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IkotUduak Episode: Stormwater Management as a Challenge in Sustainable Development of Urban Residential Communities in Calabar

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Abstract:
The fact that cities provide cultural and economic benefits that rural regions are unable to offer has been the principal push-factor for rural-urban migration since the earliest days of the Industrial Revolution in the United Kingdom. In Africa, 14.9 percent of the continent's population lived in cities in 1950, but by 2000 the percentage was 37.1; and the projections for 2030 are that the percentage will increase to53.5.Correspondingly, the rapid shrinking in the percentages of the continent's rural dwellershas been observed: 85.1 percent (in 1950), to 62.9 percent (in 2000), and 46.5 percent (projected for 2030). All these indicate that the picture of urbanization in Africa is that of conurbations that are under intense pressures to expand; in order to accommodate the influx of rural immigrants. In the case of Calabar in Nigeria, territories that had previously beenperi-urban rural communities are frequently being converted into urban residential communities. IkotUduakurban residential community, the subject of this study, is one of such territories in Calabar. Since Calabar is a coastal settlement with very heavy rainfalls, one of the principal ecological problems of urbanization is stormwater management. The study has shown that, atIkotUduak urban residential community, poor management of stormwaters has resulted invery severe cases of gully erosion in the shallow flat valley of the territory. With the application of successful conceptual models (that had already been experimented in the city as far back as the 1980s), together with modern green infrastructure devices forstormwater management, this disaster could have been averted. In conclusion, the ecological disaster has resulted in destruction of the urban landscape, elimination of the territory's potential in urban agriculture and substantial damage to private property.

Keywords: *Calabar / heavy rainfalls/stormwater management, /ecological disaster / urban agriculture*

1. Introduction

Cities provide for their residents very impressive and undeniable economic and cultural advantages that have continued to make urbanization a very desirable trend. The attraction that the undeniable economic advantages of cities exert on the national population was first demonstrated as early as the 1850s "when rapid industrialization made the United Kingdom the first nation in the world to house more than half of its population in cities" (O'Meara, 1999). The spread of the Industrial Revolution from the United Kingdom to other parts of Europe, and then North America and Japan was followed closely by the spread of urbanization to those places; and those places also turned out to be predominantly urban (O'Meara, 1999). For the Global South, the urban age began to unfold in earnest in the second half of the 20th century.

As urbanization continued to intensify in various parts of the industrialized world,Aronovici (1939) summed up the situation with the declaration that rural-urban migration would constitutethe principal factor in urbanization; and would remain both inevitable and irreversible. Rural-urban migrationis propelled by the quests for a fuller life, which the cities portray; andwhich are inconceivable outside the realms of the cities (Aronovici, 1939). The trends in world urbanization turned out to confirm these declarations; presently the rate of growth of the world's urban population (estimated at about 1.8 percent) has already outstripped the rate of growth of the world's population (that stands at about 1 percent) (Cohen, 2006; Cunningham, Cunningham &Saigo, 2007). Within the space of half a century the world's urban population almost quadrupled from 733 million in 1950 (29.1 of the world's population of that time – 2.519 billion) to 2.875 billion in the year 2000 (47.1 of the world's population of that time – 6.071 billion)(Cohen, 2006). According to Cunningham, Cunningham &Saigo (2007):

Until about 1900, only a small percentage of the world's people lived permanently in urban areas, and even the greatest cities of antiquity were small by modern standards. … In 2005 half of the world's population lived in urban areas, and 60 percent will live in cities by 2030. Urban populations are growing at 1.8 percent per year, almost twice as fast as the world's total population.(Cunningham, Cunningham &Saigo, 2007: 498)

The growth rate of the world's rural populations has not kept pace with rate of growth of world's urban populations, which has been rising very rapidly. While the world's urban population nearly quadrupled from 1950 to 2000 (from 733 million to 2.857 billion), the world's rural population increased less than two-fold from 1.8 billion in 1950 to 3.2 billion in 2000 (Cohen, 2006). The city is no more a place for the exclusive few; it is now the place for all who are in search of fuller lives than what the rural regions are capable of providing (Aronovici, 1939).

In the distant past, the word *city* invoked in man mental pictures and images of a place set apart for very dignified and distinguished levels of human experiences and existence. The word *city*in English Language takes its origin from the Latin words *civitat* for "community" and *civis* for "citizen"; and good number of words that are derived from the word *city* refer to distinguished human behaviors or distinctive human experiences – *civic, civil, civilization*. Following the advent of urban age, which signifies the beginning of the proliferation of cities in human experience, derivatives from the word *urban* (in like manner as those of the word *city*) have also come to convey the same notions of distinguished human existence. The word *urbane* is applied in situations that make references to distinguished manners and good breeding especially considered to be attributes of the higher echelons of civilized human societies, namely: sophistication, enlightenment, refinement or courtesy(Itam and Archibong, 2006). However, things began to change with the Industrial Revolution; and now the city is a place that is under intense pressures to accommodate all the people (of very widely diverse social strata) that desire to flock intoit from the rural regions(Cohen, 2006; Aronovici, 1939).

The position of the developing countries is of great relevance to this work. In 1950, the Global South's share of the world's urban population was 306 million (41.75 percent of the global figure of 733); but by 2000 the share of the Global South in the world's urban population rose to 1.974 billion (69.09 percent of the global figure of 2.857 billion). Future projections also indicate that the trends of world urbanization will continue to be skewed towards the Global South. It has been projected that by 2030 the Global South's share of the world's urban population will stand at 3.930 billion (79.47 percent of the global figure of 4.945 billion)(Cohen, 2006). These indicators suggest that correct ordering of urbanization ought to be on the top agendafor the developing world.

2. Urbanization, Sustainability and Africa

Urbanization and sustainability are two concepts that are often not very compatible. In order that they should be made compatible, there are always the needs for immense efforts and very deliberate commitments by the stakeholders (Cunningham, Cunningham &Saigo, 2007; Nebel and Wright, 2000). According to O'Meara (1999) "Today, cities affect not just the health of their inhabitants but the health of the planet." Cities cover 2 percent of the earth's surface but account for extraordinarily large percentages of resource consumption as well as pollution and waste. In terms of resource consumption, destruction of natural ecosystems and depletion of ecologically productive lands (resources), the ecological footprints of cities extend very far beyond the discrete boundaries of the respective metropolitan regions (Rees, 1992; Wackernagel, 1994; O'Meara, 1999). According to O'Meara (1999):

London, for example, now requires roughly 58 times its land area just to supply its residents with food and timber. Meeting the needs of everyone in the world in the same way that the needs of Londoners are met would require at least three more Earths (O'Meara, 1999: 6-7)

Within the Global South various regions have their specific challenges in urbanization; but it would appear that the challenges facing Africa are among the most daunting. Africa's share of the global urban population increased nearly nine-fold from 33 million in 1950 (14.9 of the continent's population at the time) to 295 million in 2000 (37.1 of the continent's population at the time). By 2030 a further increase of about 150 percent is expected, lifting Africa's share of the global urban population to 748 million (53.5 of the continent's estimated population by that time). These manifestations also reflect the rapidly increasing situations in Africa's share of the world population: 4.5 percent in 1950, 10.3percent in 2000, and 15.1percent that has been projected for 2030 (Cohen, 2006). The rapid shrinking in the percentages of the continent's rural dwellers over the period (86.1 percent in 1950, to 62.9 percent in 2000, and 46.5 percent projected for 2030) indicates that a major factor influencing the rapid buildup of Africa's urban population is rural-urban migration; and this reaffirms the validity of the declarations ofAronovici, (1939) in the contemporary Africa urbanization scenarios. According to Cohen (2006):

… many cities in Africa are economically marginalized in the new global economy. African cities are growing often in spite of poor macroeconomic performance and without significant direct foreign investment, making it next to impossible for urban authorities to provide adequate basic infrastructure or essential services. Nevertheless, if the population of Africa continues to grow as expected over the next 15 years, then by 2015, incredibly, there will be more cities with at least a million people in Africa than in either Europe or North America. (Cohen, 2006: 70-71)

The picture of urbanization in Africa is that of masses of people pouring out of rural regions into cities; and that of cities in which the capacities to host the immigrants must be quickly developed in order to avert ecological disasters. It is the picture of cities in which, in respect of ecological footprints, the inhabitants cannot afford to imitate Londoners, because they lack the logistical support as well as the economic standing to do so (Cohen, 2006; O'Meara, 1999; Rees, 1992; Wackernagel, 1994). Under the current urbanization pressures, phenomenal dimensions of urban growth have ensued; demanding well-articulated and appropriately primed institutional capacities for the agencies responsible for urban developments in various parts of the continent.Unfortunately, in the case of Nigeria, the tasks of proper management of urban growth and urban development are hindered by weak institutional capacities and "the obsolescence and weakness of the existing planning tools for providing a sustainable basis for urban development" (Okosun et al, 2010).Thus, the challenge for Africa is to defy all these odds and establish the frameworks for sustainable urbanization; but so far, as has been shown inOkosun et al (2010), not much progress is being made in this direction. These challengesrelate very strongly to the subject of this study – Calabar in Nigeria (see Figure 1).

In this work it is not the objective to discuss the vast subject of urbanization and sustainability in its entirety. The aspect that constitutes the substantive focus of this work is the problem of stormwater management within the scenarios of rapid urbanization in Calabar (see Figure 1); using the example of a currently emerging urban residential community in the city – IkotUduak urban residential community. Special emphasis is placed on the ecological disasters that have erupted in association therewith.

3. The Theoretical Platforms

3.1. Urbanization and Precipitation in Coastal Environments

Understanding the problems of urbanization in coastal regions (such as Calabar in Nigeria) demands appropriate interpretation of one of the most fundamental material cycles of nature – the hydrologic cycle. Every year the total amount of water that is transported from the surface of the earth, by evaporation and transpiration (evapotranspiration), is about 496,000 cubic kilometres. The oceans, which cover 70 percent of the earth's surface, account for 425,000 km^3 (85.7 percent) of the water that is introduced into the atmosphere from the earth's surface. Through the process of transpiration from vegetation, 41,000 km^3 (8.3 percent) is introduced into the atmosphere, whereas evaporation from soil, streams, rivers and lakes (soil together with the directly associated water bodies) further introduces 30,000 km^3 (6.0 percent) into the atmosphere. Thus, the total amount of water introduced into the atmosphere from the landed surfaces of the earth (vegetation and soils, together with the directly associated water bodies) is 71,000 km^3 or 14.3 percent (Cunningham, Cunningham &Saigo, 2007).

Through the process of precipitation, the same quantity of water (496,000 km^3) returns to the earth from the atmosphere every year; but distribution is very significant. Precipitation over the oceans returns a total of 385,000 km^3 (about 90 percent of the quantity of water originally extracted from the oceans) directly back to the oceans. This quantity of water is less than the 425,000 km^3 of the water that was taken off the oceans in the first instance by 40,000 km^3. This balance of 40,000 km^3 (10 percent of the quantity of water originally extracted from the oceans) is the amount of water that is conveyed by prevailing winds to the landed surfaces of the earth. The 40,000 km^3 of water, added to the 71,000 km^3 of water that was originally released into the atmosphere (through evaporation from the landed surfaces of the earth including its associated water bodies) makes up the total of 111,000 km^3 of water that is returned to the landed surfaces of the earth (including its associated water bodies) by precipitation (Cunningham, Cunningham &Saigo, 2007).

This 40,000 km^3 of water that is conveyed from the atmosphere over the oceans to drop as rain over the landed surfaces of the earth (including its associated water bodies) performs a very critical ecological function. It represents nature's way of constantly replenishing the freshwater stock that is needed for the sustenance of life in the ecosystems located on the landed surface of the earth. However, it ultimately must return to the source – the oceans. Much of the rain that originates from this source falls over the coastal regions; making rainfalls in such places extraordinarily heavy. The management of this quantum of water in the course of physical developments in coastal human settlements determines the sustainability or otherwise of urban development processes in such places. That is the situation of Calabar in Nigeria (see Figure 1).

Figure 1: Calabar, capital city of Cross River State in Nigeria (as compiled in April 1995)
Source - URL: http://www.lib.utexas.edu/maps/africa/calabar_tpc_1996.jpg Retrieved: March 14, 2015

On the one hand, poor management of this water could result in ecological disasters such as floods and erosion. Correct management of this water, on the other hand, offers the urban dwellers such ecological benefits as groundwater discharge and freshwater in ponds for useful purposes such as agriculture, aquaculture or recreation. Thus, floods and erosion ought not to be taken as unavoidable phenomena that must accompany urbanization in coastal regions; they constitute evidence of faulty urbanization processes in the coastal human settlements (Cunningham, Cunningham &Saigo, 2007; Nebel and Wright, 2000).

3.2. Urbanization and Stormwater Management

Understanding the ecological importance of stormwater management is the key to sustainable urbanization in coastal cities such as Calabar. Viewed from the city's geographical location in which a very major characteristic feature is its proximity to the estuary and the high seas (see Figure 1), it should be expected that rainfall would be very heavy in Calabar; and that indeed is the case. To begin with, freshwater is among the most valuable resources of mankind; but it is very scarce in many parts of the earth. In places like Calabar, where rainfall is very abundant, people ought to consider themselves exceptionally favoured by nature. According to Nebel and Wright, (2000):

Furthermore, water scarcity will become a severe constraint on food production, economic development, and production of natural ecosystems if total annual supplies diminish below 1000 cubic meters per person. Twenty-six countries … are already below this threshold, and with rapid population growth, many more will cross into this category in the near future. (Nebel and Wright, 2000: 213)

Two options or pathways are available for the rainwater that hits the earth's surface. It may follow the pathway of *infiltration*, by which it percolates through the subsoil for the recharge of underground aquifers. The other pathway is for the rainwater to run along the surface in the form of *runoff*. The ratio between infiltration and runoff, known as *infiltration-runoff ratio*, is a very critical factor in physical development. In natural ecosystems such as forests 50 percent of the rain water that hits the earth's surface is directed into the subsoil by means of infiltration for the recharge of groundwaters; while merely 10 percent remains as runoff (USEPA, 2003b).Discharge of stormwaters into aquatic ecosystems must be avoided because it results in pollution and destruction of urban surface waters (Chocat et al, 2007; Chocat et al, 2004;Beasley and Kneale, 2002). Infiltration ought to be promoted inasmuch as groundwaters are vital for the sustenance of live on earth; because they provide a reliable source of safe drinking water – "much of the world's population does not have access to this essential resource" (Nebel and Wright, 2000).

Urbanization brings about physical developments that alter natural ecosystems; replacing ecologically productive lands with hard impervious surfaces (CWP, 1998). As this happens, infiltration-runoff ratio is permanently altered. Surface runoff increases from 10 percent to 55 percent, while infiltration decreases from 50 percent to 15 percent (USEPA, 2003b). In the first instance, the reduction of infiltration leads to reductions in the processes of groundwater recharge; and ultimately to over extraction and depletion of groundwater reserves – a critical phase of water shortage. This is the situation in places such as Beijing, New Delhi and Mexico (Nebel and Wright, 2000; O'Meara, 1999). Furthermore, increases in volumes of surface runoffs are accompanied by diverse ecological hazards: floods, erosion and pollution of urban surface waters (USEPA, 2003a; USEPA, 2003b; USEPA, 1999).

In Calabar the average annual rainfall is about 300mm. The heaviest rainfalls occur during the four months that span from June to September: June (390), July (440), August (390), September (400). The average for these four months is about 405 mm. During these four months of very heavy rainfalls, stormwaters have very great potentials in exacting grave ecological damage if not properly managed. Thus, it is evident that urbanization in Calabar will always be accompanied by encounters with large volumes of stormwaters; and the sustainable management of the stormwaters will always be a foremost challenge that must have to be resolved if sustainable urbanization is expected to be accomplished in the city.

3.3. Stormwater and the Urban Landscape

Towards the successful management and disposal of stormwaters within the urban landscape it is essential to understand the characteristics of flow of stormwaters. In the first instance, stormwater that is directed down a slope in a drain channel has great momentum, from which it derives immense blasting power to inflict great damage on the landscape upon which it is discharged; if appropriate precautionary measures are not put in place. Whenever this fact is ignored, very serious ecological disasters are bound to ensue. According to Document No. EPA 841-F-03-003 of the United States Environmental Protection Agency (USEPA) of February 2003, *Protecting Water Quality from Urban Runoff*:

Storm sewer systems concentrate runoff into smooth, straight conduits. This runoff gathers speed and erosional power as it travels underground. When this runoff leaves the storm drains and empties into a stream, its excessive volume and power blast out streambanks,damaging streamside vegetation and wiping out aquatic habitat. (USEPA, 2003b: 1)

Although the USEPA document addresses directly the issue of conveyance of storm sewers in closed underground conduits, the interpretations pertaining to the impacts of the immense blasting power on landscapes and ecosystems are equally valid for open stormwater drains.Furthermore, natural landscapes such as forests, wetlands and grasslands have porous soils that permit the infiltration of rainwater. When they are exposed to the great blasting power of the stormwaters that are discharged freely upon them, their internal structures easily crumble, resulting in the immediate washing away of the soil particles (USEPA, 2003b); and erosion thus ensues very rapidly.

3.4. Green Infrastructure for Stormwater Management

The contemporary worldview about water is directed towards the holistic approach known as *Total Water Management* (TWM). Under this approach, the strict division of water into compartments such as potable water, stormwater or wastewater is rejected. It is now understood that the urban water shortages that are currently threatening many parts of the world have arisen out of the wrong concept of treating stormwaters as waste products that must be summarily discarded. Changes in levels of comprehension have led to the new understanding that it is more beneficial for manto recycle stormwaters into nature by enhancing infiltration into the subsoil for recharge of underground aquifers; than to discharge them into urban surface waters as waste products(Zhou, Q. (2014); Chocat et al, 2007; Chocat et al, 2004). According toRodngo, Lopez Calva, and Cannan (2012):

Total Water Management (TWM) is an approach that examines urban water systems in a more interconnected manner, focusing on reducing water demands, increasing water recycling and reuse, creating water supply assets from stormwater management, matching water quality to end-use needs, and achieving environmental goals through multi-purpose, multi-benefit infrastructure.

(Rodngo, Lopez Calva, and Cannan, 2012: iii)

Application of the modern and ecologically more beneficial techniques of stormwater management is the key to sustainable urbanization in coastal cities such as Calabar. These techniques, which have been described as“multi-purpose, multi-benefit infrastructure” in Rodngo, Lopez Calva, and Cannan, (2012),are more generally categorized as *green infrastructure* (USEPA, 2014). These techniques are usually developed and applied in furtherance of the fundamental objective of facilitating the infiltration of stormwaters into the subsoil (for recharge of underground aquifers) at the points at which they are generated on the urban landscape. Recharge of underground aquifers is, for several strong reasons, a fundamental objective in urban development in the contemporary era of phenomenal population growth. Firstly, underground aquifers constitute the foremost source of freshwater for most people in the world; and constant recharge of underground aquifers is essential in averting water scarcity, which has become a very significant ecological threat in the contemporary era(Nebel and Wright, 2000; Chocat et al, 2007, USEPA, 2014; Rodngo, Lopez Calva, and Cannan, 2012). Secondly, the rate of refilling most underground aquifers is very slow; it could take thousands of years for an aquifer to be replenished once depleted. This fact makes the constant recharge of underground aquifers very essential(Cunningham, Cunningham & Saigo, 2007; Nebel and Wright, 2000). Finally, it has been shown that over extraction of groundwaters could create vacuums in underground cavities; and such vacuums could result in subsidence at the earth’s surface. This is currently being experienced in Mexico City (O'Meara, 1999).

The range of green infrastructure, currently in use, are designed to collectively facilitate the infiltration of stormwaters into the subsoil; thereby leapfrogging the ecological hazards that are associated with the flow of stormwaters over the urban landscape – floods and erosion. The use of *porous pavements* in car parks and roads permits rainwater to percolate through the pavements for infiltration through the subsoil below. *Ponds and constructed wetlands* collect stormwaters from drain channels and hold them, while they gradually infiltrate into the subsoil. *Infiltration trenches* are used for collecting stormwaters from drain channels and impervious surfaces; and then facilitating their infiltration into the subsoil. In all, they work collectively towards facilitating the recharge of underground aquifers(USEPA, 2014; Rodngo, Lopez Calva, and Cannan, 2012; Chocat et al, 2007;Chocat et al, 2004; USEPA, 2003a; USEPA, 2003b; USEPA, 1999).

4. The IkotUduak Episode in Calabar, Nigeria

IkotUduakurban residential community in Calabar is a relatively new urban district in which intensive urbanization has been taking place since the last decade of the 20th century. It is made up of two sectors that lie to the east and the west of a flat valley of which much of the original natural forest and natural vegetation covers had remained intact; because the flat valley is not very attractive for housing developments (see Figure 2).

Figure 2: IkotUduak urban residential community in Calabar; showing the eastern and western sectors of the residential community lying on either side of the flat valley that separates them.
(Source: Google-Earth imagery of January 20, 2011)

Figure 3: IkotUduak urban residential community in Calabar; showing the principal zones of emergence of serious ecological disasters in the valley that separates the two sectors of the residential community.
(Source: Google-Earth imagery of January 20, 2011)

On the image shown in Figure 2, a broad uneven line is visible, running approximately diagonally along the bottom of the valley. It is evidence of gully erosion that had already become manifest in this valley as far back as January 20, 2011, when this image was recorded. It can further be observed that the gullies are tied into the western sector of the urban residential community at three points: point A1 in Impact-zone A as well as points B1 and B2 in Impact-zone B respectively. Point A2 in Impact-zone A is located on the eastern sector of the urban residential community (seeFigure 3).Stormwater was collected from all over the western sector of the urban residential community and conveyed to these two impact-zones for discharge into the valley. At Impact-zone A, there is also the point A2, which represents the point of discharge of stormwater directed from the eastern sector unto the walls of the valley. At the time of recording of the image shown in Figure 3, in January 20, 2011, the ecological problems of the valley were just beginning to manifest; but now they have magnified into a full-blown gully erosion site. On the whole, this study has revealed that the methods adopted for the discharge of the stormwater on the walls of the valley were altogether very faulty. In addition, effective monitoring and response at the early phases of the incipience of the ecological problems would have helped in averting the deterioration of the situation into a full-blown ecological disaster.

Figure 4a
View of the major paved road that runs towards Impact-zone A, on the eastern sector of IkotUduak residential community.
(Photocredit:Ukorebi, U. A.)

Figure 4b
Point of discharge of stormwaters from the road and concrete drain channels on to the walls of the valley in Impact-zone A, at the point A1 in Figure 3
(Photo credit: Ukorebi, U. A.)

Figure 4c
View of the damaged building shown in Figure 4b
(Photo credit: Ukorebi, U. A.)

Figure 4d
View of the gully from the side of the building shown in Figs. 4b & 4c(Photo credit: Ukorebi, U. A.)

Figure 4

4.1. Impact-zone A

On the western sector of IkotUduak urban residential community, the estate road leads directly to this impact-zone (see Figure 3); it is finished with impervious pavements and lined with concrete drain channels on either side. These concrete drain channels are connected to other secondary drain channels that collect stormwater from various parts of this sector of the urban residential sector. At the end of the road, and in front of the property line of the building that lies at the end of the road (see the arrow in Figure 4a), the two concrete drain channels are unified into one single concrete drain channel. The unified drain channel discharges stormwater directly unto the sides of the valley, at the point of impact identified as A1 in Figure 3. This has become the cause of the serious ecological disaster that has ensued in the zone (see Figs. 4a, 4b, 4c and 4d).

On the eastern side of this zone (at the point indicated as A2 in Figure 3) in the eastern sector of IkotUduak urban residential community, there is another point of direct discharge stormwater from roads and concrete drain channels, unto the sides of the valley. At the time of recording of the Google-Earth imagery of January 20, 2011, there were only little traces of ecological problems at this point. Over the last few years, the situation has very greatly deteriorated. A concrete drain channel (marked D1 in Figure 5) has been constructed to convey the stormwater into a larger concrete drain channel (marked D2 in Figure 5) located at the bottom of the valley.

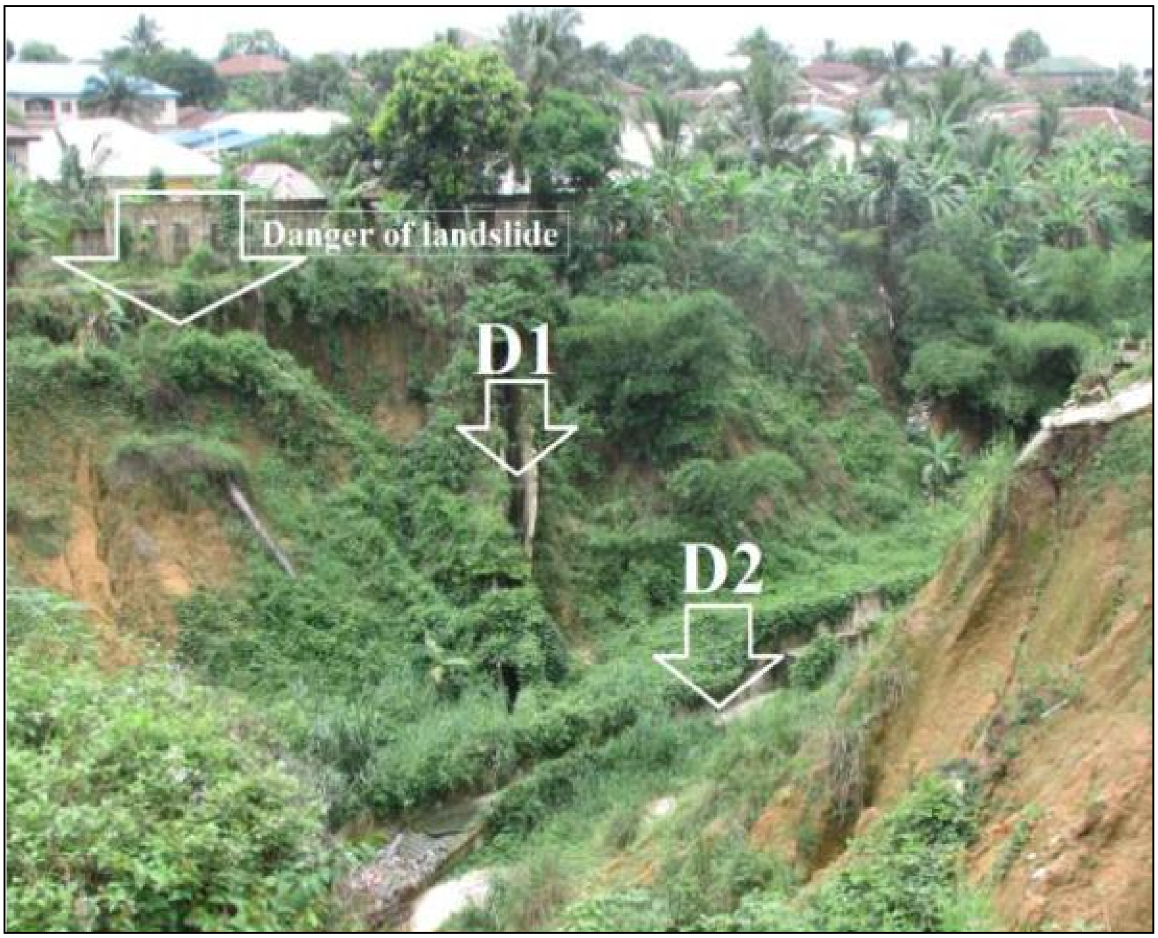

Figure 5: View of the impact point identified as A2 in Fig, 3.
(Photo credit: Ukorebi, U. A.)

From visual inspection of the scenarios, the inference has been reached that these civil works (the concrete drain channels D1 and D2) are certainly later-day additions that were incorporated into the stormwater management scheme long after very extensive ecological damage had already ensued. The application of green infrastructure for stormwater management at the outset would have helped in averting this disaster; significantly also, the costs of this alternative would have been much lower. In spite of these latter-day civil works, danger has still not been fully averted. The weakening of the walls of the gullies, by persistent actions of stormwater, has placed the buildings on the foreground in Figure 5 (on the eastern sector of IkotUduak residential community) in constant danger of landslide.

4.2. Impact-zone B

This impact-zone is located less at a distance of between 500 metres and 1 kilometre south of Impact-zone A. A number of concrete drain channels (see Figure 6a) were constructed for conveying large volumes of stormwater from the immediate vicinity as well as from other far-away locations for discharge at the point designated as B1 (see Figure 3). At point B2 another set of concrete drain channels was constructed for conveyance of stormwater from the immediate vicinity into the shallow flat valley. The stormwater was released freely into the shallow flat valley that separated the western sector of IkotUduak residential community from the eastern sector. No precautions were taken to strengthen the sides of the valley (with stone-pitching) against the forces that would be unleashed on them by the stormwaters. The stormwater discharged into the valley at this impact-zone constitutes more than 75 percent of the total volume of the stormwater that is discharged into the entire valley. The result turned out to be the deep ravine seen in Figs. 6b and 6d.

Figure 6a
View of the concrete drain channels that convey large volumes of stormwater (from the immediate vicinity and far away) into the shallow flat valleys at Impact-zone B (Photo credit: Ukorebi, U. A.)

Figure 6b
View of the deep ravine that developed on account of the faulty discharge of stormwater into the shallow flat valleys at Impact-zone B(Photo credit: Ukorebi, U. A.)

Figure 6c
View of the road with the concrete drain channels that convey stormwater to point B2 in Impact-zone B.
(Photo credit: Ukorebi, U. A.)

Figure 6d
View of the deep ravine at point B2 in Impact-zone B.
(Photo credit: Ukorebi, U. A.)

Figure 6

4.3. Threat to Private Property and Livelihoods

The threat to private property, associated with ecological disasters such as this, has often been very substantial. Home owners are forced to flee their homes (see Figure 4c); while other homes are placed under the constant threats of landslides (see Figs. 4d, 5, 6a, 6b and 6d). The misfortune of all these home owners consists in the fact that ecological funds have hitherto only been expended exclusively on remediation of ecological damage done to the urban landscape. So far no records have been found in Calabar, in respect ofany payment of compensations to homeowners on account of damage occasioned on their private property as a result of the ecological consequences of poorly conceived public works.Homeowners are exposed to great losses and uncertainties following ecological disasters of this nature.Thus, the issues ofpayment of compensations on account of threats to public property, arising from the consequences of ecological disasters, constitute an area that demands further attention in urban policy in Calabar.

4.4. Loss of Ecologically Productive Land

A major consequence of theIkot-Uduak episode is the loss of the ecologically productive land that was once located in the shallow valleys (see Figure 1). An entire territory that was once rich in natural vegetation has now been denuded and is now full of ugly gullies; resulting in loss of potential for urban agriculture. As the urban residents turn around to depend on crops and vegetables transported (at high costs) from distant rural places, the ecological footprints of the city are expanded and food insecurity is heightened. Generally the situation in the Global South is that the absence of dependable regional transportation infrastructure and logistical support constitutes a formidable impediment in the task of movement of materials from rural regions to cities. Following the loss of the ecologically productive land, urban poverty escalates as skillful farmers are left without any access to farmlands that constitute their means of sustainable livelihood. Thus, every occasion of careless destruction of ecologically productive lands in the city leads to urban food insecurity through the loss of the capacities for local food production and to urban poverty, which finally threaten the sustainability of the city(Rosenburg and Yuen, 2012; Andres and Lebailly, 2011; Halloran, 2011; de Zeeuw.and Dubbeling, 2009; Wackernagel, 1994; Rees, 1992).

5. Discussion

The concepts of stormwater management exhibited atIkotUduak were exceedingly simplistic and contrary to the principles of sustainable development (WCED, 1987). In Impact-zone B, stormwater,collected from within the community as well as adjoining urban communities, was literally discharged upon the shallow flat valley without regard for its natural forest ecosystems. In Impact-zone A, stormwater was discharged by the side of a private building into the shallow flat valley that lay behind it (see Figs. 4b and 4c). Both instances betray total lack of understanding of the characteristics of the stormwater that was being discharged. They also display lack of appreciation of the characteristics of the porous soil structure as well as of the forest ecosystems of the shallow flat valley or their very significant ecological values. Safe discharge and management of stormwater on sloppy terrains, such as the sides of the shallow flat valleys of IkotUduak urban residential community, ought not to constitute serious problems in Calabar. There is a good precedence in the city to serve as a good conceptual framework for resolving such problems.

In the mid-1980s (almost two decades ago) extensive urban renewal works were carried out on the urban sector that is located at the top of the cliff at the Marina in Calabar (in the vicinity of the CFAO Building). The urban renewal works consisted in the construction of hard impervious pavements and concrete stormwater drains on Anderson Street and other nearby streets located directly above this section of the Marina cliff. At first, the stormwater was freely discharged over this sloppy terrain, in the hope that it would roll down safely into the concrete drain channels located at the base, on the sides of the Marina. In the course of the rainy season of the first year, it was discovered that very substantial ecological damage had already occurred on the slopes. This situation led to the implementation of remedial works (in the form of slope-stabilization by stone-pitching) to halt the deterioration of the slope. The remedial works were completed in that same year; and have withstood two decades of the very heavy rains of Calabar without any signs of failure. The slope-stabilization works did not end up with bare hard concrete surfaces; rather the surface has now sustained good vegetation cover, which makes it difficult to see the stone-pitching works in some places(see Figs. 7a, 7b and 6c). Thus, the problems of stormwater management on sloppy terrains that are presently being encountered in Calabar are not without precedence of successful conceptual frameworks for safe resolution within the city.

Two lessons ought to have been derived from the Marina project experience. Firstly, on account the heavy rainfalls of Calabar, the stormwater possesses great blasting force which grants it great potential in causing severe damage to the urban landscape. Secondly, the conceptual framework applied in the Marina project has withstood the test and ought, therefore, to have been adopted as part of the standard blueprint for stormwater management in Calabar. However, in spite the extant successful model, the current experience is that large volumes of stormwater continue to be spewed out on unprotected urban landscapes; with very predictable and dire consequences – severe cases of gulley erosion. In the place of well-tested and time-proven techniques, such as the example of successful slope stabilization project at Marina in Calabar, diverse trial-and-error approaches have been applied in various situations in the city. The end result has remained the same – failure,such astheIkotUduak episode(see Figs. 4c, 4d, 5, 6a, 6b and 6d).

Safe discharge and management of stormwater could have been attained in the shallow flat valleys of IkotUduak with the application of appropriate ecological techniques from the outset. This approach would have begun with stone-pitching at the points of discharge. Thereafter, the application of green infrastructure would follow to improve the capacity of the environment for holding the stormwaters in position; while the slow processes of infiltration into the subsoil would be allowed to take place. Green infrastructure suitable for this situation includes: ponds, constructed wetlands, infiltration trenches and urban agriculture (USEPA, 2014; USEPA, 2003a; USEPA, 2003b; USEPA, 1999; CWP, 1998).

Figure 7a: Example of successful slope-stabilization works (executed by stone-pitching) at the Marina in Calabar. (Photo credit: Ukorebi, U. A.)

Figure 7b
Left wing of the successful slope-stabilization works at the Marina in Calabar.(Photo credit: Ukorebi, U. A.)

Figure 7c
Right wing of the successful slope-stabilization works at the Marina in Calabar.(Photo credit: Ukorebi, U. A.)

Figure 7

A recommended version of stormwater retention pond that would be very compatible with the original forest ecosystems of the shallow flat valleys of IkotUduak is shown in Figure 8. In the place of the massive destruction of the urban landscape (see Figs. 4c, 4d, 5, 6a, 6b and 6d), the stormwater collected in the surface pond would have been of immense ecological values. The water in the pond could be applied in supporting the natural forest ecosystems as well as for the promotion of urban agriculture and aquaculture. Other major ecological and social benefits of the pond include recharge of groundwaters through infiltration as well as recreation.

Figure 8
Recommended version of stormwater retention basin suitable for original forest ecosystems of the shallow flat valleys of IkotUduak
Source: Retention basin "NeuköllnerStraße" in the northeast of Aachen, Germany
"AachenRRBNKS 9272" by © Túrelio (via Wikimedia-Commons), 2008 /. Licensed under CC BY-SA 3.0 de via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:AachenRRBNKS_9272.jpg#/media/File:AachenRRBNKS_9272.jpg

6. Conclusion

In Calabar the major ecological problem in urban development centres on the management of stormwater in an urban terrain that consists of several gentle slopes that drain into flat valleys occupied by ecologically productive lands. The stormwater that rolls down the gentle slopes gathers great blasting force, which enablesitto inflict graveecological damage on unprotected urban land surfaces. The matter demands very careful scientific studies of each situation, in order to evolve the most suitable solution for the given situation. The IkotUduak episode has shown that there is no room for trial-and-error approaches. It is entirely sad to note that theIkotUduak episode is not an isolated incident; it is one of the several ecological disasters that are issuing out of random applications of trial-and-error approaches to the management of stormwater in urban residential communities in many parts of Calabar.

The ecological disaster of IkotUduak has resulted in immense damage to the urban landscape. By reason of the instability of the land on the sides of the gullies, the threat to private property is enormous; and some people have already been rendered homeless. Furthermore, the ecologically productive lands previously located in the rich valley have been washed away; leaving ugly gullies that are incapable of supporting urban agriculture. Thus, the means of livelihood of some of the residents of IkotUduak residential community has been cut off.

The great misfortune of the IkotUduak episode is that much money is always being spent on the remediation of ecological damages that ensue from the failures of random trial-and-error approaches. The application of well-proven ecological techniques and green infrastructure would save much money; and at the same time save the urban landscape of Calabar from frequent ecological disasters.

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