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Assessment of Urban Flood Disaster: A Case Study of 2011 Ibadan Floods

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Abstract

Increase in both precipitation due to climate change and imperviousness due to urbanization coupled with encroachment in to areas liable to floods have continued to increase the frequencies and risk to floods in urban centres of the world. In the developing countries indiscriminate dumping of refuse and siltation in waterways and drainage system are common practices, which reduce the carrying capacities of the stormwater channels and increase the risks of flooding and associated hazards. Ona River and its tributaries in Ibadan city was hit by floods in 2011, the University of Ibadan, the Eleyele and IITA dams were at the receiving end. Many communities downstream suffer serious damages and over 100 lives were lost. This paper reviews the immediate causes and possible measures to prevent further occurrence.

Key words: climate change, impervious, urbanization, floods, Drainage system

Introduction

Urbanization lead to increase in population and associated construction of houses and infrastructural development reduces areas for natural infiltration of storm waters while paved surfaces are increased. Common feature of urban development in the developing countries are property development in the floodplains and indiscriminate dumping of solid natural and artificial channels which reduces the carrying capacities of the stormwater channels and increase the risks of urban flooding. Urban flooding arises when the urban stormwater channels capacities are overwhelmed by stormwaters generated from rainfall and spills into adjoining properties which are inundated throughout the period the conditions are sustained. Associated consequences include disruption of social-economic activities, utility supplies, communication, transportation, loss of properties and human lives. The flowchart presented in figure 1 explains the processes of urban floods and its consequences.

Several cases of flooding of urban cities of Nigeria has been reported in recent times particularly Sokoto, Lagos, Ibadan, Abeokuta, Gusau, and Makurdi, Alayande (2010), Alayande et. al (2011), NWRI (2008, 2011) to mention but a few. Most of these floods arose from a combination of heavy downpour, poor and inadequate capacities of existing storm water drainage systems, and bad solid waste management systems. Climate change which has in recent time caused unusually high rainfall pattern across the globe; raises the water levels in the Oceans and caused back flow at the delta, is also fingered as another cause of flash floods across Nigeria. Excess releases from dams whose operational capacities could not cope with excessive inflows into their reservoir areas has also been fingered as responsible for flooding in Nigeria particularly in the Cities downstream major dams Alayande and Agunwamba (2010).

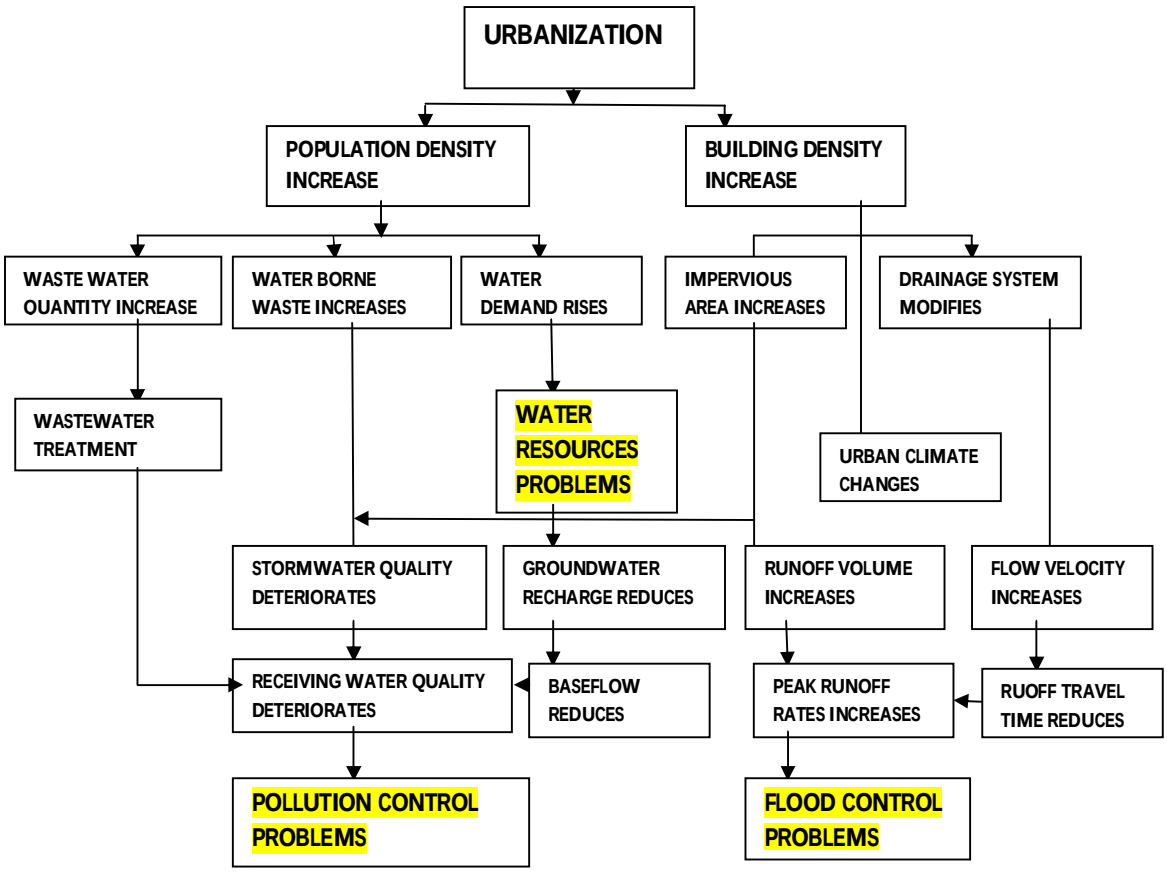

Fig. 1: Hydrological impacts of urbanization (Andjelkovic, 2001)

On Friday 26th August 2011 following heavy downpour of rainfall the Ona River busted its banks and spill flood waters along its course in Ibadan causing an unprecedented flood disaster in the Oyo State Capital. The extent of damages and coverage exceeds those caused by the Ogunpa flood disaster of 31st August 1980. This paper presents an assessment of the immediate and remote causes of the August 26, 2011 Ibadan flood disaster.

Study Objectives

The assessment was conducted in fulfillment of the mandates of the National Water Resources Institute, Kaduna which empowered it to "**Perform applied research functions in all aspects of water resources development and management (i.e. flood control, river regulation, reclamation, drainage, irrigation)".** The study team was constituted to conduct an assessment of the August 26 2011 Ibadan flood disaster and make recommendation to government.

Physical Characteristics

The Ona River is in Ibadan Southwest Local Government Area (7°25"N, 3°25"E) of Oyo State, Nigeria. The area is characterized by a tropical wet and dry climate. While the wet season last for about 8 months the dry season is in the neighbourhood of 4 months with a mean annual rainfall and temperature of about 1,205 mm and 28°C respectively. Estimated

potential evapotranspiration is 1100 mm (Martins and Bello, 1997). The city is underlain by crystalline pre-Cambrian basement complex of igneous and metamorphic origin (Fagoyinbo, 1996). The river and its tributaries constitute part of the general catchment that forms the physical landscape of northern and south-western part of Ibadan city. The upper catchment of the river is densely built up consisting of communities like Moniya, Part of Bodija, Agbowo, Ojoo, Sango, Sasa, Orogun, Army Barrack etc. hence most of the areas are highly impervious. Collected storm water from the numerous sub-catchments is drained by open gutter system draining into smaller streams that finally empties into the Ona River.

Hydrology of the Study Area

The Ona River and its tributaries drain the western and the northern part of the City in a south western direction. The Awba River a major tributary of the Ona River took its source around Moniya, upstream of the IITA. The IITA dam was constructed on the Awba River in 1967 and provides a dependable source of agricultural and domestic water supply for the entire Research Institute. The Ona River took its source around Bodija, a highly built up elite settlement and flows through Agbowo into the University of Ibadan (UI) where another tributary, Orogun River which drains the Ojoo Area discharges into the Ona River upstream of the confluence of Awba River and Ona River at Ajibode-Sassa road, immediately upstream of the UI Botanical gardens. The UI dam was constructed on a tributary of the Ona River which has its headwaters at Sango. The main Ona River channel was dammed at Eleyele, downstream of the IITA and UI dams, a waterworks was constructed downstream of the dam and had since 1942 provided a dependable source of water supply to Ibadan, producing 37,000m3/day of treated water. Fig. 2 shows the three dams and the densely built up areas in the upper catchment of the Ona River and its tributary.

Methodology

Baseline Data Collection

Data on the affected areas and water resources infrastructures were collected from the Oyo State Emergency Management Agency; Oyo State Ministry of Water Resources, University of Ibadan, and the International Institute for Tropical Agriculture (IITA). The affected locations were visited to conduct an on the spot assessment of the level of damages and interviews were conducted to ascertain the causes of the flood and the immediate response of the communities when the disaster occurred. Several sections of the main channel of the Ona River were also inspected especially at built up locations to assess the channel conditions. Rainfall data for the month of July and August 2011 was also collected from the Nigerian Hydrological Services Agency, Ibadan. Google Earth images of the entire City of Ibadan were downloaded to study the flow of the stormwater and the interconnectivity of the stormwater drainages across the City.

Fig. 2: The three Reservoirs within Study Area. (Google Earth, 2011)

Data Analysis

Ona River channel assessment

A physical assessment of the upper reach of the river shows a significant part of the flood plain and the river channel has been encroached by housing, commercial and industrial developments. The Channel bed is characteristically flat in most reaches having lost its depth to siltation arising from silts, debris and solid wastes it carries in its flow. The hydraulic implication of this is the loss of river channel's runoff carrying capacity. Of great concern is the presence of thick vegetation comprising of bamboos, typha and elephant grasses and big trees along the river channel as it flows through the City. This help in trapping debris and volume of solid waste in the runoff thereby creating high frictional flow with attendant high time of concentration. In the event of high rainfall like the one experienced on August 26, 2011, the channel capacity easily become overwhelmed resulting in the flooding of its floodplain and adjoining properties. Figure 2 presents the situation of the Ona River Channel at Oluyole Estate.

Fig. 2: Ona River Channel at Oluyole Estate Ibadan

Sanitation status assessment

Solid waste collection and disposal system in the City are poorly managed. According to Onibokun & Kumuyi 1999, Sangodoyin 1991, Olaseha & Sridhar 2004, Adenji & Ogundiji 2009, and Olaseha, I. O. and Sridhar, M. K. C. (2004) that the solid waste management service in Ibadan are inadequate, with a preponderant proportion of the refuse generated remaining uncollected and with large parts of the city, particularly the low-income areas, receiving little or no attention. The wastes are generally disposed in the storm drainage and river channels, constituting major friction to flow of stormwater in the channel and become trapped at bridges and culvert locations causing over spilling of flood waters at such locations. Figure 3 shows a typical solid waste problem at Oluyole Estate Ibadan.

Fig. 3: Solid Waste Blockage at The Culvert Entrance at Oluyole Estate

August 2011 rainfall report

An all time high of 187.5mm rainfall was experienced on August 26, 2011. The rain started at 16.40hr until 20.00hr then intermittent drizzling until 23.00hr, it was also accompanied by wind speed as high as 65km/hr. IITA (2011) reported that the rainfall was most intense between 18.10hr and 19.20hr when 75% or 140.63mm of the rain fell. This translates to an average rainfall intensity of 127.84mm/hr. On the same day, the raingauge at the new airport at Alakia recorded 86.20mm; while the old Airport recorded 153.50mm during the period. According to IITA's weather data, the average daily rainfall in August 2010 was 8.9 mm considering all days, and 25mm considering only the rainy days. Maximum daily rainfall for August 2010 was pegged at 62 mm. The resultant effect was that the channel was unable to pass the flow downstream as quickly as it should, thus water built up in the channel to as much as 2.5m depth all across the path, inundating properties along its way.

Both the IITA and Old Airport are located within the upper catchment of the Ona River Basin while the new Airport is located in another catchment and this explained why the level of devastation was higher along the Ona River and its tributaries. The rainfall was unarguably high and its occurrence or otherwise is outside human control. Technology development has however made the prediction of its occurrences relatively accurate as the Nigeria Meteorological Services had early in 2011 predicted that the country will witness high rainfall this year.

Response of the three dams to the flood

Three dams were located within the upper catchment of the Ona River and the three dams were visited to determine how they had responded to the flood flow during the period. Table 1 is a summary of the team observations and figure 4 to figure 6 presents the conditions of the three dams after the flood.

Table 1: Response of the Dams within Ona River Catchment to the August 26, 2011 Flood.

Reservoir/Dam	Type	Level of Damage	Operating efficiency
IITA	Free flow	No damage to the dam. The spillway was found operating normally and has effectively discharged the excess flood to the downstream river channel without damage to the spillway or the immediate downstream channel. However, as a result of high winds that follow the rain storm, many trees were uprooted and many crops were damaged at some of experimental plots in the complex.	Said to be Okay
University of Ibadan	Free flow	Did not show any sign of stress as a result of the flood. The spillway was functioning normally and the downstream channel did not indicate an unusual flood	It was reported that the reservoir is silted up and its current capacity is not sufficient to meet the Institution water demand, hence supplementary supplies are received from the Eleyele reservoir.
Eleyele Reservoir/ Dam	Free flow	The dam was stable but the stilling basin and the downstream walls were damaged while the Waterworks was completely submerged as the water level downstream of the dam rose to about 2.4m above the channel floor. The station transformer, pump house, pumps, control panels and the clear water well were completely submerged for the duration of the flood event.	Restored to its original status

The level of damages on the floor of the stilling basin of Eleyele dam / Reservoir, downstream channel walls, culvert and the level of submergence of the downstream treatment plant testifies to the unusual nature of the runoff in volume and energy. However the spillway capacity is sufficiently adequate to allow the passage of the flood without threat to the dam and the spillway structures. The findings went contrary to the belief that the dams in the upper catchment gave up and were the cause of the un usual flow that causes the floods.

Fig. 4: The IITA Spillway and Dam Embankment after the Flood (7th September 2011)

Fig. 5: The UI Dam Embankment and Spillway after the flood 6th September 2011

Fig. 6: The IITA Spillway and Dam Embankment after the Flood (7th September, 2011)

Downstream impacts assessment

The flood wrecked havoc in the City particularly within the Ona River Basin. It washed off the Apete Bridge and overwhelms many bridges and culverts causing damages to the road and bridge / culvert structures at Ijokodo, Polytechnic road, Apata, Odo Ona Elewe and New

Garage, other place. Heap of garbage were seen deposited at the entrances of most of the bridges and culverts indicating that there capacities has been overwhelmed. Road pavements and the coal tar were peeled up and transported downstream thereby causing serious traffic disruptions. The Oluyole Power Holding Company of Nigeria (PHCN) substation, the fish ponds belonging to the Fisheries Department University of Ibadan, several residential houses were damaged and over 100 human lives were lost during the flood disaster. Figure 7 shows some of the properties damaged by the flood.

Fig. 7: Some cases of Property Submergence during the Flood

Conclusion

The Friday August 26, 2011 flood disaster in Ibadan was rainfall induced. The Ona River basin particularly experienced over 15.56% of the basin's long term annual rainfall and equally high intensity rainfall of 127.84mm/hr over a period of 1.1hrs. The volume of runoff generated by the rainfall was unprecedented and rose to as much as 2.5m above the channel bed all along its reaches as it flows out of Ibadan. Unfortunately, during this event, the river floodplains were enchroached in many locations and the river channels were constricted in many sections due to deposition of tonnes of solid wastes and vegetation growths including trees, in the river channels at several locations. These situations increases the time of concentration of flow and channel friction leading to unprecedented rise in water level that overwhelm bridges and culverts along its path; submerged properties and caused the loss of over 100 human lives.

Recommendations

To effectively deal with the problem of flooding in the urban centres of Nigeria, there is the need for decisive actions first to understand the forces at play in the disaster because we can't stop rain from falling any time even in a magnitude greater than what was experienced in Ibadan on 26th August 2011. Proper floodplain management systems must be developed and enforced for all the rivers within the State Capital. The following short time measures are recommended for the consideration of the government.

Short Time Measures

The government of Oyo State should be aware that the densely populated Capital City and environs are on the headwaters of the Ona River and Ogunpa River. The attendant soil

imperviousness associated with urban development allows for rapid runoff generation, even from small amount of rainfall, which must be discharged effectively. Therefore:

a. On the immediate term, efforts should be made **to restore and preserve the natural resources and functions of the Ona River floodplain for beneficial use**. Floodplain naturally supports agriculture, fisheries, wild life and cattle grazing. All these potentials are wasting away along the Ona River floodplain due to the growth of bamboos, typha and elephant grasses within the floodplain. The Ona River is no longer "a river in the wild" but an urbanized river that must wear a serene look befitting its present status. The Ona River and its major tributaries channels must be de-silted for the entirety of their lengths across Ibadan and cleared of the various forms of vegetation which have overgrown the channels. Green areas must be created and regulated along the river floodplain. Presently, the potential of the floodplains to be food basket is being allowed to waste by allowing the growth of wild and uneconomical plants to thrive in the floodplain. Harnessing the agricultural potentials of the Ona River floodplain could create jobs and supply the City of Ibadan and environs quality leguminous and vegetable products.
b. An efficient waste management system including engineering landfills must be put in place against the backgrounds of the environmental circumstances of Ibadan. The poor waste management in the City may account for the situation that thirty one years after the "Omiyale" of 31st August 1980, a re-enactment of it occurred again on 26th August 2011 despite the channelization efforts of the Ogunpa. This is because government after government did not prioritize efficient solid waste management in the capital City, thereby facilitating flood disasters.
c. Repair of the damaged section of the Spillway of the Eleyele dam should be given immediate priority to prevent another danger and loss of that dam and the services it provides.

Long Term Measures

The long term measures are in the form of a road map for effective flood control in the Capital City of Oyo State with each proposed measure interrelated with others and thus should be taken as whole.

1. Modify Human Susceptibility to Flood Damage

a. Flood Risk Zones Mapping
   The State Government should partner with the Ogun Osun River Basin Development Authority, National Environmental Standards and Regulation Enforcement Agency, National Emergency Management Agency and the National Water Resources Institute to identify and map flood risk zones along the major drainage channels across the City and package an enforceable floodplain regulation to regulate future land use within the floodplain. Flood risks zones should be clearly demarcated with visible beacons and enforce restrictive land-use regulations including prohibitions and penalties for violating the regulation.
b. Application of Redevelopment Policies: The certificate of occupancies of all properties under the risk of 50yr recurrence interval flood and higher can be revoked, properties acquired, removed from the floodplain and the open space put

under permanent restrictions for re-allocation for dry season (fadama) agricultural use only.

c. Flood Forecasting and Emergency Plan: The Federal Ministry of Environment, Nigerian Meteorological Services Agency and National Emergency Management Agency should not only play the role of "fore teller" but localize their predictions and coordinate relevant State Agencies for preparedness actions. We should move away from being alarmist to developing practical preparedness measures against these disasters because the safety of Nigerians should be one of the specific objective of the early warning as obtained in other countries. These Agencies should go extra miles to save lives and properties in the endangered communities by partnering together to develop early prevention strategies and disaster preparedness measures. People living in the disaster prone areas should constantly be educated on disaster prevention, disaster preparedness, and post disaster recovery.

2. **Modify the Impact of Flooding on Individuals and the Community.** Governments should sustain disaster management relief efforts aimed at reducing the socio-economic impacts of these disasters through mobilization of relief materials by standing National and State Emergency Management Agencies. These Agencies should be adequately funded and their human capacities developed to handle these emergencies.

3. **Modify Flooding.** River training and construction of dykes or floodwalls are sufficient to meet today's challenges of flood control in most cities of Nigeria. The Federal and Oyo State governments should adequately plan for proper channelization of main drainage networks across the City as a long term solution to the problem of flooding in the City. This in addition to sustenance of all the measures earlier mentioned.

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