Ecological Consequences of Urbanization of Uyo Capital City, Akwa Ibom State, Nigeria

I. N. Akpan-Ebe[1*], I. R. Udotong[2] and R. E. Ekpenyong[3]

[1]*Department of Forestry and Wildlife, University of Uyo, Nigeria.*
[2]*Department of Microbiology, University of Uyo, Nigeria.*
[3]*Department of Geography and Regional Planning, University of Uyo, Nigeria.*

Original Research Article

ABSTRACT

Uyo existed as a village until the concept of urbanization came with the advent of colonization to West Africa. Before the creation of Akwa Ibom State in 1987, Uyo was a Local Government Headquarters. Today, it is the capital of Akwa Ibom State, and the largest modern city/urban centre in the state. This present status of Uyo with increased infrastructural development and amenities is not without some ecological implications on the environment. This study was aimed at identifying some ecological consequences of urbanization of Uyo as a State capital. A combination of GIS, physical observation and field sampling and analyses were adopted in this study. The results show that vegetation cover and land use pattern have changed with increasing residential and built-up areas over the years. The ecological implications of this are enormous. Other consequences of urbanization of Uyo identified in this study include increased waste generation, increased flooding and erosion, air pollution and water and sediment contamination. It is recommended that Environmental Impact Assessment (EIA) tool should be adopted for urban renewal and

_____

*Corresponding author: E-mail: isonnelson@yahoo.com, dr_nundaeyo@yahoo.com;

infrastructural development projects to check its negative consequences on the environment. This study noted with sadness that EIA was not carried out prior to urbanization of Uyo and concludes that this may have been the cause of the many unmitigated and irreversible negative consequences of urbanization of Uyo identified during this study.

1. INTRODUCTION

The components of creation consist of living and non-living things. The living things constitute the biotic components which, broadly put, include man, animal and plant of different forms and sizes. The non-living or abiotic components include rocks, soil, water, air and man-made structures of our environment. In nature, the environment could function in a homeostatic state if adequate attention were paid to its natural ecology in relation to its utilization. Stiling [1] defined ecology simply as the relationship between living organisms and their environment. Ecology therefore strives to maintain stability in a given ecosystem, be it natural or man-made, as a result of the relationship or interacting processes of the component units. The science of ecology is basically concerned with the environment of all plants and animals and so [2] warned that we should be constrained by the principles of ecology when altering the environment. Man's impact on the environment is principally as a result of his quest to meet basic needs, while the rate of modification of the environment is dependent on technological development of modern civilization.

Man, more than any other creature, has had an overwhelming influence, with dire consequences on the environment due to the neglect of the ecology of its components. The world today has witnessed a faster rate of urbanization, industrialization, transportation, new farming techniques, improved information communication technology (ICT), etc. which has reduced the world into a global village at the press of button. Human population, especially in the so called developing countries has also increased tremendously over the years due to improvement in medicare and sanitation. The immediate consequence of improved human existence is the over-exploitation of available natural resources which, ironically, impoverishes man and his environment in the process. So it is with urbanization in Nigeria.

Urbanization is a process of transformation of a hitherto rural setting into a town or city by the provision of certain amenities and infrastructure that encourage people to live together to pursue their various goals. Berry [3] defined urbanization as a process of population concentration which proceeds through the multiplication of points of concentration and the increase in the size of individual concentration seems quite appropriate. The Federal office of statistics according to [4] defined an urban centre in Nigeria as a clustered settlement with a population of 20,000 and above.

The most significant effect of urbanization is observed in new land use pattern and change in land cover, together with the concentration of population within a designated land area. In nature, an undisturbed ecosystem is a complex structure whatever the vegetation type. Urbanization, especially in the tropics, involves the destruction of existing plant cover to make room for buildings and other infrastructural provisions such as roads and stadium. This leads ultimately to the loss of ecosystem complexity and the collapse of its structure due to the change in land use. The tradeoffs of urbanization are easily felt in deforestation leading to loss of biodiversity, soil degradation, air and water pollution and climate change. These environmental perturbations have serious implications on the health and wellbeing of the people who become victims of their own actions in the pursuit of good life.

Uyo, from time immemorial, existed as a village until the concept of urbanization came with the advent of colonization to West Africa in the 19th century. The process of urbanization of Uyo was gradual. The initial population was small and the environment was relatively stable. However, the population of Uyo had since grown, for instance, from 96,386 in 1963 to 234,615 in 1991 and 309, 573 in 2006 [5], probably by virtue of it becoming a state capital on the creation of Akwa Ibom State in 1987. Today, Uyo is fast expanding, transformed and modernized. By 2006, the population density of Uyo with a landmass of 284.72 km^2 stood at 1,087/km^2 [6].

The initial urbanization of Uyo which concentrated around the city centre of what is today designated as the IBOM PLAZA, has

expanded to hitherto remote areas of Mbiabong, Etoi, Afaha Oku, Ikot Oku Ubo, Ofot, Osong Ama, Itam and Mbierebe. This has posed serious challenges to the ecology of the city which this study seeks to address. There is strong need to carry out an in-depth assessment of the consequences of urbanization of Uyo with regard to the ecology of the city. This explored observable changes in the environmental quality of the city especially its land cover, air and water quality, biodiversity and local climate.

2. MATERIALS AND METHODS

2.1 Study Area

Uyo is an urban city located in South-eastern Nigeria. It serves as the capital of Akwa Ibom State. It is located approximately between latitudes 3°05' and 5°55' N and longitudes 7°50' and 8°02' E with a land area of

approximately 314 km^2 [7]. The relief consists of undulating and low-lying rolling topography. The most prominent feature of the physical landscape of Uyo is the ravine lying north-easterly of the town [8]. Slopes of 6°8' are common on the interfluves and deep ravines.

The major hydrographic feature of Uyo is the Ikpa River together with tributaries of perennial streams on the ravine bed. Other water bodies within the study area include the Afia stream and Akpan Mbat stream. Uyo records relatively uniform temperature values throughout the year, varying between 25°C and 28°C with the hottest and coolest months being March and August, respectively [9]. The mean relative humidity in Uyo varies between 71% and 86% as against 80 to 90% for the entire State [10]. Today, the vegetation is scanty, comprising mainly exotic species such as *Gmelina arborea, Gliricidea sepium, Cassia siamea,* and
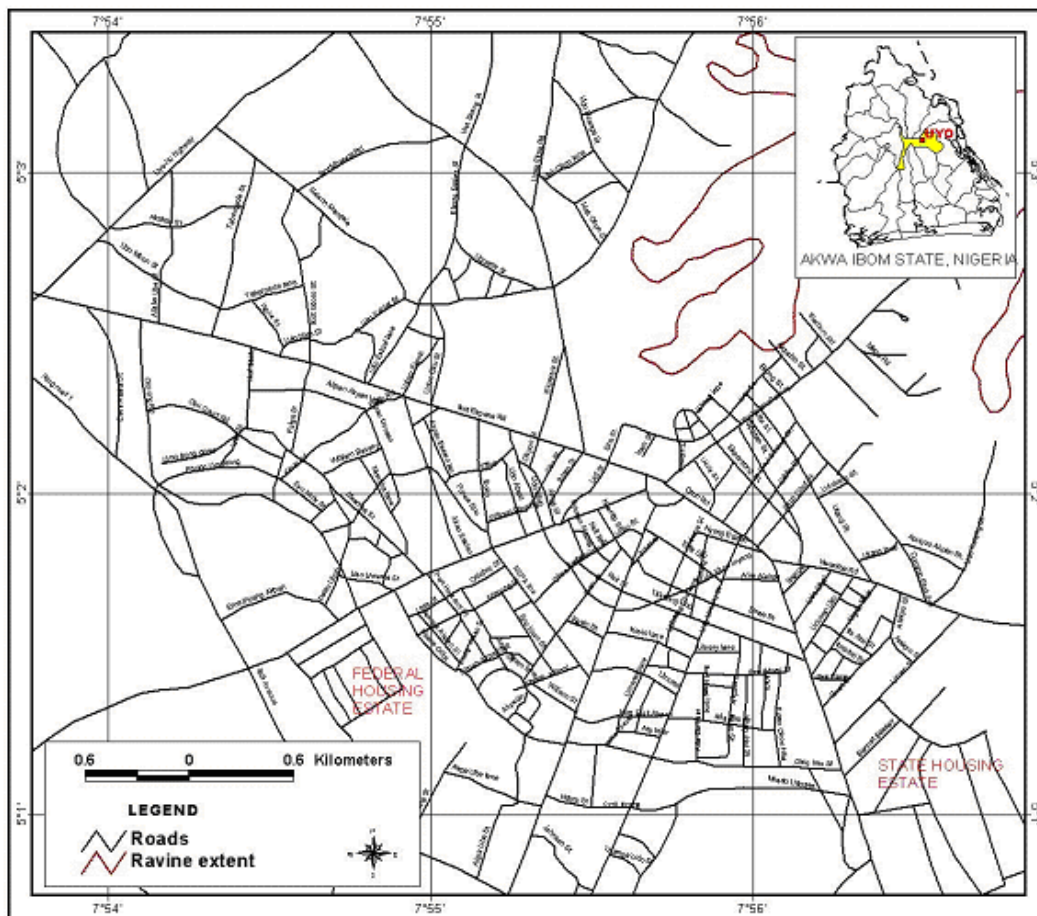

Fig. 1. Map showing the location of study area

Anacardium occidentale raised in plantations to check erosion in the ravine area. Indigenous species include *Anthocleista djalonensis, Barteri nigritiana, Anthonota macrophylla* and *Elaeis guineensis,* and homestead species such as *Dacryodes edulis, Persea americana,* among others. The town fringe is a continuum of palm belt interspersed with farm bush. The mean annual rainfall is about 2,500 mm and is bi-modal with peaks in July and September.

2.2 Datasets and Sources

2.2.1 Map data

The portion of a topographic map - Ikot Ekpene SE, showing Uyo was scanned to produce the map (Fig. 2). The Federal Surveys produced the topo map in 1965 using aerial photographs of the area taken in 1965. Fig. 2 shows the extent of the built-up area as at 1965.

2.2.2 Satellite data

To show the effect of urbanization, satellite data - Landsat TM images of Akwa Ibom State for two time periods (1986 and 2007) were used. This was downloaded from the internet. Also, a personal computer with ERDAS IMAGINE image processing and Arcview GIS 3.2a software was used.

2.2.3 Image classification

Land cover maps of the two time periods were produced using supervised classification algorithms. First a color composite of the images for the two time periods were created using
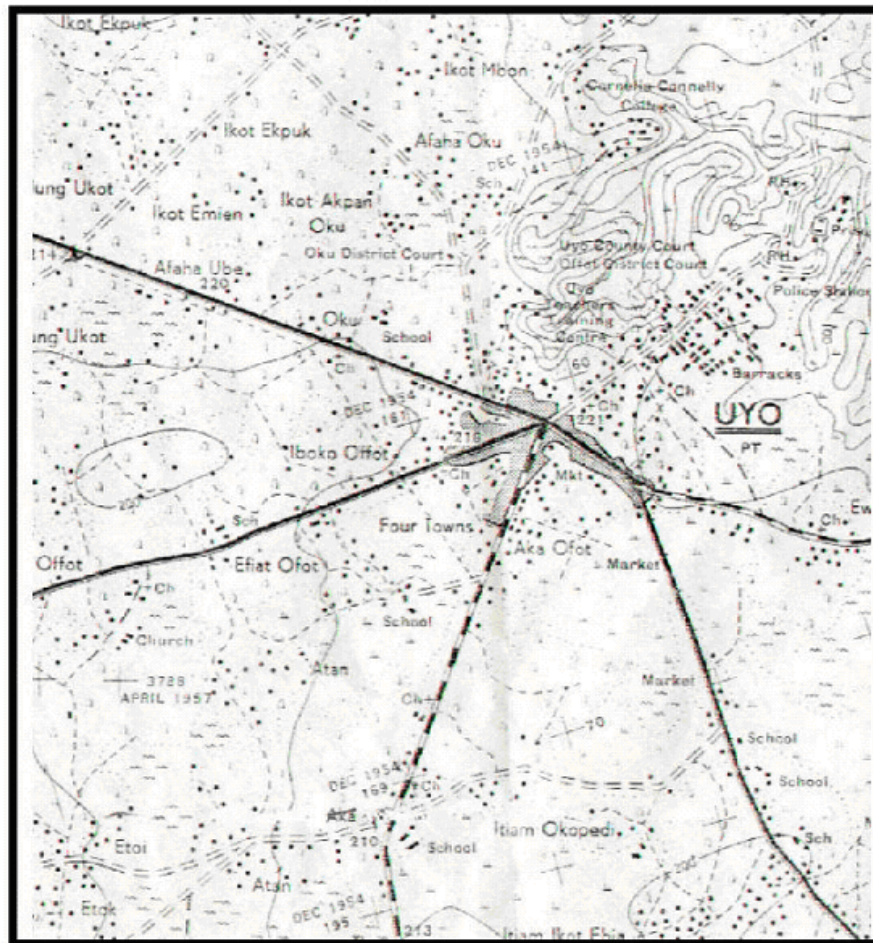

Fig. 2. Topographic map showing Uyo urban as at 1965

4

bands 3, 4 and 5. Then unsupervised classification was carried out to map the features/land cover type in the area. This approach allows natural spectral clusters to be defined with high level of objectivity and reliability. This exercise also helped in the pre-determination of the co-ordinates of possible training sites. This information was fed into a GPS for field verification regarding the location of the land cover type. Based on the result of the unsupervised classification and field verification, 5 major land cover classes were identified in the study area.

To perform supervised classification, the color composite images of the respective time periods were displayed using ERDAS IMAGINE software. Thereafter, the training sites were created/identified and demarcated based on the coordinates gathered during field verification.

Supervised classification using the Gaussian maximum likelihood classifier was carried out on the colour composite created from bands 3, 4, and 5 [10,11]. The zoom tool was then used to zoom into Uyo. Figs. 3 and 4 show the result of the supervised classification. The built-up area of Uyo increased from approximately 1567.8 ha in 1986 to 9748.6 ha in 2007 [12].

2.2.4 Demarcation for changes in city outlook

The physical demarcation of the city of Uyo into ten waste management zones by [13] was adopted as the basis of resources studies. A reconnaissance survey of all the ten zones and the suburbs was conducted regularly between 2001 and 2010 for an unbiased assessment of observable changes in city outlook during the period.

2.2.5 Acquisition of secondary data

Relevant literatures were reviewed and further information obtained from relevant Ministries responsible for the physical planning and development of Uyo.

2.2.6 Determination of air, water and sediment quality in Uyo

a. **Air quality studies:** Air quality checks to determine some air quality parameters were conducted using gas monitors with samples taken between April and October 2009 for the wet season and between November 2006 and March 2010 for the dry season.

b. **Water quality studies:** Level of water pollution in the city was determined from water samples collected from the upstream and downstream of the four water sources in the city and stored in the refrigerator at a temperature of 4±2℃ and later analyzed using standard laboratory procedures.

c. **Sediment quality studies:** Pooled sediment samples collected from the bank and bed of the four streams were analyzed for physico-chemical parameters.

d. **Microbiological studies of water and sediment samples were carried out**

3. RESULTS AND DISCUSSION

3.1 Impact of Urbanization

In 1967, twelve states were created in Nigeria to ensure stability. South Eastern State was one of them. The state was later renamed Cross River State. In 1987, Akwa Ibom State was carved out of Cross River State. At the time Akwa Ibom was created, the area comprised ten Local Government Areas. Today, there are thirty one Local Government Areas and thirty one Local Government headquarters/urban centers. The consequence of the foregoing is large scale human activities that have attracted many people to the urban areas especially Uyo capital city. This has over the years resulted in changes in landuse/land cover. These changes have also resulted in the expansion of the built-up area/baresoil as shown in Figs. 3 and 4. The city has not only changed in size and shape but has also become more compact/dense. This growth pattern has given rise to quite a number of environmental problems which are considered in this study. For example, a critical visual interpretation and comparison of the 1986 and 2007 (Figs. 3 and 4) images of the urban area studied revealed that, the settlement was surrounded by agricultural land/forest [i.e. farm/fallow land as at 1986]. This implies that, the growth [expansion] of the urban areas in 2007 had encroached on valuable agricultural land. This was a serious threat to food production/food availability/food security and sustainable agriculture in the area under study. This also had implications on the climate among other things some of which are considered in subsequent sections of this study.

3.2 Deforestation and Erosion

Researchers have proposed the use of GIS and Remote sensing techniques for environmental monitoring and evaluation of the lower Qua Iboe

River estuary. In this study, the GIS techniques were adopted to monitor and evaluate the consequences of urbanization of Uyo capital city in terms of deforestation and built-up areas.

Alteration of the land due to the removal of vegetation cover is a noticeable sign in the process of urbanization of most Nigerian cities. Uyo, situated in the tropical rainforest belt was once green with a variety of hard tropical tree species such as *Mimusops heckelii, Mammea africana, Milicia excelsa, Nauclea diderrichii, Distemonanthus benthamianus, Brachystegia eurycoma, Pcynanthus angolensis*, etc [14]. Today, those species cannot be seen in the city any more. Few of them encountered in the suburbs are either planted in homestead gardens or in abandoned farmlands. Until recently, the buildings in Uyo city were a combination of modern and traditional mud and wattle houses. Wood is a prominent material in building and construction used for roofing trusses, door panels, furniture and utensils. Timber has been unsustainably exploited to meet the demands of urbanization over the years thus modifying the ecology of vegetation in and around the city of Uyo. Akpan-Ebe and Amankop [15] noted that Akwa Ibom State landscape has been badly devegetated so much that about 70% of the State land area has been changed to derived savanna forming a mosaic of wild palm trees, tall grasses and secondary regrowth in abandoned

farmlands for soil fertility restoration. Uyo, which today falls within the newly derived savannah zone has suffered serious land degradation as an aftermath of indiscriminate exploitation of its floral resources occasioned by urbanization and influx of people into the city. An increase in population will decrease all types of natural resources and result in environmental pollution [16].

The huge floral loss experienced in Uyo resulted from indiscriminate farming even along the slopes of the gaping Uyo ravine which is a severe erosion risk area. Waterleaf (*Talinum triangulare*) cultivation along the slopes to meet the dietary needs of Uyo city dwellers is high. Urbanization and attendant influx of people into the city of Uyo has also exerted considerable impact on the city environment as a result of increase demand for fuelwood and to some extent charcoal. All these have combined to expose the ravine walls to severe sheet and gully erosion that has engulfed the city, sometimes leading to the destruction of lives and properties. High population growth in the urban centres has also resulted in the spilling over of urban residents into the unplanned urban suburbs, thus there is a heavy demand of urban centers on their immediate hinterland which are being exploited to meet urban needs for food, buildings, raw materials and fuel wood [17].
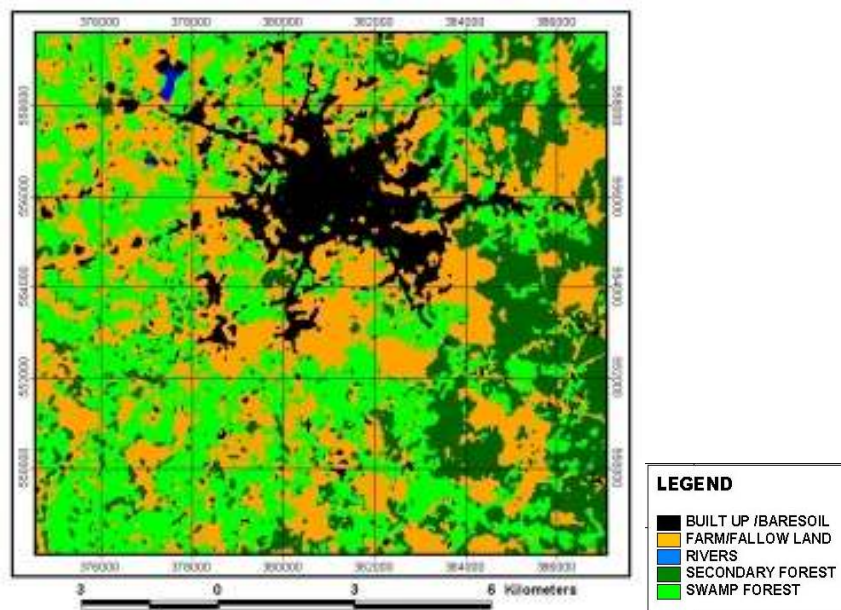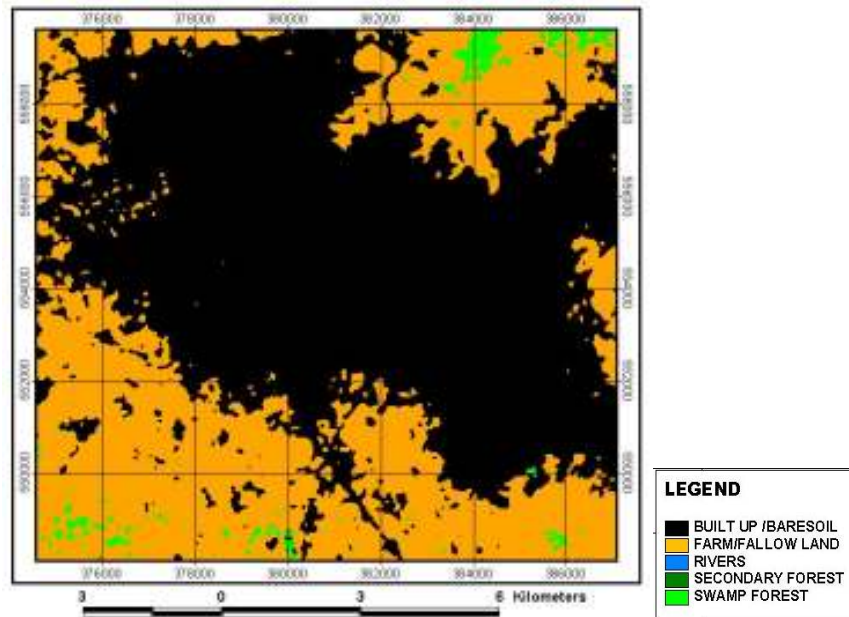

Fig. 3. Built-up area of Uyo urban as at 1986 [1567.8ha]

Fig. 4. Built-up area of Uyo urban as at 2007 [Area=9748.6ha]

Another debilitating effect of ground cover loss in Uyo is the frequent flooding of the city by storm water during the rains. Marshall and Shortle [18] noted that when a parcel of land is converted to urban uses, there are impacts arising from such land uses which may affect the original conversion site with spillover impacts that may be felt at a much larger spatial scale. Conversion of forest land to mixed agriculture and urban development have resulted in the degradation of the environment through floods, accelerated soil erosion and other forms of soil degradation in the built up areas of Cross River basin including Uyo [19]. This is very much true of what is experienced in Uyo and its suburbs. Notable is the vast construction work in Uyo which has decreased the land surface area available for water infiltration after the rains. Such impervious surfaces include asphalted roads and streets with flexible pavements, roof tops, parking areas, side walks, compound floors and drain surfaces. This has given rise to flash floods after a heavy downpour due principally to increase in overland flow, sometimes rising more than one meter above the ground surface at critical areas like Oron Road/Uruan Street junction, Nsikkak Eduok by Oron Road and B Line in Ewet Housing Estate, among others. Ministry of Environment (Uyo) reported that properties worth millions of Naira were lost while 32 families were rendered homeless in Uyo in 2001 by flash flood after a heavy downpour in August. Despite all efforts by

the State Government to control flooding in Uyo, the problem still persists.

The last four years have witnessed the transformation of Uyo both in infrastructural development which, of course, increases the impervious surface of the city landscape, and in landscaping and street tree planting which adds to the aesthetics, greenery and ground cover of the city environment. Flood and erosion control especially with regard to storm water and flash flood is equally receiving attention with the preparation of a comprehensive drainage system for the city by the State Ministry of Environment in 2001 with the first phase tagged "*Nkemba Trough*" which had been recently completed and commissioned.

Despite all the efforts so far put in place, erosion control in Uyo still remains far fetched. The problem has to do with planning, design and construction of the structures and need to be fully addressed by the engineers for a permanent solution to be found. For a start, a comprehensive study on the actual amount of precipitation over some years and the rate of flow of the run-off has to be done to aid in the proper design of the drain channels. Spath [20] asserted that knowledge of the amount of probable maximum run-off quantities from specific areas is the prerequisite for planning and designing any runoff retention, diversion or dispersion

constructions and water harvesting structures believing that it is a first step in controlling the erosion process.

For the control of sheet and rill erosion in arable lands and on undeveloped plots within the urban, the application of the Universal Soil Loss Equation [21] can be very effective. This takes into account local precipitation, soil erodibility, the gradient, field dimension, erosion control practice and land use. The advantage of this method is that it could be applied in almost all types of climate [20]. The Universal Soil Loss Equation (USLE) is given as:

$$A = R\ K\ L\ S\ C\ P$$

Where,

A *is the soil loss in t/ha/annum*
R *rainfall factor*
K *Soil erodibility factor*
L *Length of slope*
S *Percentage of slope*
C *cropping management factor*
P *erosion control practice factor*

For the calculation of the different factors [20,21]. The USLE is an empirical formula based on experience and observation, and so good judgment must be exercised in deriving values for each of the factors [20]. Increasing or decreasing the erosion risk from direct impact of precipitation on the soil will affect the R value either way. In general, the numerical reduction of any of the USLE factors will result in a decrease in sediment load. This will bear a useful application in our effort to check erosion and conserve arable land in and outside Uyo metropolis.

3.3 Waste Management

The concentration of population in urban cities has brought about a plethora of activities which have resulted in the generation of high waste streams in Uyo. Oyediran [22] stated that about 0.43 kg/head of solid waste is generated in Nigeria daily with organic waste constituting 60 – 80%. Waste management appears to be the most intractable problem in the management of Nigerian cities including Uyo. The bulk of the waste generated in Uyo is domestic and biodegradable with a small percentage made up of metal scraps, broken glasses, empty cans and cellophane materials. These have been deposited on major and side streets forming mountains of unsightly heaps. Some are dumped into drain channels obstructing run-off flows causing flood and erosion in the city.

Etuk street and Aka road at the city centre, Ikot Ekpene road by Itam peace column, and Abak road by Udi street have remained environmental flash points where waste have constituted health hazards to the inhabitants of those areas for quite a while. Efforts of government in the management of municipal solid waste in Uyo of recent is yielding fruit although the method of waste disposal in the city is far from conforming with best available practices (BAPs) that is obtainable. Public Private Sector participation (PPSP) approach has been adopted in waste disposal in the city following the failure of institutionalized agency in this regard.

To effectively tackle the waste management problem using the PPSP approach, Uyo has been divided into ten service areas and contracted to private service companies for waste collection and disposal. This is greatly facilitated by the assistance of the Niger Delta Development Commission (NDDC) with the donation of about twenty waste disposal trucks to the State Government. The unsorted wastes are brought from individual households and deposited in the metal waste receptacles placed on the road shoulders from where they are carted into trucks and most unhygienically disposed into the ravine behind the University of Uyo in the city centre. The urban environment now becomes cleaner but the environmental health of the city dwellers faces greater risk from environmentally-unfriendly waste disposal system which can pollute the air, soil and ground water sources. A built-up of toxic metals and compounds may result from the dumping of waste and misuse of some substances in the soil [23].

A successful waste-to-wealth management scheme begins with a detailed study on application, generation, sources, types and quantity of the waste in any given place. So far, no scientific study has been conducted to determine the volume, types and individual household waste stream generation in Uyo. Thus, baseline data are lacking for effective planning of waste management in the city, and this should engage the attention of the State Ministry of Environment as a starting point in effective waste management.

The Streets are strewn with waste droppings from open waste-evacuation trucks during

disposal. This can be overcome by the introduction of domestic waste disposal bags into which individual households will tie their waste and dump same into the waste receptacles placed at designated evacuation points on street shoulders for final disposal by the trucks. The current method of dumping loose waste on the ground is distasteful and unsightly. More waste receptacles are also needed to reduce the distance from individual households to dump site and possibly eliminate the dumping of waste at unauthorized places in the city. The appointment of sanitary inspectors to enforce compliance with laid down rules on waste disposal will bring sanity to the city dwellers. Experience has, however, shown that the inspectors themselves should be closely monitored to avoid compromising standards for pecuniary gains.

3.4 Air Pollution

Bush burning, garbage decomposition, smog and smoke from industries, domestic fires and fume from vehicular emissions lead to building up of noxious gases in urban atmospheres. These pollutants lower the air quality making it unsafe for humans, plants and animals causing air pollution disasters in the process. Air pollution can be defined as the presence in the atmosphere at any given point in time of one or more contaminants beyond the threshold. World Bank [24] defined air pollution as the presence in the outdoor atmosphere of one or more contaminants (such as dust, fumes, gas, mist, odour, smoke or vapour) in such quantities, characteristics and duration as to make them actually or potentially injurious to human, plant, or animal life or to property, or which reasonably interferes with the compatible enjoyment of life and property. In the views of Oyeshola [25], air pollution is said to occur when the atmosphere is over-burdened with gases and chemicals that it can no longer function properly.

In determining the air pollution level of Uyo, air quality checks were carried out. Some of the air quality parameters determined included suspended particulate matter (SPM), Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Hydrogen sulphide (H_2S), Carbon monoxide (CO), Ammonia (NH_3), Chlorine (Cl_2) and Hydrogen cyanide (HCN). The results (Table 1) revealed that the SPM ranged between 818.00 ppm and 925 ppm which is considered quite high against the backdrop of 250 – 600 ppm recommended by the Federal Ministry of Environment. The high

amount recorded may probably be as a result of various road construction projects going on in the city. NO_2 was below the detection limits of the instrument (≤ ≥) and is below the statutory limits allowed by the regulatory agency ranging 75–113 ppm. SO_2 was quite low and ranged between 0.00 and 0.01 ppm as against acceptable limit of 260.00 ppm. NO_2 and SO_2 can therefore be said to be not of any significant influence on the air quality of Uyo. Cl_2 ranged between 0.005 – 0.34 ppm while NH_3 was non-detectable. CO (2.02 – 4.50 ppm) and H_2S (0.00 -3.00 ppm) were considered low when compared to regulatory standard of 10 ppm and 8.00 ppm, respectively. However, an HCN value of 1.00 – 1.50 ppm, though low, was considered unsafe because of its toxicity potential.

The apparent low level of some of the noxious gases sampled had to do with the industrialization and manufacturing status of Uyo. Apart from serving as the administrative headquarters of Akwa Ibom State and Uyo Local Government, Uyo is more or less a commercial nerve centre of the State with virtually little or no industrial activities hence air pollution is minimal.

3.5 Water and Sediment Pollution

Uyo urban environment receives increased storm water runoff especially in the rainy season. This leads to higher periodic stream flow, enlarges the stream channel, causes erosion of the stream banks and increases sediment load of the stream channel which may lead to the drying up of streams especially in the dry season. The few streams found in Uyo receive sediments from gully erosion that has ravaged the ravine environment and so contaminate the water bodies (Tables 2 and 3). Other pollutants include waste loads deposited in the ravine bed, waste oil and other petroleum contaminants washed into the drain channels by mechanics, aerosols, and organic materials from decomposed refuse on land surfaces, sewage water, human faeces, pesticides and inorganic fertilizers from neighbouring farmlands.

Analysis of the water and sediments collected from Atiamkpat River and three others revealed that the microbial counts ranged from 6.2×10^6 to 6.4×10^7 cfuml^{-1} for total heterotrophic bacteria. The percentage crude oil degraders in the samples, though generally low were in most cases below 1%.

Table 1. Mean data for air quality, solar radiation and noise studies in Uyo

Parameters / Location		4		5		6		7		Control 1		Control 2		FMENV recommendation
		UPW	DNW	UPW	DNW	UPW	DNW	UPW	DNW	UPW	DNW	UPW	DNW	
1	SPM ppm	820.0	818.0	900.00	895.0	890.0	925.0	898.10	907.0	703.0	706.0	625.0	680.0	250-600
2	NO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75-113
3	SO_2 ppm	0.10	0.10	0.10	0.10	0.00	0.01	0.10	0.10	0.05	0.05	0.10	0.10	260.0
4	H_2S ppm	1.00	1.00	0.00	0.00	3.00	3.00	1.05	1.00	2.00	1.00	2.00	1.00	8.0
5	CO ppm	4.50	4.00	3.50	3.30	3.50	3.50	2.02	2.10	1.30	1.40	1.00	1.00	10-20
6	NH_3 ppm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	200
7	Cl_2 ppm	0.00	0.05	0.10	0.10	0.25	0.20	0.00	0.00	0.30	0.34	0.00	0.20	-
8	HCN ppm	1.00	1.00	1.00	1.20	1.00	1.40	1.50	1.20	1.00	1.00	1.00	1.00	-

FMENV = Federal Ministry of Environment, UPW = Up wind, DNW = Down wind

Table 2. Heavy metal concentration in sediment samples from water bodies near the proposed information Technology Park Area (µgg⁻1), Uyo

Locations	Cd	Co	Cu	Pb	Ni	Mn	Zn	Cr	V	Tiss	Fe	Ni/V ratio
Ikpa River	0.059	0.174	0.291	0.066	2.271	1.304	3.325	0.02	0.885	<0.01	21.85	2.57
Akpan Mbat stream	0.089	0.049	0.290	0.066	0.260	0.378	1.994	0.01	0.093	<0.01	9.63	2.79
Headwater sediment	ND	0.039	0.018	ND	0.113	0.089	0.129	ND	0.093	ND	1.320	1.36
Normal range in soils/ sediments	0.01-7.9	-	2.0-100	2-100	10-100	200-2000	2-200	-	-	-	50,000-300,000	

Source: AKSG (2006)

Table 3. Total Heterotrophic Bacteria (THC), Total Fungi (TFC) and Hydrocarbon Degraders (HDC) Counts (cfuml⁻1) in water

Sampling points	$THC10^6$	Bacteria HDC 10^5	%HDC	THC 10^4	Fungi HDC10^3	%HDC
A_1	3.1	2.5	8.1	34.0	3.2	0.94
A_2	20.8	11.0	5.3	65.1	1.5	0.23
B_1	35.2	3.0	0.85	28.8	2.1	0.73
B_2	64.0	2.3	0.36	22.4	2.2	1.0
C_1	14.2	2.4	1.7	11.2	6.4	5.7
C_2	12.8	3.5	2.7	15.5	9.6	6.2
D_1	22.2	4.1	1.8	3.8	1.2	3.2
D_2	6.2	3.2	5.2	10.2	2.6	2.6

Note: Sampling Point A = Atiamkpat Stream
B = Adepekpa Stream
C = Etok Idim Itam Stream
D = Edep Udombat Stream

4. CONCLUSION

Urbanization is a welcome development because it contributes to national economic and social development of the city on one hand, but has some devastating ecological consequences on the urban environment on the other hand. The challenges of urbanization therefore are the ability to balance the benefits of urbanization with its negative ecological consequences.

This study has revealed that urbanization of Uyo capital city has had irreversible ecological consequences on the environment. From the satellite imagery maps, the vegetation and land use cover/land use pattern has changed over the years with residential land change increasing rapidly with the lateral expansion of the city. The ecological implications of this increased residential land use pattern are enormous.

Apart from land use/land cover change due to urbanization, other negative consequences of urbanization of Uyo have been identified to include: -

i. Increased waste generation without corresponding increase in efforts to effectively dispose of the waste with best available technologies (BATs).
ii. Increased flooding and erosion within the city due to increased paved/concreted surface areas like tarred roads, markets, filling stations etc.
iii. Increased air pollution due to increased vehicular traffic and expansive road and other infrastructural construction within the city.
iv. Water and sediment contamination due to increased storm water drainage into natural water bodies.

It is important to emphasize that to check the negative consequences of urbanization. Environmental Impact Assessment (EIA) must be carried out. Guidelines for EIA of urban renewal and infrastructural development projects were published by Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment FMENV [26]. It is sad to note that there was no EIA for the urbanization of Uyo and none still for the expansion work still going on in the city. The negative consequences were therefore not mitigated after construction. Revegetation of Uyo through green belts, landscaping of open places and avenue tree planting is strongly recommended, while integrated waste management system should be urgently put in place.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Stiling PI. Ecology, theory and application. Simon and Schhusters. Aviacion Company, University of South Florida. 1996;455.
2. Verma PS, Agarwal UK. Cell biology, genetics, molecular biology, evolution and ecology. S. Chand & Company Ltd. Ram Nagar, New Delhi. 2006;294.
3. Berry BJI. Human consequences of urbanization. The University of Chicago. Chicago; 1973.
4. Uyanga J. Population. In: Peters SW, Iwoh ER, Uya OE (eds.) Akwa Ibom State: The land of promise – A compendium. Gabumo Publishing Co. Ltd. 12A Moris Street Yaba. Falomo, Ikoyi, Lagos, Nigeria. 1994;377.

5. Anon. Akwa Ibom State population results for census 2006 information Buttetin. National Population Commission, Uyo; 2007.

6. NPC (National Population Commission). Population density of Uyo. Information Buttetin, National Population Commission, Uyo; 2006.

7. AKSG (Akwa Ibom State). Physical background, soils and landuse and ecological problems technical report of the task force on soils and landuse survey, Akwa Ibom State, Uyo. 1989;602.

8. Ekpenyong RE, Okoji MA. Guide maps of the University of Uyo and Environs, Department of Geography and Regional Planning, University of Uyo. 1998;20.

9. AKSG. Environmental impact assessment of Akwa Ibom State information Technology Park. Ministry of Science and Technology, Uyo. 2006;175.

10. Jensen J. Introductory digital image processing: A remote sensing perspective, New Jersey: Prentice Hall; 1995.

11. Lillesand TM, Kieffer RW, Chipman JW. Remote sensing and image interpretation. New York: John Wiley and Sons; 2004.

12. Ekpenyong RE. A remote sensing and GIS mapping of land cover change and Erosion Risk in Akwa Ibom State, Southern Nigeria. Unpublished Ph. D Thesis; 2012.

13. MOE (Ministry of Environment). The physical demarcation of the city of Uyo Akwa Ibom State; 2010.

14. FD (Forestry Department). Uyo, Akwa Ibom State, Nigeria Annual Report; 1981.

15. Akpan-Ebe IN, Amankop KS. The dearth of timber and non-timber forest products in Akwa Ibom State In: Udo ES (ed.) Forestry and sustainable environment. Proceedings of the 1st workshop of the forestry association of Nigeria Akwa Ibom State Branch. 2001;44-55.

16. Shukla RS. Chandel PS. A textbook of plant ecology (12th Edition). Chand S, and Company Pvt Ltd. New Delhi. 2015;285-286.

17. Akpan PA. Urban settlements. In: Usoro EJ, A kpan PA. (eds.). Akwa Ibom State: A geographical perspective. Immaculate Publications Limited, Enugu, Nigeria. 2010; 191-214.

18. Marshall EJ. Shortle urban development impacts on ecosystem. Rontledge Publisher, New York; 2005.

19. Udosen C. Gully erosion and cities: An Unwanted Partnership. Faculty of social sciences lecture series, 2014. Department of Geography and Natural Resources Management, Faculty of Social Science, University of Uyo, Nigeria. 2014; 67.

20. Spath haus-joachim agronomic problems in designing water erosion control structures in semi-Arid regions. Applied Sciences and Development. 1979;13: 27-64.

21. Wischmeier WH, Smith DD. Predicting rainfall erosion losses from cropland east of the Rocky Mountains. USDA – ARS Agric. Hab. 1965;282.

22. Oyediran ABDO. War on filth. Archieves of Ibadan Medicine Monograph. 2004;2:42.

23. Ibia TO. Soil, sustainable agriculture, and forestry development. In: Okon E, Brown D, Isichei A, (eds.). Nigerian forest: Protection and sustainable development. Proceedings of JABU environment symposium, Joseph Ayo Babalola University (JABU), Osun State, Nigeria. 2013;80-110.

24. World Bank Environmental Consideration for the Industrial Development Sector, Washington D. C; 1978.

25. Oyeshola D. Politics of international environmental regulations. Daily Graphics (Nigeria) Ltd. Isebo- Alakia Ibadan. 1998;174.

26. FEPA (Federal Environmental Protection Agency). Sectoral guidelines on the Environmental Impact Assessment (EIA) of Urban Renewal and Infrastrural Development. Federal Environmental Protection Agency (FEPA); 1995.

_____