FLOODING IN LAGOS METROPOLIS: URBAN DEVELOPMENT AND MUNICIPAL SOLID WASTE PERSPECTIVES

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ABSTRACT

This study succinctly appraised the contributions of urban development and municipal solid waste to flooding with specific reference to compliance to space standards, municipal solid waste disposal methods and frequency of collection. It argued that urban managers need to develop an inclusive framework built around the management of urban development and municipal solid waste towards reducing the frequency and subsequent impacts of flooding. This, it posits, can be achieved through the gazetting of a broad-based and inclusive urban development policy, strict enforcement of the provisions of urban development regulations, initiation of an integrated municipal solid waste management strategy, and the use of information technology. Understanding the occurrence of flooding from urban development and municipal solid waste perspectives will help urban managers and other stakeholders to appreciate the need for the development and implementation of inclusive policies to tackle the menace of flooding in the Lagos metropolis.

INTRODUCTION

As of 10 October 2020, flooding has affected around 2.1 million people in West and Central Africa, with many regions recording excess rainfalls. The impact in 2020 is particularly severe, and the number of people affected already is almost double last year's, when floods affected 1.1 million people in 11 countries (UN OCHA, 2021). Flooding is the leading cause of natural disasters worldwide and is responsible for 6.8 million deaths in the 20th century (Glickman *et al*., 1992; IFRCRS, 1998; Jonkman, 2005; Jha *et al*., 2012; Doocy *et al*., 2013; Nwigwe and Emberga 2014; Oladokun and Proverbs 2016; Jongman, 2018). In year 2020 alone, flooding in different parts of Nigeria has killed 68 people and affected 129,000 others in terms of its devastating impact on lives, properties, and farmlands (National Emergency Management Agency, 2020). Flooding is the most common and recurring disaster in Lagos State, Nigeria. According to Etuonovbe (2011), between 1970s and 2011, flooding has been responsible for building collapse, destroying properties, and affecting more than 300,000 people in Lagos. In Lagos, the total economic losses due to flooding across the state have been estimated at USD 4 billion per year, which is 4.1% of the state's GDP or 1.0% of national GDP (Croitoru, *et al*., 2020). Can you check the department of meteorological agency for recent data? Flooding has long been an issue of increasing severity in Lagos. Flooding has been reported in the city since at least 1947, was described as widespread in the 1970s, and is now an annual occurrence (Adelekan and Asiyanbi, 2016; Atufu and Holt, 2018). More importantly, the frequency and spatial coverage of flooding within the metropolis, with the attendant havocs, call for serious concern and attention, considering the economic and political status of the state. Lagos State has the most extensive infrastructural facilities in Nigeria (Olufemi *et al*., 2013). Industrial and commercial establishments in Lagos State are over 70% compare with other states in Nigeria (Ajibola, *et al*., 2012). Lagos is the financial hub of Nigeria with over 2000 manufacturing industries, over 200 financial institutions, and the nation's premier stock exchange facility (Ajibola, *et al*., 2012; Ogbonna, 2018). The gross domestic product (GDP) in Lagos outstrips that of any three other West African countries (Ajibola, *et al*., 2012).

Owing to the topographical traits and coastal location of Lagos metropolis, researchers have focused on climatic parameters (Action Aid, 2006; Eckert, 2008; Adelekan, 2009, 2010; Ekanade, *et al*., 2011), topographic variables (Ologunorisa, 2009; RIBA, 2009; Fuchs, 2010), and drainage pattern (Taiwo, 2009; Akpodiogaga and Odjugo, 2010; Ikhile and Olorode, 2011) to understand the causes of flooding with little empirical evidence on the relationships between flooding and urban development and municipal solid waste parameters. This study provides a succinct appraisal of the contributions of urban development and municipal solid waste to flooding with specific reference to compliance to space standards, municipal solid waste disposal methods and frequency of collection. It posits that urban manager need to develop an inclusive framework built around the management of urban development and municipal solid waste towards reducing the frequency and subsequent impacts of flooding.

Integrated Urban Flood Risk Management (IUFRM)

Integrated urban flood risk management (IUFRM) is a multi-disciplinary and multi-sectoral framework that falls under the responsibility of diverse government and non-government bodies, developed after Disaster Risk Management and Disaster Risk Reduction (Jha *et al,* 2012). Flood risk management measures need to be comprehensive, locally specific, integrated, and balanced across all involved sectors (Jha *et al*, 2012). As pointed out by Andjelkovic (2001), IUFRM is a unified approach, which incorporates an array of urban flood risk management activities. It involves planning for environmental and socio-economic sustainability. Because planning is future-oriented, integrated planning is geared towards forestalling future problems associated with the inadequacy of human actions. In the area of urban flooding, the integrated approach involves harmonizing and articulating all the components of urban flood management system. This holistic approach aims at integrating the stakeholders, elements, and aspects of flood management into a development plan (Jha *et al.*, 2012).

The conceptual framework for urban flood risk management for local adaptation is captured in Figure 1. The model shows that urban flood risk management has various elements: structural and non-structural. These system elements must all be articulated in any urban flood risk management planning. This is the unified model, as provided by Andjelkovic (2001), in which non-structural measures, including emergency response measures, flood preparedness measures, local and state legislature, financing, and environmental impact assessment are incorporated with structural and flood recovery measures, such as insurance, financial assistance, rehabilitation, and tax adjustment designed to cushion the effect of flooding in urban milieu.

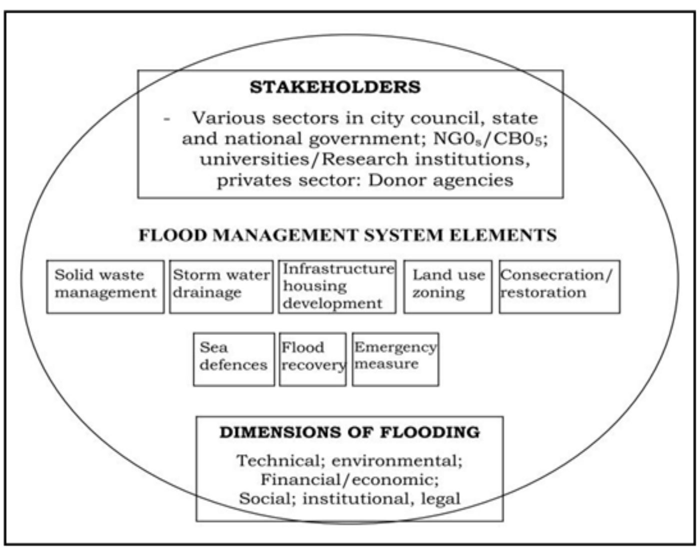

Fig. 1: Model of integrated urban flood risk management
Source: Klaudert and Anschiitz (2000)

Twelve key principles of integrated urban flood risk management were identified by Jha *et al*. (2012). First, every flood risk scenario is different, that is, there is no flood management blueprint. Understanding the type, source and probability of flooding, the exposed assets and their vulnerability are all essential if the appropriate urban flood risk management measures are to be applied. Second, the suitability of measures to context and conditions is crucial, which means a flood barrier in the wrong place can make flooding worse by stopping rainfall from draining into the river or by pushing water to more vulnerable areas downstream; early warning systems can only have limited impact on reducing the risk from flash flooding. Third, designs for flood management must be able to cope with a changing and uncertain future, particularly in areas of urban development. Fourth, rapid urbanisation requires the integration of flood risk management into regular urban planning and governance. Urban planning and management, which integrates flood risk management, is a key requirement, incorporating land use, shelter, infrastructure and services. Fifth, an integrated strategy requires the use of both structural and non-structural measures and good metrics for 'getting the balance right'. Each measure contributes to flood risk reduction, but the most effective strategies will usually combine several measures–which may be of both types.

The sixth principle states that heavily engineered structural measures could transfer risk upstream and downstream. Urban flood managers have to consider whether measures adopted to control flooding are in the interest of the wider catchment area. Hard-engineered measures are designed to defend to a predetermined level. They may fail. Other non-structural measures are usually designed to minimize rather than prevent risk. The seventh axiom has it that many flood management measures have multiple co-benefits over and above their flood management role. The linkages between flood management, urban design, planning and management, and climate change initiatives, are beneficial. For example, the greening of urban spaces has amenity value, enhances biodiversity, protects against urban heat islands, and can provide firebreaks, urban food production and evacuation space. Improved waste management has health benefits as well as maintaining drainage system capacity and reducing flood risk. City managers, communities at risk, urban planners and flood risk professionals, must therefore make qualitative judgments on these broader issues.

Urban development and incidence of flood

Urban development is a system of residential, commercial and industrial expansion that creates cities (Cap-Net, 2011; Brooks, 2014). It involves both spatial and demographic transformations of settlements from rural to urban form, where humans exhibit complex socio- economic and political relationships. These natures of transformations have both positive and negative effects. On the positive side, growing urban centres can take advantage of agglomeration economies and globalisation trends to generate jobs and increase incomes. On the negative side, some cities undergoing rapid growth are suffering from inadequate infrastructure and services, severe environmental degradation, increasing traffic congestion, and proliferation of slums and squatter settlements. Weiland (2006) opines that a variety of indicators and indicator sets exist, including those in the field of urban development, but, to date, no methodical standard has been derived on how to develop indicators for urban development. An indicator can be characterised as 'a summary and synthesised measure that indicates how well a system might be performing' (Marcotullio, 2004). An indicator is according to the widely accepted definition of the Organisation for Economic Co-operation and Development (OECD), a parameter or a value derived from parameters, which points to, provides information about, and describes the state of some phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value (OECD 1994:9).

The indicators developed by Westfall and de Villa (2001) could lead to sustainable urban development out of which environmental protection, the thrust of this study, is one. Good governance, quality of life, and environment interact to influence economic growth, which, in turn, facilitates urban development. This study considered urban land and municipal solid waste management (determinants of quality of environment) as indicators of urban development that contribute to incidence of flooding in urban environment, particularly in cities of emerging economies. The variables for urban land management are distance of buildings from canal/lagoon, percentage of plot developed, percentage of plot landscaped, distance of buildings from property line and adjoining buildings, and topography. That of municipal solid waste management include quantity of municipal solid waste generated, quantity of municipal solid waste collected, methods of waste storage and disposal, waste disposal charges, frequency of waste disposal, availability and distance to communal waste dumpsite.

Urban development is a global issue. It occurs as countries switch sectoral composition away from agriculture into industry, and as technological advances, domestic agriculture release labour from agriculture to migrate to cities (Henderson, 2003). It is acknowledged that, increasingly, since 1970, a larger share of the world's population has been agglomerating to form megacities, each with a population size in excess of ten million people. For instance, whereas 37 per cent of the total world population lived in cities in 1970, the figure increased to 43% in 1990, and will, by projection, reach 50 per cent by 2050 (Francisco, 2006). In 2014, more than half (54%) of the global population were living in cities: a proportion that is expected to increase to 66% by 2050 (Population Division of UN DESA, 2014). That is, additional 2.5 billion people are predicted to live in urban areas by 2050.

Urbanisation is not synonymous with environmental challenges, such as municipal solid waste management, flooding, and traffic bottlenecks, but a dearth of development plans, which manifest in intractable spatial growth of settlements conventionally referred to as 'informal'. Informal settlements, otherwise known as slums, or blighted communities, have become thorn for sustainable development. Approximately, a quarter of the world's urban population lives in slums (UN-Habitat, 2013). In the State of the World's Cities 2012/2013, UN-Habitat estimated the number of people living in the slums of the world in developing regions as 863 million, in contrast to 760 million in 2000, and 650 in 1990. Given current urbanisation trends, this figure is likely to have increased in 2014. These estimates suggest that one-third of the developing world's urban population is living in slums (UN-Habitat, Global Urban Indicators Database, 2012), representing 15% of all the people living in those regions. Most of these settlements (Kibera, Kenya; Clara Town, Liberia; Ezbet el-Haggāna, Cairo**;** Little Ireland, England; Kowloon Walled City, in Hong Kong, China; Makoko, in Lagos, Nigeria), are located in hazardous areas that are prone to flooding and other hydro-meteorological disasters.

With rapid population growth, cities are bound to still grow larger, and because poor migrants cannot afford middle-class housing, slums will be part of the picture, especially in Africa (Fengler, 2012). However, this does not mean that African cities are too big. On the contrary, they are probably still too small, compared to other parts of the world. With a population of 3.5 million, Nairobi is only one-tenth the size of Tokyo, the world's largest city; and Mombasa with less than a million residents does not even make the top 500 of the world's largest cities (Fengler, 2012).

Urban developments have direct effects on the terrestrial ecosystems they occupy, but also indirect effects on aquatic ecosystems, resulting from changes in the processes that link streams, lakes, estuaries, and other wetlands to the surrounding landscape (Konrad, 2005). The construction of impervious surfaces during urbanisation alters runoff generation mechanisms, by reducing the effective permeability of the soil (Moscrip and Montgomery, 1997). According to Genovese (2006), the permeable soil is replaced by impermeable surfaces, such as roads, roofs, parking lots, and sidewalks that store little water, reduce infiltration of water into the ground and accelerate runoff to ditches and streams in urban environment. Not only that, urban governance and decision-making often fall short of what is needed to adequately respond to the needs of growing population in areas of housing provision, waste management, transportation, and drainage management. As a result, physical development of all types takes place without recourse to town planning instruments, particularly in aspects of surface paving, floodplains development, circulation, observation of statutory air-space between buildings, and zoning ordinances. Raheem (2011) asserts that blocked drainage channels in urban areas worsen the externalities associated with flooding.

Intractable urban growth, coupled with absence of development plan, has left the human race at the mercy of floods. Floods pose serious challenge to development and the lives of people, particularly the residents of the rapidly expanding towns and cities in developing countries (Abhas *et al*., 2012). The occurrence of floods is the most frequent among all natural disasters; and in 2010 alone, 178 million people were affected by floods (Justmean, 2012). The total losses in 1998 and 2010 exceeded $40 billion (Abhas, *et al*. 2012). More than half of the world's population is living in cities, and by 2050, this will increase to more than two-thirds of the global population (Parvin and Shaw, 2011). Similarly, Justmean (2012) opines that, by 2050, the human population will reach 9.3 billion, and 70% will be urban dwellers. With increasing human alteration and development of the catchment area, the runoff generation process has changed, especially through decreasing the infiltration capacity of the soil and the change of soil cover (World Meteorological Organisation-WMO) *et al*., 2008).

The outcome of the study conducted by Nicholls *et al*. (2007) on 136 port cities with more than one million inhabitants, whose populations are exposed to coastal flooding, has placed Lagos, Nigeria, 15th among the first 20 in the world (Table 2.2). This study is also influenced by perceived inadequate urban planning activities in the Lagos metropolis that culminated in uncontrolled urban development in flood-prone areas (Oduwaye and Gamu-Kaka, 2007). In 1960, according to Adelekan (2010), Lagos covered an area of about 200 square kilometres; but by the beginning of the twenty-first century, its contiguously built-up area was estimated at about 1,140 square kilometres, and sections of the metropolis along the coastline have high population densities (Table 2.3).

Table 2.2: Top 20 cities ranked in terms of population exposed to coastal flooding in the 2070s

Rank	Country	Urban Agglomeration	Exposed Population Current (2007)	Exposed Population Future (2070)
1	INDIA	Kolkata (Calcutta)	1,929,000	14,014,000
2	INDIA	Mumbai (Bombay)	2,787,000	11,418,000
3	BANGLADESH	Dhaka	844,000	11,135,000

4	CHINA	Guangzhou	2,718,000	10,333,000
5	VIETNAM	Ho Chi Minh City	1,931,000	9,216,000
6	CHINA	Shanghai	2,353,000	5,451,000
7	THAILAND	Bangkok	907,000	5,138,000
8	MYANMAR	Rangoon	510,000	4,965,000
9	USA	Miami	2,003,000	4,795,000
10	VIETNAM	Hai Phong	794,000	4,711,000
11	EGYPT	Alexandria	1,330,000	4,375,000
12	CHINA	Tianjin	956,000	3,790,000
13	BANGLADESH	Khulna	441,000	3,641,000
14	CHINA	Ningbo	299,000	3,305,000
15	NIGERIA	Lagos	357,000	3,229,000
16	COTE D'IVOIRE	Abidjan	519,000	3,110,000
17	USA	New York-Netwark	1,540,000	2,931,000
18	BANGLADESH	Chittagong	255,000	2,866,000
19	JAPAN	Tokyo	1,110,000	2,521,000
20	INDONESIA	Jakarta	513,000	2,248,000

Source: Nicholls *et al*. (2007).

Table 2.3: Urban characteristics of LGAs in coastal Lagos

Local government area (LGA)	Total area (Km^2)	Built-up area (km^2)	Built-up area as % of total area	Population (2006)*	Population Density of Built-up area (per km^2)
Apapa	26.44	13.90	52.57	222,986	15,632
Eti-Osa	193.47	84.07	43.45	283.791	3,423
Lagos Island	8.59	5.28	61.47	212,2700	39,661
Lagos Mainland	19.81	11.29	56.99	326,700	28,154
Shomolu	11.46	10.31	89.97	403,569	39,053

Sources: *Federal Republic of Nigeria (2009), 2006 Census Final Results, Federal Republic of Nigeria Official Gazette, Vol. 96, No. 2, Abuja, Nigeria cited by Adelekan (2010).

Okude and Ademiluyi (2006) carried out an analysis of the changing land cover in the Lagos coastal area between 1986 and 2002. They found that the amount of developed land comprising residential, industrial, commercial, transportation and other uses increased from 85.4 square kilometres (43.36 per cent) to 111.9 square kilometres (56.8 per cent). Similarly, natural vegetation cover, including mangrove and swamp thicket, got reduced from 59.2 square kilometres (30.1 per cent) to 38.3 square kilometres (19.4 per cent), while naturally-occurring water bodies, including the ocean, lagoons and streams, were reduced from 52.4 square kilometres (26.6 per cent) to 46.9 square kilometres (23.8 per cent) during the same period. Yeboah (2000) used urban change mapping, which involves mapping of built-up areas from topographic maps and aerial photographs taken over at least two times, to determine changes in the built-up area of Accra, by mapping out the expansion of the city from a series of multi-date air photographs and a 1975 topographical map. However, Yeboah's method of mapping is not detailed enough. Taiwo (2009) employed geographical information systems approaches to study wetlands in selected local government areas of Lagos State. He revealed that, between 1986 and 2006, wetlands cover, which is an important buffer against coastal floods, had significantly reduced in coastal LGAs. Between 1986 and 2006, Apapa LGA lost 5.4% wetland, Eti-Osa lost 16.6%, Lagos Mainland lost 10.3%, and Shomolu lost 100%, and as at 1986, Lagos Island LGA had no wetland, thereby exposing coastal beings to the risks of floods (Table 2.4).

Ajibola *et al.* (2012) employed an exploratory approach to establish that urbanisation in the Lagos metropolis resulted from influx from the rural areas, which had resulted in the quest for more spaces to provide accommodation or employment for the teaming population. They concluded that wetland loss in the Lagos Metropolis occasioned by human activities which include incessant sand filling and conversion of wetland environment to economic uses, (construction) cause perennial flooding in the metropolis. The study recommended that human activities (both individuals and government) should be reduced while efforts should be on those activities that encourage wetland conservation and preservation. Urban development that stimulated the construction of two breakwaters between 1908 and 1912 at the entrance to Lagos harbour from the sea have been reported by Nwilo (1997) as the cause of erosion and flooding that have become permanent features in Victoria Island, Lagos, Nigeria.

Table 2.4: Wetland loss in coastal Lagos (1986–2006)

Coastal local government area (LGA)	Wetlands within LGA (%)		Wetlands loss (%) (1986-2006)
	1986	2006	
Apapa	14.0	8.6	5.4
Eti-Osa	41.8	25.2	16.6
Lagos Island	0	0	0
Lagos mainland	17.0	6.7	10.3
Shomolu	4.4	0	100

Source: Taiwo (2009)

Urbanisation, according to Adedeji *et al*. (2012), is the major creator of flood risks for many urban dwellers in Nigeria. Lack of proper spatial planning and land use management, coupled with the incapacity of governments to ensure good urban governance, exacerbate the cases of urban flood in Nigeria. They recommended a GIS-based spatial planning and land use management tool in building capacities for flood disaster reduction and preparedness to ensure sustainable urban development. Eyoh *et al*. (2012) explored the implementation of a loosely coupled logistic regression model and geographic information system in modelling and predicting future urban expansion of Lagos from historical remote sensing data (Landsat TM images of Lagos acquired on 1984, 2000 and 2005). An urban expansion of 129.49% was predicted between 1984 and 2030 for Lagos State. Bako and Ojolowo (2020) reported that the residents of Victoria Island were caught unaware on 08 July 2017 because of inadequate spatial knowledge; despite the fact that flooding had been occurring annually since 2012, only 13.7% of the respondents exhibited the act of preparedness.

In a study of the flooding problems in Lagos State, Adeloye and Rustum (2011) indicated that climate change was not the culprit but anthropogenic factors. The investigation revealed that, contrary to popular wisdom, climate change or unusually high rainfall was not the primary cause of the flooding problems in Lagos. Rather, increased urbanisation, lax planning laws in relation to the erection of buildings in floodplains and the inadequacy of storm drainage facilities in the city were to blame. In the works of Aderogba (2012) on South Western Nigeria, flood incidences were attributed to illegal structures on/across drainage channels, canals and mere erosion passages (100.00%), inadequate drainage channels (100.00%), outright blockage of canals/drainage channels (100.00%), and torrential rain storms (100.00%), as the major substantive conservative causes of the floods. Others were land reclamation/encroachment (82.08%), collapsed dams/embankments and bridges (95.42%), construction and reconstruction (92.25%), poor physical planning (92.25%), and nature of terrain (96.24%).

Satellite remote sensing technology was employed by Nirupama and Simonovic (2007) to classify landuse. The information obtained was integrated with meteorological and hydrological data records analysed to obtain a quantitative estimate of the potential risk from river floods to London.

The results showed that, between 1974 and 2000, there has been a considerably elevated risk from floods due to heavy urbanisation in the watershed of the Upper Thames River, which the city of London is a part of.

The effects of urban growth, witnessed between 1990 and 2010, in Makkah city, Saudi Arabia, on runoff volume and peak discharge were investigated by Al-Ghamdi *et al*., (2012) using the curve number (CN) flood-modelling methodology. Shapefiles of residential areas were compiled and integrated in a unique geographic information system (GIS) environment. Datasets of geological structures, soil types, and a digital elevation model (DEM) were collected and utilized. Peak discharges were computed on the Wadi Scale, while the total flood volume was estimated on the residential sub-basins scale in order to get a detailed view of urbanisation impacts on flood hazards. The results obtained showed that the residential regions of Makkah city have been increased over the period 1990 to 2010 by 197%, while the total flood volume have been enlarged by 248%. Furthermore, the results showed significant positive correlations between urbanisation and both peak discharge and flood volume. Accordingly, they recommended that these findings should be taken into account in future urbanisation, sustainable development, and flood management plans of the Makkah metropolitan area.

Brody *et al.* (2006) examined the relationship between wetland alteration and coastal watershed flooding in Texas and Florida over a 12-year period. The wetland alteration permits required under Section 404 of the US Clean Water Act was geo-referenced. Subsequently, the number of granted permits was correlated with the degree of flooding measured by stream gauge data. The results indicated that specific types of federal permits exacerbated flooding events in coastal watersheds and recommended environmental and socio-economic consideration before permission is granted for development. Karley (2009) carried out situational analysis of flooding and physical planning in Accra, Ghana. He interviewed local experts, officials of agencies responsible for flooding matters and physical planning. Analysis of the data revealed that for the city, there was no evidence that unusual rainfall has been occurring recently that could explain the increased occurrences of flooding being experienced. Rather, the cause of the problem was the lack of drainage facilities to collect the storm water for safe disposal. These could be attributed to the ineffective planning regulations, which either ignore or even condone the illegal erection of buildings and other structures on floodplains, and the unhealthy habit of dumping refuse and other solid wastes in the usually open channel drainage systems. It was recommended that, in order to have a long-lasting solution to the flooding problems, the city and others in similar situations should embrace sustainable urban drainage systems.
Moreover, Nirupama and Simonovic (2007) used Landsat 5 and 7 images of three dates: July 7, 1974; July 23, 1990; October 30, 2000, to establish rate of urban growth around Upper Thames River in the City of London U.K, province of Ontario in Canada and hydrologic data for flood risks analysis. The outputs revealed progressively decreasing percentage in original landuse from 83.14% in 1974, and 78.41% in 1990 to 73.16% in the year 2000. Homestead decreased from 3.14%, in 1974, to 2.05%, in 1990, and, finally, 1.86% in 2000. The trend of water was not different, as 3.65% was established in 1974; it reduced to 2.82%, in 1990, and 2.73%, in the year 2000. Of all the variables employed to assess the risks of flood, only urbanisation skewed; it increased from 10.07%, to 16.72%, and finally, to 22.25% in the years 1974, 1990 and 2000, respectively. However, the contributions of urban development was adequately established but that of municipal solid waste was not, perhaps not peculiar to the environment studied.

The research conducted by Dagnachew (2011), titled “Road and urban storm water drainage network integration in Addis Ababa” asserted that urbanisation, along with its impermeable structures, was the major cause of flooding in urban areas. The findings of this study included the major causes of flooding which were found to be the blockage of urban storm water drainage lines, along with inadequate/poor integration between road and urban storm water drainage infrastructures. This study strongly recommended improvement in the integration of road and urban storm water drainage infrastructure and integrated solid waste management, to prevent overflowing of stormwater because of blockage of drains.

While investigating the cause of the flood of the 26th August 2011 in Ibadan, Agbola *et a*l. (2013) used a structured questionnaire and key informant interviews to elicit information from residents of Apete, Moniya, Bodija, and Odo-Ona. Of the 12 factors identified, nine were anthropogenic (building close to riverbanks, changing course of rivers by development, inadequate housing development monitoring, ignorance, lack of early warning information, dam breaking, dumping refuse in drainage channels, deforestation, increased impervious surfaces) and were identified as having contributed to the flood. The consequences were categorized into economic, infrastructural, hydrological, physical displacement, and psychological. It was recommended that the Oyo State Government should take, as a matter of priority, the collection of climate-related data and creation of awareness through the mass media to reduce the risks of flood.

Humans do not have much control over the natural causes of floods, such as the magnitude and frequency of rainfall (and associated floods), except, perhaps, to avoid encroachment into the natural floodplains to prevent flood disaster. However, humans have total control over the anthropogenic causes of floods, such as limiting construction or development on natural floodplains, eliminating blockages from the natural floodplains to allow free passage of floodwater and increasing the capacity of hydraulic conveyance structures to conveniently carry flood flows. Conventional wisdom dictates that man should stay away from floodplains, or appreciate the risks associated with encroaching on the floodplain. Flood disasters are associated with the unnecessary risks people take when they encroach on the floodplains. There will be no flood disasters if human beings put floodplains to sustainable and healthy use.

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Brody *et al.* (2006) examined the relationship between wetland alteration and coastal watershed flooding in Texas and Florida over a 12-year period. The wetland alteration permits required under Section 404 of the US Clean Water Act was geo-referenced. Subsequently, the number of granted permits was correlated with the degree of flooding measured by stream gauge data. The results indicated that specific types of federal permits exacerbated flooding events in coastal watersheds and recommended environmental and socio-economic consideration before permission is granted for development. Karley (2009) carried out situational analysis of flooding and physical planning in Accra, Ghana. He interviewed local experts, officials of agencies responsible for flooding matters and physical planning. Analysis of the data revealed that for the city, there was no evidence that unusual rainfall has been occurring recently that could explain the increased occurrences of flooding being experienced. Rather, the cause of the problem was the lack of drainage facilities to collect the storm water for safe disposal. These could be attributed to the ineffective planning regulations, which either ignore or even condone the illegal erection of buildings and other structures on floodplains, and the unhealthy habit of dumping refuse and other solid wastes in the usually open channel drainage systems. It was recommended that, in order to have a long-lasting solution to the flooding problems, the city and others in similar situations should embrace sustainable urban drainage systems.

Moreover, Nirupama and Simonovic (2007) used Landsat 5 and 7 images of three dates: July 7, 1974; July 23, 1990; October 30, 2000, to establish rate of urban growth around Upper Thames River in the City of London U.K, province of Ontario in Canada and hydrologic data for flood risks analysis. The outputs revealed progressively decreasing percentage in original landuse from 83.14% in 1974, and 78.41% in 1990 to 73.16% in the year 2000. Homestead decreased from 3.14%, in 1974, to 2.05%, in 1990, and, finally, 1.86% in 2000. The trend of water was not different, as 3.65% was established in 1974; it reduced to 2.82%, in 1990, and 2.73%, in the year 2000. Of all the variables employed to assess the risks of flood, only urbanisation skewed; it increased from 10.07%, to 16.72%, and finally, to 22.25% in the years 1974, 1990 and 2000, respectively. However, the contributions of urban development was adequately established but that of municipal solid waste was not, perhaps not peculiar to the environment studied.

The research conducted by Dagnachew (2011), titled “Road and urban storm water drainage network integration in Addis Ababa” asserted that urbanisation, along with its impermeable structures, was the major cause of flooding in urban areas. The findings of this study included the major causes of flooding which were found to be the blockage of urban storm water drainage lines, along with inadequate/poor integration between road and urban storm water drainage infrastructures. This study strongly recommended improvement in the integration of road and urban storm water drainage infrastructure and integrated solid waste management, to prevent overflowing of stormwater because of blockage of drains.

While investigating the cause of the flood of the 26th August, 2011 in Ibadan, Agbola *et a*l. (2013) used a structured questionnaire and key informant interviews to elicit information from residents of Apete, Moniya, Bodija, and Odo-Ona. Of the 12 factors identified, nine were anthropogenic (building close to riverbanks, changing course of rivers by development, inadequate housing development monitoring, ignorance, lack of early warning information, dam breaking, dumping refuse in drainage channels, deforestation, increased impervious surfaces) and were identified as having contributed to the flood. The consequences were categorized into economic, infrastructural, hydrological, physical displacement, and psychological. It was recommended that the Oyo State Government should take, as a matter of priority, the collection of climate-related data and creation of awareness through the mass media to reduce the risks of flood.

Humans do not have much control over the natural causes of floods, such as the magnitude and frequency of rainfall (and associated floods), except, perhaps, to avoid encroachment into the natural floodplains to prevent flood disaster. However, humans have total control over the anthropogenic causes of floods, such as limiting construction or development on natural floodplains, eliminating blockages from the natural floodplains to allow free passage of floodwater and increasing the capacity of hydraulic conveyance structures to conveniently carry flood flows. Conventional wisdom dictates that man should stay away from floodplains, or appreciate the risks associated with encroaching on the floodplain. Flood disasters are associated with the unnecessary risks people take when they encroach on the floodplains. There will be no flood disasters if human beings put floodplains to sustainable and healthy use.

FLOODING IN LAGOS: THE MEMORY LANE AND ATTRIBUTED CAUSES

The chronology of flooding in Lagos coastal city and their sources from 1947 to 2011 was provided by Olaniran (2002) and Adelekan (2012). According to them, the first flooding was recorded on 7 January 1947 as reported by *Daily Times Newspaper* of 15 July, 1974. The flooding which lasted for 14 days owing to torrential rainfall, damaged many houses, walls, roads and other properties, but there was no casualty. This could be attributed to the small spatial and demographic size of the city then, as only the colony area and Mushin were flooded. In 1973, on the 4 and 5 August, (*Daily Times Newspapers* 5 August, 1973) another flooding was recorded and many people were displaced, probably as a result of increase in spatial and demographic attributes. Onikan area in Lagos Island LGA was flooded on the 3 July, 1974 (*Daily Times Newspapers* 4 July, 1974) after a torrential rainfall; many houses and properties were wrecked including the walls of the National Museum.

It was not until 20 years later, that another four days of flooding was recorded due to the heavy rain that fell from 10 October 1994 and led to the Ocean surge that destroyed property worth millions of naira (Olaniran, 2002). In the following year, the most devastating flooding occurred on 17 August 1995 between 06.00 to 10.00GMT (Olaniran, 2002); when Ocean surge coincided with high tide thus producing waves of over 4 meres high, which inundated large parts of Victoria Island. Many of the streets and drainage channels were flooded resulting in an abrupt dislocation of socio-economic activities in Victoria and Ikoyi Islands for 4 days (Olaniran, 2002). The Nigerian Tribune Newspapers of 18 July, 1996 reported that the flooding of 17 July led to the death of two people at Nitel NITEL office Marina. In 1999, flooding occurred on 28 April, destroyed buildings and took lives (*Nigerian Tribune newspapers* 29 April, 1999). Another flooding occurred in July 1999, one life was lost and properties worth billions of naira were damaged (Olaniran, 2002). Furthermore, the coastal erosion that washed several metres of coastline away occurred in August 1999, at Lagos Bar Beach (Olaniran, 2002).

The flooding that occurred in Lagos city on 20 and 22 May, 2000 as a result of torrential rainfall was up to a metre (yard) deep in several low-lying areas of the city; tens of thousands of homes were inundated with water; several roads blocked and 10 lives were lost (*Punch Newspapers* 23 May, 2000). Global Flood Register (2002) reported that a mother and baby were drowned after a torrential rainfall on 24 July, 2002. In 2004, Global Flood Register also reported that ten hours rainfall cum blocked drains by uncollected refuse caused flooding in large areas of Lagos city on 17 June 2004. The rain that fell for 15 days on 1 August 2007 made Ogun River to overflow its bank and consequently inundated Ikorodu and Kosofe LGAs of Lagos State. As a result, over 4000 people were made homeless, 200 buildings destroyed and 6 deaths recorded (Global Flood Register, 2007).

Lagos Mainland and Apapa LGAs were flooded on 30 June, 2009 after a 2-day torrential rainfall that blocked roads and covered shops forcing their owners to leave the areas for fear of getting infected in the dirty water (*Vanguard Newspapers* 1 July, 2009). From 2009 onward, flooding has become an annual event in Lagos metropolis. On 7 July, 2010, most streets in the Central Business District, Lagos Island LGA were swallowed up in flood and motorists forced out of business (*Business Day Newspapers* 7 July, 2010). The flood of 14 June 2010 was exceptional as some people resorted to using canoes to ferry people in both Lagos Island and Mainland LGAs (*Daily Champion Newspapers,* 19 June, 2010).

Furthermore, the flooding of 10 July, 2011 in Lagos metropolis killed more than 25 people, affected 5,393 households in 31 streets and loss to property was estimated at ₦100 billion (*Business Day Newspapers* 29 July, 2012). A number of houses and roads were again submerged and seven people died after a 2-day of torrential rainfall of 27 and 28 June, 2012 in Lagos metropolis (*Vanguard Newspapers*, 29 July, 2012). In 2013, Ocean surge caused flooding at Lekki (*The Street Journal*, 9 August, 2013). The Punch Newspapers of 2 July, 2014 reported one death at Surulere in Surulere LGA of Lagos State during a flooding event. Out of the 21 times that flooding was recorded from 1947 to 2014, flooding occurred owing to torrential rainfall on 17 (81.0%) occasions, ocean surge three (14.2%) occasions, and coastal erosion caused flooding once (4.8%). In summary, reference was not made to buildings erected in wetlands, in/on the verge of the drainage channels that hindered free flow of storm water. However, municipal solid waste was attributed to flooding only in 2004.

THE NEED TO CONSIDER URBAN DEVELOPMENT AND MUNICIPAL SOLID WASTE IN THE MANAGEMENT OF FLOODING

Understanding urban development as the spatial and demographic growth of an urban area occasioned by buildings and other auxiliary structures or facilities that are required to meet the needs of the increasing population will help urban managers appreciate the need to factor urban development and municipal solid waste into the management of flooding. The transformation of urban land is required to engender socio-economic, environmental and political development of any city. However, irregular urban development has led to the indiscriminate development of buildings (residential, industrial, commercial and recreational) without recourse to urban planning regulations, particularly in gorges, wetlands and areas abutting water courses. Urban planning, according to Keeble (1969:1), is “the art and science of ordering the use of land and the character and sitting of buildings and communication routes so as to secure the maximum practicable degree of economy, convenience and beauty”. The instruments of urban planning include and not limited to zoning, sub-division regulations, building codes, space standards and density regulations. Urban planning regulates types and intensity of development that should take place in towns and cities.

The population of urban settlements with buildings without considering ecological elements could trigger flooding. Buildings constructed in wetlands and on the verge of drainage channels restrict where runoffs can go and may cause inundation. Also, obstructing sections of natural channels with buildings and solid waste could cause flooding in the adjoining areas. Three thousand, six hundred and forty-seven buildings were discovered to have contravened space standards owing to their erection within statutory setbacks of 10m and 50m to canals and lagoon respectively in the Lagos metropolis. Out of this number only 578 (15.8%) have been removed by the officials of Lagos State Building Control Agency (LASBCA). Sixty-four per cent of buildings sampled were developed beyond the statutory maximum building-plot ratio of 45%. Covering large parts of the ground surface with roofs of buildings, roads and pavements disturbs infiltration and subsequently engender excessive runoff that may transform into flooding. Out of the 1025 buildings sampled in this study, 92.2% have paved compounds. When it rains, some of the water that is supposed to be retained by grass, vegetation, and the rest travels over the land as surface runoff. The removal of these water-retaining features and pavement of compounds owing to urban development, increases impermeable surfaces that may facilitate excessive runoff, causing siltation and blockage of hydraulic facilities, which eventually lead to flooding. Apart from the indiscriminate spatial development, municipal solid waste management is another challenge closely associated with flooding owing to the intractable growth in the number of urban dwellers.

The volume of waste being generated continues to increase at a faster rate than the ability of the authorities to improve on the financial and technical resources needed to respond to this growth (Akinwale, 2005). Collection of waste from households, factories, and other generation sources to dump sites is an intractable challenge in developing countries. This is because waste management usually accounts for 30–50% of municipal operational budget, but despite these high expenses, cities, especially in developing countries can only collect 50–60% of the refuse generated (Arunprasad, 2009). In India, for instance, less than 50% of the refuse generated is collected, 33% in Karachi, 40% in Yangoon (formerly Rangoon) (Medina, 2002). Collection rate is about 33-77% in Cairo (Zayani, 2010). In Lagos (Nigeria), the collection rate is about 43% (Lagos State Waste Management Authority [LAWMA], 2012). Between 2007 and 2013, a total of 77,757,749.8 tons of municipal solid waste was generated in the Lagos metropolis out of which 21,550,809.73 tons (27.7%) was collected leaving 56,206,940.07 tons. The poor frequency of collection was also another issue; the study revealed that about 59.0% of the respondents had their waste collected once a week, 27.0% twice a week and 14.4% daily. Uncollected solid waste that blocked drainages channels might cause flooding, and subsequent spread of waterborne diseases. Methods of waste disposal/collection in the metropolis as revealed by this study are also another contributory factor to flooding. Lagos State Waste Management Authority, 9.9% by private sector service providers, 29.2% by cart pushers and 49.7% dumped in canals/lagoons, collected Eleven per cent of municipal solid waste. Two hundred and twenty-two points where two or more storm water drainages crossed including where storm water drainages discharged into canals/lagoons were discovered to have been blocked by municipal solid waste thereby triggering flooding in the metropolis. Flooding, however, can be mitigated if urban managers, developers and urban dwellers in general consider the following policy recommendations:

Plate 1: Solid waste blocked drainage channels and caused flooding along Bakare-Faro Street, Ajeromi-Ifelodun LGA, Lagos, Nigeria
Source: Authors' Field Survey, 2018

Plate 2: Buildings erected within the lagoon at Muwo Town, Ojo LGA, Lagos, Nigeria
Source: Field Survey, 2018

1. Gazetting inclusive urban planning policy

There is a need to review the 2010 urban planning policy frameworks in order to integrate flood risk into landuse planning. The policy only stipulate setbacks from water bodies and electricity facilities without providing guidelines on the nature and characteristics of buildings to be erected after the statutory setbacks. Provisions for collaborations among Ministries in charge of urban development and municipal solid waste management and stakeholders were also missing. However, development within 30 metres immediately after the statutory setbacks along rivers, canal, lagoon and oceans should be consistent with the need to minimize damage likely to be occasioned by flooding. It would be necessary to provide codes that promote resistance of buildings to flooding within 30m after the statutory setbacks. The review should also include collaboration between the Lagos State Ministries of Physical Planning and Urban Development and Environment in the management of drainage infrastructure by ensuring that development permit is granted by the Lagos State Physical Planning Permit Authority (LASPPPA) with the input of the Drainage Department (DD). Allowing officials of DD to jointly visit proposed sites for development with LASBCA and LASPPPA before a development permit is granted would not only provide adequate engineering-related advice, but also exterminate the compromise that often led to approval of development in flood-prone areas. The roles of stakeholders in the management of flooding should not be undervalued. Therefore, an inclusive policy shall provide a platform for effective and efficient management of flooding in the metropolis.

2. Strict enforcement of provisions of urban development regulations

The setbacks stipulated in Section 16 sub-section 5 (a-d) of Lagos State of Nigeria Official Gazette Vol. 40, otherwise known as Lagos State Physical Planning and Development Regulations, 2010 should be enforced by LASBCA to facilitate unrestricted flow of storm water in the metropolis. The standard is that the minimum distance between buildings and the Ocean line is 150 metres; that of lagoon is 50 metres; rivers and creeks 15 metres; while that of gorge/canal/drainage is 10 metres. However, the current minimum distance from canals should be reviewed upward to 15 metres, because this strand is a low-lying land. The increased space would create more space for water detainment, storage and draining necessary during raining seasons. The Ministry of Physical Planning and Urban Development should ensure that agricultural and recreational activities take place within the buffer zone. This could be achieved by ensuring that development permit is not granted to any other land use than crop farming, animal husbandry and recreation. This would not only protect the wetlands, but also contribute significantly to urban food security and at the same time reduce the risks of flooding.

3. Evolving an integrated municipal solid waste management strategy

A detailed waste infrastructure development master plan incorporated into the broad objectives of the Lagos State physical development plan that takes flooding into consideration is required to guide future developments in waste infrastructure. Improved relationship between LAWMA and other agencies/organisations with oversight for waste management and drainage is required so as to create new synergies to curb indiscriminate waste deposition in drainage channels and eventually reduce risks associated with flooding. There is a need to design a sustained public education programme on waste prevention, reuse and recycling targeted at household levels, markets, motor parks, schools, churches, mosques and community groups in Lagos State. Organised workshops and seminars to train specialised manpower in critical areas of waste management should be initiated urgently. This programme can be implemented by inviting experts in municipal solid waste management and spatial information techniques to deliver lectures.

To effectively control indiscriminate municipal solid waste disposal in the metropolis of Lagos, there is the need to integrate cart pushers into the collection systems. This recommendation is based on the findings that 297 (29.0%) of the respondents still patronised cart pushers, in spite of the ban. Registering the cart pushers should do this and allocating areas of operations to them, particularly areas that are not accessible by waste collection trucks. The LAWMA should designate officials to monitor the operations of registered PSP to ensure weekly collection of waste. These officials will record the number of times the PSP collect municipal solid waste in a month and report to research unit of the agency. This will not only help to generate data on rate of waste collection, but also ensure that the PSP operators efficiently perform their statutory responsibilities. Regular collection of municipal solid waste would reduce haphazard deposition in drainage channels, gorges, canals and lagoon and thus reduce the incidence of flooding.

4. The use of information technology

The empowerment of all the agencies involved in urban development controls and waste management to employ remote sensing (RS) and Geographic Information Systems (GIS) technologies in their operation shall assist in the making of objective spatial decisions for floodplains and other areas vulnerable to flooding. The rate of spatial growth and municipal solid waste generation in the Lagos metropolis can only be managed effectively with information technology which is fast, robust, reliable, precise and durable. The technology shall not only help to monitor development in floodplains, but also assist in monitoring the performance of municipal solid waste collection trucks and keeping of records and information.

CONCLUSION

In closing this policy brief, it is important to note that an improved and robust policy without the political wills to implement the provisions make it inoperative and non-beneficial to the people and environment at large. This means that all the provisions in urban planning and municipal solid waste policies be implemented to the letter with the active participation and collaboration of the organised private and civil society sectors. All forms of compromise should be eschewed to build a flood-free metropolis. However, the crucial point this policy brief has sought to make relate to the imperative of mitigating flooding in the Lagos metropolis based on the effective management and control of urban development and municipal solid waste. Indeed, the metropolis of Lagos is situated in lowland that is susceptible to flooding, the greatest safeguard against flooding, therefore, is the consciousness of all stakeholders and their readiness to comply with all the rules and regulations guiding urban development and municipal solid waste management. To this end, an inclusive and broad-based policy has the potentials of raising the stakes for all stakeholders in the management of flooding in Lagos State.

CALL TO ACTION

The following recommendations are made towards ridding the Lagos metropolis of flooding:

- Codes for buildings to be erected within 30m after the statutory setbacks away from water bodies should include height above observed flood level and flood-resistant material. It may apply to foundations, floor beams, joists, enclosures, and equipment servicing the buildings such as electrical, plumbing, mechanical, ducts, etc.
- All the Departments involved in the management of urban development and municipal solid waste should collaborate for efficiency.
- Scheduling of periodic meetings before flood season to discuss the issues with key stakeholder groups such as policy makers, operations managers, technical advisors, social scientists, economists, farmers, agricultural extension workers, health and sanitation experts, utility managers, market and community associations, developers, non-governmental organisations, students etc.
- All the buildings that contravened urban development regulations in gorges, along rivers, canal, lagoon and oceans should be removed.
- The Ministries should organise workshops and seminars for their officials to learn basic terminologies in remote sensing and GIS.

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