional core areas of the city—Ibadan North, Ibadan North East, Ibadan North West, Ibadan South-West, and Ibadan South East (Oyo State Government 2011). The floodplains of the Ogunpa and Ona Rivers within Apete, Bodija, Odo-Ona, and Moniya have been encroached by development. Other notable areas with large number of buildings within the approved statutory setbacks include Akinyele and Egbeda, emerging industrial areas.

Perception of flood hazard is an important component in flood response. The perception of flood hazard influences people's choices of location, developmental activities, and responses. This perception may be influenced by level of environmental awareness, education, social class, and income. Because they do not envisage that flood could reach their locations, people often construct buildings within floodplains and engage in indiscriminate dumping of wastes. Their assumption is usually that rivers and streams have limitless capacity to accommodate and transport wastes. Adelekan (2010) noted that floodplain dwellers did not anticipate flood events despite the fact that they were located within floodplains and were not prepared for floods. Ashley and Ashley (2008) affirmed that human behavior contributed to fatal flood occurrences where prevailing poverty was reinforced by poor economic policies.

Besides building constructions within the gazetted setbacks and within the floodplains, another construction-related factor identified was the hydrological modification of streams and rivers within the city of Ibadan through diversion and land reclamation activities by filling river courses with sand to gain additional land space to build. The natural courses of rivers and streams have been diverted using various manmade structures. Areas that were initially floodplains have been sand-filled and transformed to accommodate residential, commercial, and religious land use. The raising of some floodplains has drastically reduced the capacity of the remaining floodplains to contain stormwater discharge during heavy rainfalls and increases the risk of flooding. The diversion of river courses for construction purposes has not been limited to affluent low-density residential areas, but also has been common in high- and medium-density residential areas. The diversion obstructed the normal flow of water and created unnecessary artificial meandering of these rivers. In some instances, where the rivers' courses had not been diverted, their widths had been reduced by sand-filling for construction of buildings and commercial outlets, such as petrol stations and shops. During the 2011 flooding, some of these stream channels were unable to accommodate the volume of stormwater due to high and continuous rainfall, and floodwater spilled over onto adjacent land where it overran properties nearby. In all, 83 percent of the respondents agreed that human alteration of river channels could precipitate flooding and increase injury and death, 3 percent disagreed, and 15 percent were not sure (Table 2). Twenty-nine percent of respondents from Apete, 26 percent from Bodija, 23 percent from Odo-Ona, and 22 percent from Moniya agreed that hydrological modification of river channels was a major contributing factor to the flooding. No significant spatial variation was noticed ($X^2 = 13.393$, $P \geq 0.05$). The recognition of the role of this variable was almost uniform in all the sampled localities. The continuous encroachment on areas that could

ordinarily have been preserved was a result of perceived economic returns from investment on such land. The perceived status of the neighborhood and the scarcity of alternative lands were two critical factors indicated by the respondents as driving the hydrological modifications of land. In urban areas floods were not often caused by absolute surplus of water alone, but may also result from irrational land use patterns that turn useful precipitation into flood (Zheng and Qi 2011).

Deforestation was also identified as an important contributing factor to the incidence of flooding in Ibadan. The increasing urbanization of the city has resulted in the conversion of areas hitherto used for small- and medium-scale agriculture or forestry into building sites. The situation was compounded by the increasing deforestation of the wetlands and riparian forest areas including the Eleyele watershed, which served as storage areas for floodwater. Most of these wetlands and riparian forest areas had been cleared and laid out for residential development as in Apete community. Another concern is the clearing and development of the *Igbo Agala* sanctuary forest in a hilly part of the city. The clearing and development of the sanctuary forest exposed the area to direct rainfall on the soil surface and heavy runoff was the immediate consequence. Today, most of the sanctuary has been built up and this is increasing the stormwater that flows downstream to some of the neighborhoods and localities in the city that now experience flood regularly. Thirty-nine percent of the respondents believed that deforestation was a contributing factor in the August 2011 flood, 9 percent disagreed, and 52 percent were not sure (Table 2). The highest percentage of respondents who identified deforestation as exacerbating the flood was in Bodija (39%), while the least was in Moniya (18%). A significant spatial variation (X^2 = 9.619, $P \leq 0.05$) was reflected in the opinion of respondents concerning the relationship between deforestation and flooding. This could be attributed to the variation in their level of education. While Bodija is a high-income elite community (government reservation area adjoining the state government secretariat), Moniya is a low-income residential community.

One of the outward manifestations of urbanization in Ibadan is the increased percentage of impervious surfaces restricting where floodwaters can go. Impervious surfaces include hard concrete surfaces such as pavements and roads that do not allow water to seep into the soil, obstruct natural channels movement and ensure that water moves to rivers more rapidly than it does under natural conditions (Douglas et al. 2009). The higher the percentage of impervious surface area, the higher the runoff contribution will be to stormwater; all the water collected from rooftops and other impervious surfaces within a given area flow directly into the drainage channels, thereby increasing the amount of stormwater in the drainage channels. Information on current impervious surface coverage in Ibadan is unavailable. However, Akintola (1994) observes that the percentage of impervious surfaces in the city increased, particularly between 1965 and 1994. In the traditional core area of the city, the impervious surface increased by 175.9 percent, the modern low-density areas recorded a 302.3 percent increase, in the modern high-density areas it increased by 169.6 percent, while in the utilities and government reservation areas it increased by 386.1 percent in these 30 years, at an annual rate of 5.8, 10.1, 5.6, and 12.8 percent respectively. Although only 9 percent of the respondents believed that impervious surfaces contributed to the 2011 flood in Ibadan (Table 2), it is one of the most important factors cited in flood studies (Akintola 1994). There was a significant spatial variation (X^2 = 9.111, $P \leq 0.05$) in the perception of the role of impervious surfaces as one of the contributing factors to the flood. The low level of awareness of the contribution of impervious surfaces could be due to the assumption that rivers and streams have unlimited capacities to contain any amount of water. Despite government regulations on what percentage of a plot should be built up in low density (35%), medium density (40%) and high density (50%), many people were either not aware or simply ignored the regulations. Impervious surfaces were prevalent in residential areas because most people claimed that they did not have time to weed grasses, while some claimed that they could not tolerate reptiles and scorpions that were likely to hide in the grasses. They preferred concrete around the buildings to shrubs and grasses. Female respondents particularly pointed out that concrete made cleaning easier compared to having to weed grasses although many would prefer a landscape with flowers and grasses. The cost of landscaping also made people opt for concrete surfaces in their compounds because the maintenance of a natural landscape would have required annual budgeting for landscaping.

4.4 Awareness Factor

The lack of precise and specific early warnings from mass media was another contributing factor to the high number of fatalities recorded from the August 2011 flood. Some respondents indicated that there was generalized information on the radio pointing to the possibility of heavy rainfall in the city. Good as this information was, it was not specific as to when to expect the flood, what people should do when the rain started, and what might be readily available adjustment options they should take advantage of to save themselves. Only one radio station out of the six in the city aired the warning about the anticipated flood on that day. Ninety-two percent of the respondents in the city indicated that they listened to radio at least once a week. Radio is one of the most effective means of disseminating information on flood in local communities (National Population Commission 2009). The percentage of people that believed that provision of adequate early warning and response information would have reduced fatalities from the 2011 flood was 53 percent (Table 2). There was no significant variation in the opinion expressed by respondents in the four localities about the role of early warning in reducing the devastating effect of the flood (X^2 = 18.333, $P \geq 0.05$). The respondents who indicated that early warning information would not have made any impact argued that

floods did not occur frequently in the city. Compliance with early warning instructions might not have been effective, knowing that compliance to a given instruction could be significantly influenced by previous experience.

The factors contributing to flood severity identified by respondents in this study correspond to ones identified by Oguntala and Oguntoyinbo (1982); Olaniran (1983); Akintola (1994); Oriola (1994); Adewale, Sangodoyin, and Adamowski (2010); and Adelekan (2010). Numerous factors combined to precipitate the 2011 flood. Although largely caused by the high and prolonged rainfall, it was exacerbated by improper waste management, building construction within flood zones, institutional weakness, lack of awareness of flood vulnerability, hydrological modification of rivers and streams, dam breaking, and expansion of impervious surfaces. The respondents indicated river channelization, early warning, proper environmental sanitation and management, and dam construction as some of the most viable ways of reducing flooding, and that the use of insurance should be encouraged to reduce post-flood stress on people. They felt that the responsibility of flood management should be shared by the community and the government, but that they would expect the government to provide the framework for this partnership. Identifying the factors that caused the flood is not enough; there is also the need to determine its consequences. By addressing the consequences of the Ibadan flood, the integration of the anthropogenic causes into flood study will contribute to a holistic understanding of factors that should be considered in flood modeling and in the design of an effective early warning system. Identifying the consequences will also help in strengthening the existing institutional framework for disaster response.

5 Consequences of the 2011 Urban Flood in Ibadan City

The various consequences of the 2011 urban flood in Ibadan can be broadly categorized into economic, infrastructural, hydrological, physical displacement, and psychological impacts. These impacts are in addition to the fact that the flood caused death and injury to over a hundred people. The psychological impact manifested itself in the form of fear of rains and flood with implications for the health and income of people. After the flooding, any sign of rain made people anxious. Some indicated that they were worried that another flood would occur. Popular anxiety was further heightened when people noticed that the flood happened in August, when the city was supposed to be experiencing the August rainfall break. Radio communications reminding people to expect more floods in the year made them even more frightened.

In terms of the effects of their fear on economic activities, 19 percent of the respondents indicated that they now returned home early from their offices/shops because they observed that the rains fell mostly in the evenings. They did not want to get caught up in the rain but be home before the rain started. This reduced their daily business profits. Traders noted that they did not make as many sales in the evening anymore. Most people preferred to shop from early morning to late afternoon. The reduction in sales and earnings for traders and business people might have direct impacts on their standard of living.

The flood affected critical infrastructures such as electricity poles. In many neighborhoods, electricity supply was disrupted for days because the flood toppled many poles. The absence of electricity affected some artisans and business people who depend on electricity for their daily activities. Some people opted for generators, which increased their costs of production and increased air pollution. Because of the damages to the stilling basin and the downstream walls of the Eleiyele Dam, water supply in many parts of the city was also interrupted. By September 2012, thirteen months after the flood disaster, the dam had not restarted pumping water to the city and many people cannot access water from public taps until the government fixes the dam. Oyekan and Roger (1982) noted that after the 1980 flood, the city of Ibadan was left without safe drinking water for more than three weeks due to the damage of Eleiyele Dam. The 2011 flood also affected many roads. In Apete, Moniya, Bodija, and Odo-Ona many roads were rendered impassable by the floodwater. The culverts and bridges gave way under the heavy pressure of the floodwater and many communities and neighborhoods were isolated. Among the communities affected were Awotan and Apete, which were isolated for days, and cost of transportation increased fourfold. Children whose schools were outside the community could not go to school for days. A number of these roads would require major structural redesigning, particularly the bridges and culverts that suffered from structural damages because of the flood.

Infrastructural damages at the University of Ibadan were considerable. The University lost properties estimated at ₦10 billion to the disaster. These included many gigantic buildings, laboratories, and expensive equipments destroyed in the flood. A portion of the university's perimeter wall was also pulled down, together with 13 electric poles. This development compounded the already poor electricity supply to the institution. Similarly, many people spent large sums of money to repair their broken perimeter walls, household items, and vehicles damaged by the floodwater. This affected the financial status of most victims.

The flood resulted in the forced physical displacement of 4 percent of the respondents from their homes for different lengths of time. This displacement was most prominent in Apete and Odo-Ona areas, especially among the flood victims that lived close to the rivers. Although not all the people affected relocated from the flood hazard zone, some did relocate to new places because of the fear of another flood. There were also those that relocated because their residential buildings were badly damaged by the floodwater. Most buildings that suffered less from the heavy flooding had structural damages that might become a problem over time. Others indicated that they had to relocate their shops from perceived

flood-prone sites to secure sites. Some respondents (79%) indicated that they might come back when they thought that the situation had normalized. Ologunorisa and Adejumo (2005) noted that many times flood victims did not relocate from their affected properties and residences largely because of the relatively affordable accommodation cost in the locations. To relocate to new locations might imply increased cost of accommodation, especially given persistent inflation in the country and the prevailing poverty. The high cost of rent coupled with unemployment, underemployment, and uncertainty in the economy compelled a large number of people to remain in their present locations, in spite of the destructive flood they had witnessed there.

The flood particularly affected certain economic activities. Twelve percent of the respondents claimed that the floodwater entered their shops and spoiled their wares worth millions of naira. A number of companies could not continue production until they had fully ascertained the integrity of their machines and electric wiring system. Two percent of the respondents who were farmers claimed that the floodwater washed away fish from their fishponds, estimated at millions of naira. Poultry farmers also indicated that the floodwater damaged their poultry farms; many livestock were washed away, particularly on farms close to riverbanks. The Agriculture and Allied Matters Trade Group (AAMTG) of the Ibadan Chamber of Commerce and Industries (ICCI) estimated that fishponds and poultry of members, worth hundreds of millions of naira, were washed away by the flood (Momoh 2011).

Finally, the August 2011 Ibadan flood had hydrological implications in the form of sediments and waste yields from the flood. The floodwater left behind sediments and wastes both in the river channels and in the adjoining land areas to the channels. Mainly, the wastes were household items. The sediments and waste materials inhibited the free flow of water in the channels, reduced channel sizes, and urgently needed to be cleared up.

6 Conclusion: Policy Implications

To effectively deal with the challenge of urban flood in the city of Ibadan, it is imperative that the Oyo State government invest in regular and up-to-date climatic and weather-related data collection so that it can make adequate and precise forecasts about the weather patterns in the city. The provision of this weather forecast service will require considerable investment and staff capacity building. The state should coordinate activities with the various research institutes and the University of Ibadan, which has a computerized weather station, to promote capacity building and exchange of ideas on climate change modeling.

There is a need to disseminate information about floods and other natural disaster incidences using the radio media. Radio appeared to be the most widely accessible and utilized media in local communities. Radio advertisements in the form of jingles and drama can be used to create awareness on floods and emphasize the importance of proper waste disposal methods required for a good and safe standard of living. Because of the greater need for public awareness and sensitization on floods and on what needs to be done to reduce fatalities, all these media opportunities have to be exploited. Ologunorisa and Adejumo (2005) observed that flood control needed the cooperative agreement between government and local communities, and an enlightenment program through environmental education and mass media that can be largely accomplished using radio.

In order to reduce mortality from flood events, there should be proper land use planning in the city. The state government, in collaboration with the eleven local governments and the public, should invest in the preparation of a strategic development plan to guide the use of land and the character of development in the city. At the same time, regulations concerning the use of open space for development in the city must be enforced. One of the most efficient means to mitigate damage to lives and properties is discouraging inappropriate land use in or near floodplains, as inappropriate land use is often associated with impenetrable surfaces that exacerbate flooding. Most countries attempt controlling nature rather than working with it, and this may explain the preference for engineering solutions to flooding, which typically require little or no change in individual or collective human behavior (Nash 1982). People's ability to manipulate nature to protect lives and properties from flooding may be limited. There is a need for the government and other stakeholders to review existing regulations concerning setbacks to rivers and streams with a view to accommodate the effects and impacts of climate change and increasing floodwater on the new setbacks.

The experience of the August 2011 flood not only showed the need to increase the existing setbacks at the rivers and streams, but indicated the need for a better strategy to keep the larger parts of the floodplains in the city fairly clean. There is no drainage master plan in existence in the city and this explains why the drainage and river/stream management has been haphazard over the years. In order to facilitate a coordinated effort aimed at managing stormwater and flood in the city, the existing master plan of the city needs to be updated for massive urban renewal, and a contemporary drainage master plan needs to be developed as a tool for urban managers. The government also needs to conduct a spatial analysis to delineate the city into different flood hazard zones. This delineation will help to identify the most prevalent hazard exposures in different localities and neighborhoods in the city. This will inform real-time intervention from relevant agencies.

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