CLIMATE CHANGE AND THE INCREASING RISK OF FLOODING IN THE BUILT ENVIRONMENT

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ABSTRACT

The United Nations Intergovernmental panel on Climate Change (IPCC) early this year warned on the effects of Climate Change being severe globally. There are potent and new evidences emerging from the scientific world strengthening the argument on climate change, the impact of which is likely to be erratic and very harsh. The hydrological systems in many countries and regions of the globe are going to be severely affected, just as variations in precipitation or melting ice will impact on water resources and its quality. This paper considers the potential risks of flooding in urban centres and the extended implications on rural communities and especially in the Niger Delta region. With most of the Niger Delta exposed to the coasts, the issue of submergence, coastal flooding, and coastal erosion comes to the fore because Coastal systems are significantly sensitive to changes in sea level and ocean surge. The Urban areas and its built assets will be exposed to massive urban or coastal flooding and its large populations displaced due to land loss to rising sea levels and storm surges. With Port Harcourt in sharp focus, this paper will examine the current disposition of flooding within the urbanscape, the possible causes and also look at what mitigation factors will be necessary to address the situation. With the IPCC report warning of grave danger to entire ecosystems and the built environment due to climate change, and consequent altering of hydrological systems, this paper will also consider how the fencing of properties have exacerbated flooding of properties, roads, drainages and water courses within the urban centre and remote locations in the face of anticipated extreme precipitation expected to cause both inland and coastal flooding as rivers and tributaries swell. This is based on the premise that most urban centres hold large populations and huge economic and other physical assets and this gives credence and justifies the need for this research to isolate the possible risks and proffer mediatory routes to the emerging and intractable problem.

Keyword: Climate Change, Flooding, Built Environment

INTRODUCTION

Flooding is one of the most universal and destructive challenges facing cities around the world. World Bank research suggests that floods are the most frequent of all natural disasters and that the number of flood events is rising rapidly. In 2010 alone, 178 million people were affected by floods, with losses exceeding $40 billion [1]. From obstructed and inadequate culverted water courses, open drains and a gridlock of fenced properties, the picture starts emerging why flooding will continue to be a teething environmental problem considering that the scientific communities is unanimous that climate change is occurring in the most rapid fashion since record began. It is recognized that some surface water flooding solutions will take many years to implement possibly alongside the re-development of urban areas and only then that more imaginative options that 'make space for water' can be considered.

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The modification of the natural terrain is actually the potential catalyst for flooding especially modifications and activities and or barriers that impedes natural flow due to construction induced impacts and storm water runoffs exceeding the carrying capacity of constructed drainage. Pooling data on drainage assets and historical flooding should be an important activity for any pilot project to bring together data from different locations to develop a shared understanding of the problems.

Modelling and Mapping Surface Water

Rising global temperatures are causing change to rainfall patterns and climate change will affect the weather causing short intense rain storms in more frequent fashion, increasing the risk of flooding across the global landscape, particularly in urban areas with high-density development and under-capacity of drainage infrastructure. Blocked or overloaded drainage ditches, drains and sewers may overflow across roads, gardens and into property especially in specific locations within the Port Harcourt metropolis especially when rainfall is so intense and unable to soak into the ground. Port Harcourt falls in the category of cities with soggy ground; a major catalyst to flooding. Moreover, many of the world's most destructive natural disasters involve water through flooding that threaten human lives, endanger property and livelihoods, and inflict environmental damage and most of the incidents in the Niger Delta are not reported and little action is taken to assuage the plight of the masses. This paper brings to a sharp focus the intractable problems faced by millions on the issue of flooding and severe trauma suffered each rainy season and suggesting ways of creating urban resilience. Flood control is, thus, one of the major issues which urban planning must deal with comprehensively as the lack of planning frequently worsens flooding situations. Mathematical modeling of hydrologic and hydraulic processes becomes an important tool to be considered but just suggested as a way forward not covered by this paper. However excepts of the process will be discussed later in this paper.

Floods and Urban Growth

The fact that must be faced is that the city can influence runoff pattern changes and the state of ecological systems not only within itself but also in the whole river system downstream, including its surroundings [2]. Floods are natural and seasonal phenomena that play an important environmental role. However, human settlements interfere with flood patterns, majoring their magnitude and frequency of occurrence, turning higher the associated level of risk regarding people, buildings and economic activities. Urban floods range from localised micro-drainage problems, inundating streets and troubling pedestrians and urban traffic, to major inundation of large portions of the city, when both micro and macro-drainage fail to accomplish their basic functions. These problems can lead to material losses to buildings and their contents, damage to urban infrastructure, people relocation, increased risk of diseases, and deterioration of water quality, among others [3]. Strategies include Canalizing and rectifying watercourses, in order to improve conveyance. New concepts focus on flood risk management aspects, concerning a multidisciplinary approach that considers aspects of prevention, mitigation and recovery of the hazard prone areas. In order to equilibrate harmonic growing with built environment, Urban planning policies and strategies must consider the effects of uncontrolled interference with the environment including construction activities within urban centers and peripheral developments the effects of which is indicated in Table 1[4].

Again, early warning systems, spontaneous but robust disaster response and resilience planning must be an integral part of a round the clock approach in order to reduce vulnerability and minimize expected losses.

Table 1: Urbanisation Impacts over Floods

Causes	Effects
Natural vegetation removal	Higher runoff volumes and peak flows; greater flow velocities; increased soil erosion and consequent sedimentation in channels and galleries.
Increasing of imperviousness rates	Higher runoff volumes and peak flows; less surface depressions detention and greater velocities of flow.
Construction of an artificial drainage net	Significant increasing of flow velocities reduction of time to peak.
River banks and flood plain occupation	Population directly exposed to periodic inundation at natural flooded areas; amplification of the extension of the inundated areas, as there is less space to over bank flows and storage.
Solid waste and wastewater disposal on drainage net	Water quality degradation; diseases; drainage net obstruction; channel sedimentation

The effects of flooding on surface water quality is indicated on Table 2[5] some of which has some positive effects on the ecosystem but could at the same time have devastating consequences on buildings and other infrastructural facility, the economy and displacement of the population.

Table 2: Effects of Flooding on Surface Water Quality

Parameter	Flooding Effects
Surface water temperature	Increases
Salinity	Reduces
Dissolved oxygen	Increases
Conductivity	Increases
Turbidity	Increases
pH	Increases
Biochemical Oxygen Demand BOD)	Increases
Total dissolved solids in water	Increases
Depth	Increases
Waves	Increases
Current	Increases
Planktons	Reduces
Nektons	Reduces

Collection and Collation of Data

Data collection and collation on drainage assets and historical flood patterns is an essential precursor in predicting future flooding. In more advanced countries data collation is usually from;

- Water company sewer flooding records,
- Local authority flooding records;
- Environment agency flood records
- River flood risk assessments (models and maps);
- Highway drainage records;
- Aerial photography

There appear to be no robust data collection and collation strategies that spans time in Nigeria apart from the meteorological centers in the country which has no cast iron guarantees on the efficacy of data storage and handling. They put up weather warnings but disasters are ill managed with little or no infrastructural capacity for an adequate response in an emergency. The 2012 floods were grossly mismanaged with ineffective strategies to either rehabilitate victims of flooding or manage the deluge.

Port Harcourt Perspectives

Port Harcourt is the capital city of Rivers State in the heart of the Niger Delta Region. However, the topographical and climatic disposition of the Niger Delta makes it susceptible to flooding which might be in the form of fluvial, flash flooding, tidal and pluvial flooding and sometimes flooding from reservoirs e.g. dams, all due to its rainfall patterns indicated in Table 3. A critical examination of the Niger Delta terrain makes it vulnerable to flooding because its area of about 29,900 square kilometers is the largest wetland in Africa as well as occupying the third largest wetland in the world. The Niger Delta is situated between longitudes 50 E to 80E, latitudes 40N to 60N in the Gulf of Guinea. The Niger Delta ecosystem, contains one of the highest concentrations of biodiversity on the planet, in addition to supporting the abundant flora and fauna, arable terrain that can sustain a wide variety of crops and economic trees and having more species of freshwater fish than any ecosystem in West Africa (Wikipedia 2007). Due to the saturated nature of wetlands and or sodden landscape from previous precipitation, Port Harcourt terrain is therefore susceptible to flooding like most Niger Delta region.

Table 3: Climate Data for Port Harcourt

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average high °C (°F)	32 (90)	33 (91)	33 (91)	32 (90)	31 (88)	30 (86)	30 (86)	29 (84)	29 (84)	30 (86)	31 (88)	32 (90)	31 (88)
Daily mean °C (°F)	26.5 (79.7)	28 (82)	28 (82)	27.5 (81.5)	27 (81)	26.5 (79.7)	25.5 (77.9)	25.5 (77.9)	25.5 (77.9)	26 (79)	26.5 (79.7)	26.5 (79.7)	27 (81)
Average low °C (°F)	21 (70)	23 (73)	23 (73)	23 (73)	23 (73)	23 (73)	22 (72)	22 (72)	22 (72)	22 (72)	22 (72)	21 (70)	22 (72)
Precipitation mm (inches)	29 (1.14)	62 (2.44)	136 (5.35)	188 (7.4)	235 (9.25)	288 (11.34)	345 (13.58)	302 (11.89)	367 (14.45)	246 (9.69)	76 (2.99)	20 (0.79)	
Avg. precipitation days	2	5	9	12	14	17	20	20	21		6	2	144
Mean monthly sunshine hours	143	123	115	132	140	102	78	74	78	102	132	149	1,368

A case study as here documented shows an area of Port Harcourt and precisely along the Obi Wali road to East –West axis, where rainfall within this zone created severe flooding situation as always, inundating drainage infrastructure and penetrating properties and crippling economic life. Investigation revealed that, contrary to popular wisdom, climate change or unusually high rainfall is not the primary cause of flooding but rather, the increased urbanization, lax planning laws in relation to the city are to blame. It is augured that a lasting solution to flooding problems will require the incorporation of sustainable drainage system within the existing flood management strategy for the city and planning must be initiated with no further delays [7].

Figure 1: Flooding along Obi Wali road, PH

Figure 2: Rain as source of the Deluge in PH

About 30% of all precipitation becomes runoff and that amount might be increased if in temperate climate by water from melting snow. A flood raises rapidly, within a relatively small area if the area was already saturated from previous precipitation (Henry, 2006). The Port Harcourt scenario is worsened by uncontrolled use of walled fences which block off natural flow channels and compounds the situation as shown in Figure 1 and Figure 2. In all cases of flooding in Port Harcourt, the drainages are poorly designed and grossly inadequate and most drainages lead to nowhere despite the proximity of the coastline that will comfortably take the runoffs.

Disaster Response

To cope with the onset of water pouring into streets, homes, commercial buildings and settlements where it applies, cities need resilient drainage systems powered by reliable and powerful pumps.Setting up of evacuation camps to move victims to higher grounds and provision of relieve materials and tents are essential aspect of flood response as illustrated in Figure 3 and Figure 4. Medicare for displaced persons should be part of the equation.

Figure 3: Flood Deluge

Figure 4: Resettlement camp

Strategies for cleanup and reconstruction of damages resulting from severe flooding must be considered from the unset of preparations. Rapid response organization or agencies experienced with the handling of flood disasters must be part of the response theme.

Solutions to the problem of Flooding

A careful analysis of the Port Harcourt flooding indicates poor drainage infrastructure where existing drainage system is leading to no evacuation routes and or grossly inadequate to contain the runoffs. Figure 5, shows drainage relief openings in the property wall and the road in a known area of flood risk, to convey flood flows away from the property and into underground drainage system. Landscaping the land surrounding individual or groups of buildings to encourage drainage away from a property is an effective measure. Figure 6, shows what has been described as the Smart System where two layers of carriageway is proposed to convey vehicular traffic and the lower level a water tunnel. In order to manage the passage of water along specific flow routes, e.g. around or underneath the property, buildings and infrastructure can be designed in sympathy with the existing topography with the possibility of re-contouring the land at the edges of flood plains to allow for new development without increasing flood risk. In the GRA area in Port Harcourt, road construction and rehabilitations has ignored topographical re-contouring with elevated streets swallowing entire buildings and turning them into an instant reservoirs and completely destroying entire neighborhoods of life investment without adequate compensation.

Figure 5: Drainage Relief Openings

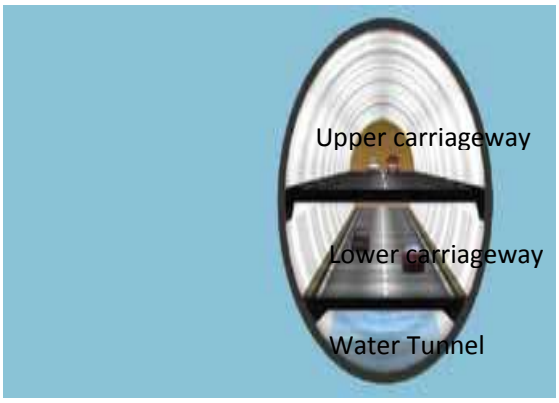

Figure 6: Smart System (Courtesy of HR Wallingford Ltd.)

There are some measures that can be taken at the building level to reduce the impact of floods; some are based on architectural choices, such as the layout of the internal space, elevated construction or imaginative designs, whereas others relate to the use of warning systems. Boundary walls and fencing can be designed to create flood resistant barriers. Living accommodation, essential services, storage space for key provisions and equipment should be designed to be located above predicted flood level. The use of ground floor areas will normally be agreed at planning stage, but options could include designs for provision of additional flood storage or conveyance areas and car parking. Canalization solution is able to deal with floods in a certain area, transferring waters downstream with no major consequences.

DISCUSSIONS

It is a well-known fact that due to poor regulatory framework and implementations of planning laws and building regulations, urbanization due to economic growth and the determination of the rich and powerful to develop at all cost itself has placed Streets, buildings and urban facilities now to occupy banks and the original flood plain thus limiting river canalization enlargement or adjustments to existing drainage infrastructure or the creating of new ones. This has led to the roads being elevated at the detriment of property owners who will have to demolish their properties to build new ones or sell off to developers that have the resources for new builds, a colossal loss indeed. Heavy rainfall, highly accelerated snowmelt, severe winds over water, unusual high tide, tsunamis, or failure of dams, levees, retention ponds, or other structures that retained the water are agents of flooding. Flooding can be exacerbated by increased amounts of impervious surface or by other natural hazards such as wildfires, which reduce the supply of vegetation that can absorb rainfall (Welch *et al.*, 1977)[8]. However not all about flooding is of negative connotation, the organic materials and minerals deposited by the river water keep the soil fertile and productive (Abowei and Sikoki, 2005)[9]. Hunter (1994), [10] in a paper presentation stressed that it is important to maintain channel conveyance capacity, by treating flood causes and not its consequences. A drainage system working as designed can be able to sustain nearby communities safety and health. Public parks and squares, as well as riverine areas may be used as detention ponds, opening the possibility to

construct multifunctional landscapes (Miguez *et al.*, 2007) [11]. Parking lots can also be used, in order to provide temporary storage for flood control. However, the use of existing coastal fronts as storm water runoffs remains the most potent option if adequate topographical information is available to indicate natural gradients and routes to channel a network of drainage systems.

CONCLUSIONS

The increasing effect of global warming, the very disturbing and aggressive weather patterns will continue to affect the level of precipitation in various regions of the globe including the resulting rising sea level. The latter being the effect of melting of ice due to spike in global temperatures. The Port Harcourt terrain requires a holistic approach of all the aforementioned strategies and much more depending on how the local governance appraises the need to keep its population safe not only from flooding but any other form of disaster or emergency as at when and where they do occur. A robust strategy must be in place and those saddled with the responsibility must be properly funded to respond to emergencies in real time. The last major flooding in Rivers state was poorly managed due to lack of coordination and the absence of the tools and expertise to manage the situation. Urban regeneration schemes that target those who have built on water courses, flood plains and even on drainage routes must be checked. The waste management strategies must be reappraised as individuals just dump their refuse in gutters while it is raining. One normally would find plastic bags and bottles among others blocking existing drainages thus impeding flow and this must be nipped in the bud by concerned authorities and agencies saddled with such responsibilities.

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