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Review

Geographic information system planning and monitoring best practices for West Africa

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Phenomenal increases in the number and sizes of urban settlements across the West African coastal region are leading to massive reclamation of swamps and destruction of natural ecosystems. Poor urbanization policies, inefficient planning and monitoring technologies are evident. The consequences include some of the worst types of environmental hazards. Best urbanization practices require integrated planning approaches that result in environmental conservation. Geographic Information systems (GIS) provide the platform for integration and processing of multi-sector Geosciences data in order to accurately predict results of different planning options. This paper presents the West African urban environmental problems. Using some concluded studies, it illustrates the functionality of integrating data in GIS for efficient planning and monitoring while calling on the governments of West Africa to adopt GIS based planning for best results.

Key words: GIS, Urban Planning, Urban Monitoring, West Africa, Best Practices, Pollution, flooding

INTRODUCTION

As the cities of West Africa are growing in sizes and numbers, the attendant urban problems are increasing. For years now, West African urban areas have recorded devastating environmental problems including such phenomena as flooding, erosion, pollution.

Many researchers have done quite some work on the West African environment and seem to all point to the same environmental planning as a major issue in handling the environmental problems of urban West Africa. Aderogba (2012) studying recent floods and sustainable growth and development of cities and towns in Nigeria concluded, “More attention has to be paid to urban physical planning”.

Koenig (2009) writing on the challenges of urban growth in West Africa with case study of Dakar, Senegal writes, “Dakar has made substantive efforts to create forward looking plans that take into account the needs and desires of all major groups. However attempts at participatory planning are not always easy to reconcile with grand strategies proposed by important economic and political actors.”

Odufuwa et al. (2012) studying floods in Nigerian Cities concludes, “Impact of floods is more pronounced in low-lying areas due to rapid growth in population, poor governance, decaying infrastructure and lack of proper environmental planning and management.”

Karley (2009) writes, “... for the city (Accra Ghana), there is no evidence that unusual rainfall has been occurring recently that could explain the increased occurrences of flooding being experienced. Rather, the cause of the problem is the lack of, drainage facilities to collect the storm water for safe disposal. These could in turn be attributed to the ineffective planning ...”

This paper proposes that planning of the West African urban environments be made more efficient by integrating geographic information systems (GIS). This

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will enable Urban Planners and policy makers to consider best practices options for the conservation of the urban environment.

The aim of this paper is to propose to West Arican urban planners and policy makers to adopt the best practices methods and technologies offered by the Geographic Information Systems for the sustainable development of the West African environment. The objectives of the paper include: i) to highlight the growing environmental hazards in West Africa due to poor planning of the environment using other research papers; ii) to reference concluded research works in demonstrating that more efficient urban areas result from integrating geosciences data on a GIS platform in different areas of designs and planning for the urban environment; iii) to highlight immediate identifiable areas where GIS may be used in environmental planning and monitoring and iv) to call on policy makers, planners and governments of West Africa to adopt these best practices for the conservation of the West African Urban environment.

URBANIZATION PRACTICES AND PROBLEMS IN URBAN WEST AFRICA

A United Nations report on population growth in the urban centers across the world in the 21st century (Ginkel, 2008), projects that it is expected that by 2030, half of all of Africa's population will live in urban centers. However, the implication of this growth includes the increased pressure on natural resources, and the environment, in order to provide more infrastructures such as housing, water, transport, electricity, schools, etc. The consequences include unprecedented and varied impacts on the environment.

"Since 2007, the flood situation in West Africa is becoming more and more recurrent and the impact on the population and infrastructures is becoming more severe" reports Dieye (2010), for the United Nations Office for the Coordination of Humanitarian Affairs, Regional Office for West and Central Africa (UNOCHA/ROWCA).

The major cities of West Africa lie along the coastal shores of the Atlantic Ocean. Nine of all the 11 countries that line up the shore of the West African coast have their capital cities in the delta swamps by the Atlantic Ocean. It is true that the capital cities of Nigeria and Cote D'Ivoire were later moved away from the coast line to Abuja and Yamoussoukro respectively, the former seats of government and the present business capitals, Lagos, and Abidjan also sit on the coast line. These massive urban settlements are expanding fast. Demand for more land for construction of facilities coupled with citizen poverty across the region is leading to more degrading environmental practices. Ecosystems are being destroyed by efforts that convert the little spaces that can be found anywhere to farm crops for sustenance. Forests are foraged both for fuel wood, and logging to provide timber for new constructions.

Much more seriously is the impact of reclamation of land by both the government and citizens to construct new facilities. A study of the satellite images of the cities will show that the many estuaries, channels, tributaries and mangrove forests that mark the immediate shoreline of the sea are disappearing very fast or have already completely disappeared in these cities. Reclamations are happening in Port Harcourt, Warri, Benin and Lagos Nigeria, Cotonou Benin Republic, Lome Togo, Accra Ghana, Abidjan Cote d'Ivoire, Monrovia Liberia, Freetown Sierra Leone, Conakry Guinea, Bissau Guinea Bissau, Banjul the Gambia, and Dakar Senegal and many other urban centers across the region (Figure 1). The flooding of the urban cities of the West African Coast has now become perennial with its attendant loss of properties and lives.

Several papers such as Atedhor et al. (2010), in "Changing rainfall and anthropogenic-induced flooding: Impacts and adaptation strategies in Benin City, Nigeria", Karley (2009), in "Flooding and physical planning in urban areas in West Africa: situational analysis of Accra Ghana", Integrated Regional Information Networks, IRIN (2009) in "Burkina Faso: Coping with urban flood-displaced", Koenig (2009), in "The Challenges of Urban Growth in West Africa- The Case of Dakar, Senegal", and Aderogba (2012) in "Qualitative Studies of Recent Floods and Sustainable Growth and Development of Cities and Towns in Nigeria" have reported a vast array of the typical urban environmental problems in West African cities. They mostly point to the deficiencies in planning of the urban cities as key in the environmental problems that are about to overwhelm the region.

Federal Ministry of Water Resources and Rural Development Nigeria (undated), writes on a number of urban environmental problems in Nigeria, listing several devastating urban flooding events that have taken place in Nigeria over the years.

On urban resources, the Nigerian Ministry notes: "There is excessive pressure on available urban resources, infrastructure and space, evident in cities such as Lagos, Kano, Port-Harcourt, Aba, Onitsha, Ibadan, Kaduna and of recent Abuja, especially its satellite towns."

The Nigerian Ministry writes further: "Pollution from many industries is a growing problem. In commercial centres like Lagos, Port-Harcourt, Kano, Kaduna, Warri, Aba and Onitsha, coloured hot and heavy metal-laden effluent, especially that from textile, tannery, petrochemicals and paint industries, constitute severe danger to water users downstream."

Federal Ministry of Water Resources and Rural Development [Nigeria] (undated) notes further that, "The following characterise the urban and semi urban centres:

1) The various non biodegradable household petroche-

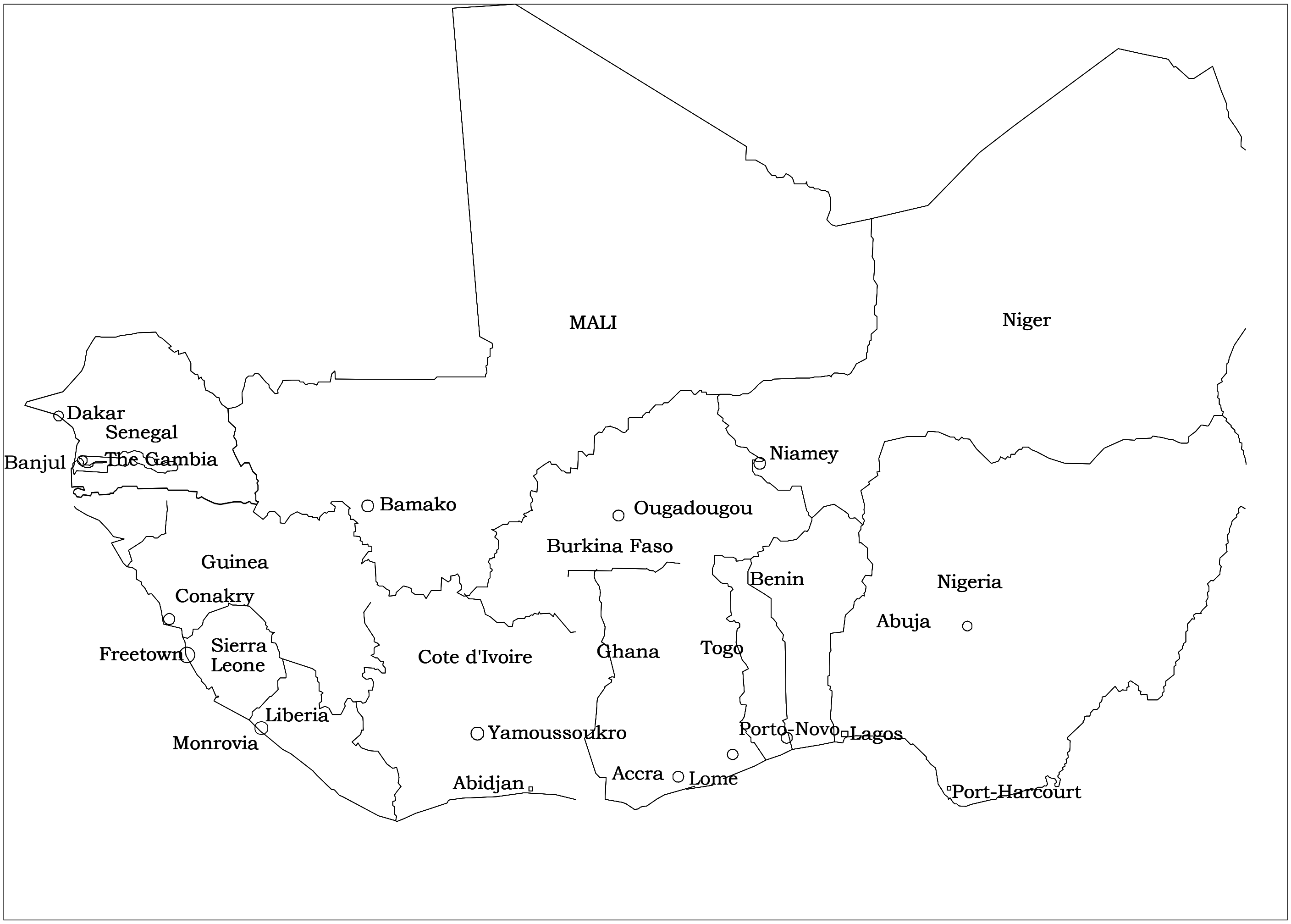

Figure 1. Map of West Africa.

mical products such as polythene bags, plastic containers, foam packages and tyres; and 2) Million litres of crankcase oil disposed from mechanic workshops, industries, power stations and commercial houses are ischarged carelessly into drains and ground surfaces at various locations within the watersheds.

The Soil Erosion and Flood Control Department further writes, “In many cities, plants are no longer used for home landscaping. Example, in Abuja many areas earmarked as green belts are being taken over by corner shops, roads and paved concrete surfaces."

Traditional urban plans rely only on the analogue topographic maps which are laid out on drawing boards. When the Computer Aided Design (CAD) is employed, the approach of the planners is fixed on providing the required facilities. Even when they know the need for conserving the environment they are not equipped to generate the information they require for efficient urban planning decisions. The plan calculations and considerations in these cases focus only on what is visible on the drawing board.

Topographic calculations for drainage installations for instance, follow on the general slope aspect. With today’s digital geospatial analysis tools, this is quite inappropriate. Decisions in urban-planning cannot be based only on what is desired to be provided in the city without looking at the effect on the environment. The Geoscientists should come up with plans that will enhance the natural landscape while compromising only what is inevitable in a sustainable way.

The urban practices already noted in the cited paper were observed with visits to the cities and studied high resolution satellite images across West Africa. Some of such practices include bulldozing of large areas of land, sometimes unnecessarily, to site possibly smaller structures.

There are general increases in industrial waste not disposed adequately. Hydrocarbon pollution and other unhealthy activities are the order of the day in these cities. There may be some exception where the government may have shown some interest in preserving the environment, like in Calabar, Nigeria. But the environmental preservation efforts are actually limited.

Governments across West Africa involve in massive constructions to provide needed infrastructure without taking into account in a scientific way the long term implications on the environment. If the environment does not survive, the humans that depend on the environment will not also survive.

NEED FOR EFFECTIVE URBAN PLANNING

Effective urban planning is a very complex issue and cannot be carried out merely to provide only the facilities humans desire to have in place in their settlements and not consider the full implications of the constructions and the altering of the natural habitat. There is an urgent need to adopt a method for regional planning which provides for integration of data from a wide span of Geosciences, Sociology and Economics to monitor and manage the existing cities and plan the next urban cities, predict the future of the cities and hence consciously channel the growth of the urban areas in a sustainable way. Data required here will be in digital form and would include but not exclusive to those from: i) Up to date topographic maps or surveys, ii) current and archived satellite images over the region of interest, iii) Direct field survey captures such as 3-dimensional coordinates of points, iv) aerial photographs, v) Up to date demographic surveys and maps, vi) Soil surveys and maps, vii) Ecosystem surveys and maps, viii) Land use maps of existing urban areas, ix) Data on the major business occupations especially those that have direct impact on the urban environment, x) Up to date data on the natural and artificial drainage and xi) Storm water precipitation data over the years.

The aims here are to: i) integrate planning at regional levels to take care of, for instance, drainage by subsheds of major watersheds using topographic data, land use and storm water data etc; ii) plan the urban areas to sustain the ecosystems and avoid such phenomena as desertification, gully erosion, and flash floods; iii) predict the growth pattern of the cities and provide for the growthin sustainable ways and iv) monitor the growth to ensure that the plan is adhered to strictly and particularly that people do not encroach into reserved areas to use as refuse dump sites or for construction of illegal structures.

Williams (2000) writes on ecosystem planning, "It is clear that a new way of addressing urban problems is needed and that it will have to be more efficiently integrated, more sensitive to ecology and community, more respectful of uncertainties, and more open to citizen involvement than what now prevails. This has led to an ecosystem approach to planning: 'an approach that begins with an ecologically-bounded area, stresses the integration of social, economic, and environmental factors, and seeks to involve all the relevant interests and power-holders in identifying desirable futures, evaluating alternative pathways and implementing preferred solutions'". The article further outlines basic principles that reflect the characteristics of ecosystem planning as follows:

1) Base planning units on natural boundaries, reflecting ecological functions while replacing a politically-oriented hierarchy of units.
2) Design with nature, and respect human activity and its effect on the environment as well as the limits of resource availability and ecosystem resilience.
3) Consider global and cumulative effects, because a much broader and longer perspective must be considered, like attention to off-site, cross-boundary, intergenerational, and cumulative effects.
4) Encourage inter-jurisdictional decision making, and overcome the present fragmentation and isolation with integrated planning and implementation.
5) Ensure consultation and facilitate cooperation and partnering, involving the widest range of stakeholders effectively and openly in the planning process.
6) Institute long term monitoring, feedback, and adaptation of plans, to assess what happens to communities and ecosystems as plan implementation unfolds.
7) Adopt an interdisciplinary approach to information, by greater information gathering (e.g. ecological capacity and functions), more integration of information, and greater cooperation among information providers.
8) Adopt a precautionary but positive approach to development that aims not just to avoid further damage but also to reduce stresses and enhance the integrity of ecosystems and communities.
9) Ensure that land-use planning integrates environmental, social, and economic objectives, but this depends on the planning body having a firm base of established institutional power to foster multi-interest cooperation and implementation.
10) Link ecosystem planning with other aspects of democratic change, social learning, community building, and environmental enlightenment.

The geographic information system (GIS) is a complex data storage, processing and display tool with inestimable capacities to integrate multi-sectored data in a scientific way. It is GIS that is needed to effectively respond to these many urbanization problems in order to generate the information needed for accurate decision making in urban planning and monitoring.

USE OF GEOGRAPHIC INFORMATION SYSTEM (GIS) IN URBAN PLANNING AND MONITORING

GIS and integration of geoscience data

The geographic information system (GIS) is a computer storage, computing and display system that links inter-related geospatial data through appropriate algorithms, to derive needed information on environmental phenomena and display same in a clearly understandable way. A number of features make the GIS most desirable in handling geospatial matters. The GIS employs the impressive capacities of the computer in storing volumes upon volumes of data, its unrivalled speed in sorting stored data and processing them for needed information. Today, there are in place seamless interfaces for data exchange between the data capture units in the field and the processing computers in the office. The miniaturization of computers with increased computing powers and storage capacities as is in the laptops and palmtops, and the unlimited link between computer systems across the globe through the World Wide Web or locally within the local network, make the system a compulsory necessity if the professional must meet with the demands of high efficiency in today’s world. In the field of Environmental Studies, Urban Planning, Engineering, Surveying and Geodesy, the GIS provides the rare opportunity of combining the perceptibility of graphics with the accuracy of digital computations at great speed. Different formats of data storage and exchange, data processing and information display, are combined in achieving and demonstrating results. For example, in considering the hydraulics of storm- water flow in a watershed, the topography of the land spread, the soil types, the land use and the land cover, infiltration rates and the precipitation rates, are all factors that need to be considered. It is obviously difficult if not impossible to independently derive information on each of the factors over a unit of space considered and to integrate these step-wise over the whole land in an analogue manner, in order to decide for example, how to place drainage to mitigate flooding and erosion.

The GIS displays graphical digital elevation models (DEM’s) and Digital Terrain Models (DTM’s) using elevation and topographic data. The needed land cover or soil type factor in infiltration, and precipitation rate over the land are held in GIS, in form of satellite image data, or map data. The factors influencing storm water runoff flow are integrated by powerful software that drive these complex computations which yield accurate predictions of future possibilities that prove extremely valuable in taking measures to mitigate potential disasters. Additionally, the GIS can handle data over very vast regions beyond what can be laid out on a table at any scale at all. The largest regions can be handled even to the minutest details by the capacity of the computer to organize geospatial data in recognizable spreadsheets and to view information as graphics, coupled with the capacity to zoom in and out on the areas of interest and beyond.

Application of GIS in urban planning

The West African urban centers can no longer be planned just in the traditional form that seeks only to provide facilities needed by humans without accurately determining the consequences of those choices on the environment and allowing alternative options. The use of GIS in urban planning is necessary to provide needed information about the environment of the proposed or existing urban area from a very complex mesh of environmental data. Ginkel (2008), writes "using earth observation and GIS, it will be possible to prepare on time, at much lower cost the optimal direction of urban growth, taking into account the local topography and many other characteristics, to guarantee a sound development of the cities and timely reduction of environmental risks."

Much of the information needed for modern urban planning are products of geospatial data integration and mathematical processing. They are such information that could not be handled independently or purely mathematically without expression in graphical space. For instance in planning a city in a way to preserve habitats, we would most likely be seeking to know what locations and what size of the space hosts a habitat of interest. We may want to know the criteria for choosing the habitat that may be altered for urban use and how the habitat may be altered. All these information are not only displayable on a GIS platform, GIS software are capable to show areas that match prescribed criteria in colour codes. If also it is needed to isolate areas that are up to certain degree of slope, and which are in areas of certain soil types from choice of sites for some facilities, the GIS is instructed by the query tools or scripting instructions. Provided that the background data on the issues in question are integrated by algorithms in the GIS over the area of the proposed or existing urban center, the result of this isolation is displayed on the GIS platform by colour coding. Data required for the slope query is the topographical data. Data required for habitats query is the land cover data. The soil data will provide for the soil type information. Some other very useful data types will include demographic data, rainfall data, land use data. Urban Planners should also be interested in utilities needed to sustain the city. For example what road types are needed for the different areas of the city? Again where will be the most suitable to locate an airport, or university etc considering ecological issues. The GIS also can enable preliminary studies that determine what type of surfacing will be most suitable given for roads given the soil type and rain data.

Availability of GIS data needed for urban planning and monitoring

The GIS data requirements are becoming increasingly available globally. Imagery coverage of the earth at 5 m resolution or higher stands now at nearly 100%. The topography of the earth is fully covered by the Shuttle Radar Terrain Model (SRTM) at 90 m, 30 m and 1 km resolution levels. Other accurate sources of digital elevation data would include all stereo-capable imaging satellites such as SPOT 5. Even though weather conditions change abruptly, GIS has made it possible for weather to be monitored in real time. Weather data have been so monitored that global weather prediction has become a near-totally-accurate science. Satellite weather data are accessible online globally and precipitation rates or volumes are accurately predicted. The Satellite images provide detailed land cover and land use data which are useful in all urban planning exercises all over the world.

The websites for these Satellite data are easily accessible through internet search engines such as Google, Yahoo search, etc. However International Water Management Institute (IWMI) website is an example of sites that warehouse diverse Remote Sensing Satellite data useful for urban planning and monitoring. It also lists a number of web links to important satellite data websites. These include among others:

i) http://www.iwmidsp.org which is a satellite warehouse of sorts.
ii) www.iwmidsp.org for advanced High resolution Radiometric AVHRR satellite data. Cost: Free download. Format: ERMapper.ers
iii) http://free.vgt.vito.bel for SPOT vegetation free download, Format: data binary.
iv) Http://edcimswww.cr.usfs.gov/pub/imswecome/ for MODIS, Terra and Aqua Satellite data, Cost: free. Format: .hdf
v) http://glcf.umiacs.umd.edu/index.shtml for Landsat data of 1970's, 1990's, and 2000's. Cost: Free. Format: GEOTIF or MrSid
vi) http://landsat.org/ for Landsat data. Cost: $50 to $600 per scene. Format GEOTIF
vii) http://glovis.usgs.gov/imgviewer/ or http://edcimswww.cr.usgs.gov/pub/imswelcome for Landsat data of recent and historical times from United States Geological Surveys (USGS). Cost: $450 to $600 per scene. Format: GEOTIF
viii) http://www.spaceimaging.com/ for Landsat (recent and historical) data for commercial sources of Space Imaging: Format:GEOTIF. Costs Approx. $1,000
ix) http://www.spotimage.fr/html/167.php for SPOT HRV data:(Historical and recent) Format:GEOTIF , costs: $2000 for 60km x 60km
x) http://http://glovis.usgs.gov/imgviewer/ or http://edcimswww.cr.usgs.gov/pub/imswelcome/ or http://asterweb.ipl.nasa.gov/ for ASTER data, Format: GEOTIF, cots: approx $50 to $150 for 60km x 60km.
xi) http://eol.usgs.gov/ or http://edcimswww.cr.usgs.gov/pub/imswelcome/ for ALI (next generation landsat data) Format: GEOTIF, Costs: approx $.500 for 100km by 100km.
xii) http://www.nrsa.gov/in/ for IRS LISS data (Historical and recent), Format GEOTIF, Costs: approx. $1,000 for 100 by 100 km.
xiii) http://www.spaceimaging.com/ for IKONOS from Space Imaging, Format: GEOTIF, Cost: 10 by 10km approx. $1500 or more
xiv) http://www.digitalglobe.com/ for quickbird from Space Imaging, Format: GEOTIF, Cost 10 by 10km approx. $1500 or more.
xv) http://www.orbimage.com/index.html Format: GEOTIF, Cost: 10 by 10km approx. $1500 or more.

There are also many other independent sites through which these data can be acquired.

PROPOSALS FOR OPTIMIZING ENVIRONMENTAL CONSERVATION USING THE GIS

Gironas et al. (2007), has proposed a morphological approach in planning urban areas. They note that up to this point, the quantification of changes to the structure of the drainage patterns caused by urbanization has not been developed in detail, and no formal methodologies are used to characterize urban catchments from a morphological and topological point of view. Finally, no special measures in storm water management are being taken in order to imitate natural conditions of the drainage pattern.

In this case, the morphological and topological features of the area of interest should be considered. For instance in planning the storm water drainage, storm water flow from the farthest distances that drain into that area should be considered and taken care of in as natural a way as possible. The urban area planning should not concentrate on the areas of developmental interest only. Every factor that contributes to the functioning of that environment should be considered

The central issues in regional planning are to effectively take care of runoff that may increase as a result of urbanization without causing damage to other habitats and to preserve as much as possible the natural ecosystems.

SOME REPORTED EFFORTS AT GIS BASED FACILITY PLANNING FOR THE WEST AFRICAN URBAN ENVIRONMENT

GIS based urban drainage network design

Chukwuocha (2012) reports on the "GIS based urban drainage network design for Owerri, South East Nigeria". This Ph.D dissertation, reports on drainage design that positioned drainages on the natural flow routes which would effectively drain the watershed subcatchments. Using the GIS, the discrete topographic data of the area was converted into a Digital Elevation Model (DEM). The DEM was then automatically analyzed on the GIS platform to determine the natural drainage routes and the corresponding subcatchments which drained into the determined routes. Needed engineering drainage details such as elevations of the nodes, sizes of conduits that would effectively drain the subcatchments were determined. Simulations were run to ascertain that these drainages would effectively drain the sub catchments.

One big advantage of this GIS based natural drainage route drainage network design ensures efficiency at several levels including the fact that these drainages were located in the best positions that drained the entire sub catchments in a an accountable manner. The method provides needed information in a number of other areas such as the velocity of runoff in each sub catchment which is useful in water-borne diseases studies; the run-off coefficient map of the studied area and so on.

Land use allocation by run - off calculation

When a region is in consideration for urbanization, systematic and scientific approaches should be used in choosing land allocations to the urban facilities. Tang et al. (2005), presents the Runoff MINinimization (ROMIN) model that may be used in sorting between sites for land use allocations. This model compares the soil type of the site in combination with the proposed land use and calculates the resultant runoff.

Comparing different land use options and their runoffs, the minimal runoff land use combination option is adopted. The ROMIN model is quite adaptable for use in a GIS platform. Data and computation of Runoff and decision of the optimal option are automated and in GIS, this can be handled over large regions impossible to be laid out fast in graphical drawing table.

ADDITIONAL POINTS ON GIS BASED URBAN PLANNING

Land use allocation by consideration of existing natural ecosystems

AmphibiaWeb (2010), reports that when amphibian habitat is drained, filled or cut and then converted into parking lots, housing developments or agricultural developments, the natural amphibian habitats are completely destroyed. Habitat alteration occurs when changes made to the environment adversely affect ecosystem function, even if not completely or permanently. An example is when heavy livestock graze in the amphibian environment. These livestock trample on the amphi-bians and other organisms that occur in the aquatic region.

Habitat fragmentation occurs when interlinked habitats are cut apart by land uses introduced between them. Hanski (1999) developed a model for the threshold for metapopulation persistence which predicts that isolated populations are more likely to go extinct in the long run than populations that are slightly connected. With the GIS as a tool we can map the entire region of interest in broad ecosystem groupings. We then consider what optimal areas of each ecosystem grouping must be preserved. The ecosystems must be allowed to link up to more natural unaltered habitats. If habitat destruction must occur, we must employ a gradual process that allows the population to migrate into safer habitats, since the amphibians and of course all other species will have links to other natural habitats.

We should determine what minimum limits of the different habitats that we must not allow urbanization to affect. In GIS, buffering is a toll that enables one to set limits of minimum or maximum distances from a known point or line. Polygonization helps us mark out areas automatically when we have defined the criteria. These tools will be useful in marking out limiting factors of every habitat that we are concerned with. The habitats are also identifiable in satellite images, using certain criteria such as, the predominant plant type, marshiness of environment or otherwise, the topography of the area etc.

Mitigation against urbanization - induced flash floods and gully erosion

GIS-based hydrologic studies and predictions lend so well to the mitigation of flash floods and gully erosions in urban areas.

Lansigan (2007) notes that effective response to these hydrological problems may include:

i) Effective comprehensive land use plan (CLUP) which include the critical areas prone to flooding, landslides and soil erosion.
ii) Regulated land use conversion of lands for urban uses with appropriate provision for adequate drainage system.
iii) Protective management of watershed areas, and clearing of watershed areas and clearing of waterways, rivers and creeks by regular removal of debris that may obstruct smooth flow of water.
iv) Information, education and communication program on flood protection, and response measures at the village-level.

In a paper, Junior et al. (2009) notes the usefulness of the GIS using multi-temporal digital elevation data analysis in studying urbanization-induced gully erosions. These studies are then used in predicting other areas prone to future gullying so that mitigation will be provided. Flood studies must be carried out at regional levels. All areas that drain into the desired urban center or hydrologically connected with it should be considered together. These areas may be vast and can only be handled digitally in a GIS platform.

Integration of vegetative cover in urbanization

The increasing level of urban air pollution has been highlighted. Also, the risk of bare soils due to the scraping of top soil by earth moving machines in urban areas is known to increase the chances of desertification and soil erosion as the soil particles become loose and cake as direct sun heat bakes the particles. Paving of much of the urban areas looks beautiful, but it leads to increase in storm water runoff and runoff velocity and force, hence increasing the potentials for flood disasters and erosions.

It is useful to make policies that encourage the sustenance of green areas in urban areas. One or two average-height trees may be required to be planted in all premises depending on the parcel size. This may mean that the sizes of the parcels allotted for instance for residences will have to be increased, but this should only require policy shift.

Grass lawns and trees planted by the side of paved walkways to increase vegetation life in the cities also help to hold together soil particles and shade them from baking under the sun, while acting as filtering agent of the air pollutants.

Furthermore, the urban planners should incorporate in each layout vegetation areas that must be preserved. The choice of where to locate green areas can also be made in watersheds by setting a given buffer from natural running waters, and marking them out both in the layout plans and on the ground.

GIS BASED URBAN DEVELOPMENT MONITORING

Monitoring urban development is as important as the planning. It is not just enough to plan urban areas, it must be seen that the plans are carefully followed. GIS employing state of the art earth observation and geospatial data capture technology, without doubt are today the most robust and effective environmental monitoring systems in the world. The capacity to detect change in the environment even long before on-site inspectors can see them is particularly very useful in urban development monitoring. The GIS has become an inevitable tool to effectively monitor and accurately predict environmental activities.

In the West African cities, environmental policies are often flouted by desperate developers. The governments obviously do not have the capacity to check every new building sprouting up in every corner. Even when local officials find illegal developments they sometimes get compromised by the developers because the authorities up the line have no means of seeing what is going on at those sites. Building houses across the natural drainage channels or constructions within reserved areas of watersheds are regular occurrences that the governments appear incapable to handle.

Various archived satellite data hold records of the state of a region as the urban area was conceived, the pre-urbanization data. The GIS platform also holds the urban concept in its designed form. As developments continue, more satellite data are captured which record the alterations that are beginning to occur due to the new urban development. These new satellite data records can be matched with the urban plan on a GIS platform to determine compliance with the plan and possibly detect deviations in land use from the plan.

It is also important to monitor the effects of even complying with the new plan. For instance high resolution satellite imagery like IKONOS and Quick bird can reveal flooding where the design had not anticipated it. Unauthorized timbre lumbering can be noticed in forest reserves, or solid waste dumping can be discovered when it has only grown a few meters, and stopped.

Land use/land cover change detection is a key feature of the geographic information system (GIS). When a satellite image or digital area photograph is superimposed over an earlier image, GIS can reveal spots where changes have occurred. The capacity of detecting very small changes is fully dependent on the resolution of the satellite images in use. Every day the resolution of satellite images available in the market are improving. Satellite Imaging systems such as Quickbird, Ikonos Geoeye, WorldView and many others are offering improvements in the already high spatial and temporal f resolution images . For instance new constructions in a reserved area can be discovered in 2 days of the project taking off if the area is monitored by GIS using constantly uploaded WorldView images. Consider the following facts on worldview taken from Mapmart web site:

WorldView-1 Imagery features a high capacity, panchromatic imaging system at half-meter resolution imagery. Operating at an altitude of 496 kilometers WorldView1 has an average revisit time of 1.7 days and is capable of collecting up to 290,000 square miles per day of half-meter imagery. Launched September 18, 2007, WorldView-I has amassed an amazing library of highly-accurate and detailed black and white imagery.

This satellite is also equipped with state-of-the-art geolocation accuracy capabilities and exhibits stunning agility with rapid targeting and efficient in-track stereo collection. This makes for a quick collection of highly-detailed imagery suitable for mapping, feature extraction and orthorectification ground control.

WorldView-1 - 0.5 meter Panchromatic Imagery, Resolution: 0.5 meter Band: Panchromatic only Projection: UTM, Lat/Long, State Plane, Datum: NAD 27, 83, WG 84

Format: Geo TIFF, JPEG, NTIF, Dates: 2007 - presentLAND INFO Worldwide Mapping, LLC (2010) published the following on the WorldView-2 satellite imaging system: WorldView-2, the world's newest high-resolution commercial color imaging satellite, was launched on October 8, 2009 from Vandenburg Air Force Base in California. WorldView-2 is the first high-resolution satellite with 8-Multispectral imaging bands. WorldView-2

Table 1. Technical features of Geoeye and Ikonos.

Satellite feature	Geoeye-1	Ikonos
Resolution	0.50 m	1 m
Blue	450-510 nm	445-516 nm
Green	510-580 nm	505-595 nm
Red	655-690 nm	632-698 nm
Near IR	780-920 nm	757-853 nm
Launch date	06-Sep-08	24-Sep-99
Revisit time	3 days at 40° latitude with elevation > 60°	3 days at 40° latitude with elevation > 60°

will simultaneously collect panchromatic imagery at 0.46m and Multispectral imagery at 1.84m. Due to U.S. Government Licensing, the imagery will be made available commercially as 0.5m imagery. WorldView-2 is capable of collecting up to 975,000 square kilometers of imagery per day (376,000 square miles). The technical features of Geoeye and Ikonos satellite images presented in Table 1 are adapted from Geoeye Inc (2011).

The implication of this is that the West African environment can be monitored to stop illegal reclamations, ecosystem destructions, illegal constructions, and scraping of land surfaces, and illegal lumbering etc. Beyond detecting infrastructural changes, it is possible to detect flooding threats by observing the colour of the water bodies on the satellite images. These colours change with depth of the water body. Integrating the water depth data with weather forecasts is inestimable in predicting flooding.

With 0.5 to 1 m spatial resolution it is possible to detect heaps of refuse being dumped in river banks or other illegal places shortly after they start accumulating. Several other harmful practices to the environment can be monitored using GIS. The long 1m lines of seismic cuttings in the mangrove are visible as grid wire lines. Logging is discovered using the change detection tool of GIS over a time. It is obvious that in the modern West African cities monitoring by GIS is inevitable.

FUTURE WEST AFRICAN URBAN CITIES

Given the improving understanding of the complex problems of urbanization, different approaches are being adopted across the globe to deal with these problems. Debates are also on going on best practices. For instance which is better: to grow a city horizontally or vertically? In horizontal expansion the argument is that lower human population density leads to less human impact on the environment. However some like Ginkel (2008), argue that vertical city growth, where housing in skyscrapers encourage high population density, limit humans from accessing and impacting more environmental space.

The future West African urban cities should be planned with an eye on responding positively to the already noted many urban environmental problems. Training of more personnel on the development and use of the Geographic Information System will be critical in handling the urban planning challenges effectively.

Some of the general points that need to be considered are briefly discussed below:

i) encourage urban cities to be more upland: Given the fact of global warming which is resulting in the overflow of the seas, it is common sense to consider that future cities should be sited on higher grounds than the level of the immediate sea shore where the present West African cities are located. This way the surge of the sea into urban habitations will be mitigated.

ii) Ecosystem planning: Planning of future cities in West Africa should take the factors of ecosystem planning seriously. Such practices such as reclamations, scraping of surfaces, bearing of earth surfaces, paving of entire premises, and disregard for the ecosystems should be discouraged.

iii) Provision of adequate infrastructure: Inadequate infrastructure for the use of the urban community quickly gets worn out and over used due to the pressure of the high population. There is the need to provide adequate infrastructure such as roads, water, sanitation, public transport, housing and electricity and domestic energy in a sustainable way. For the future urban centers of West African urban centers will need to be provided and lack of provision of necessary facilities to serve the urban cities.

iv) Effective drainage systems: The importance of effective drainage systems cannot be overemphasized given the tendencies of the urban cities to flood. Adequate and effective drainage systems should be provided to ensure that storm water runoffs are handled without inducing erosion or flooding. The effective drainage systems design should be carried out taking full consideration of the geomorphology of the area involved and the runoff potentials. For the urban area, the 100- year storm event should be used in calculating runoff.

v) Guided city growth: Urban centre managers must admit from start that the city however planned will outgrow what is provided for initially. Adequate arrangements must be made to manage the growth of the city in such a way that future growths are provided for. It is also to be considered to grow other urban centers so that no one urban area will be under too much growth pressure at any time.

vi) Collaboration among West African governments: West African Urban Planners should group land masses in regions. Normally, regions are quite large, and may incorporate multiple urban settlements, suburbs, rural areas and reserves. For ecosystem planning there is need to integrate some level of general planning by the governments of West Africa. This can be achieved through the Economic Community of West Africa (ECOWAS) or her agency. At this level the aim is to provide policies to ensure that naturally linked up ecosystems are still linked up in the resulting urban plans and that decisions on what should be preserved are taken with the entire region in view.

For optimal use and conservation of the urban environment, planners of urban areas should consider the morphology of the different areas and employ the criteria of environmental homogeneity in grouping areas under regions across a country. This will ensure that measures taken in a region to preserve the environment will have the same positive effect across. It will also provide units for gauging the effect of planning options and decisions. In the developing world, many urban areas are planned in layouts in a strip-wise manner. The detailed planning efforts of providing infrastructures, placing roads, gutters and storm water catchment basins concentrate on the strip of land in consideration. A regional level planning often called master- plan only locates the major roads and railways that will run across the entire region and major features that may serve the region such as military barracks, tertiary healthcare facilities, government centers and airports. Generally, the only scientific criteria considered in choosing the region to locate an urban area, is the extent of land required.

CONCLUSION

Urbanization is the way forward and it will continue as people clog together to offer services to earn their living. Humans cannot however continue to destroy the environment. That should be in the past now. The Geographic Information System offers the 21st century urban areas of West Africa the opportunity to optimize the use and preserve the environment.

Policy makers and urban area monitoring bodies should no longer feel helpless in the face of the rapid growth of urban centers. With GIS, hundreds of squares of kilometers can employ globally attested best practices for satisfactorily planning and monitoring the West African urban environment.

REFERENCES

Aderogba KA (2012). Qualitative Studies of Recent Floods and Sustainable Growth and Development of Cities and Towns in Nigeria. Int. J. Acad. Res. Econ. Manage. Sci. 1(3) ISSN: 2226-3624 http://www.hrmars.com/admin/pics/968.pdf Amphibia Web (2010). Information on amphibian biology and conservation, Berkeley, California. http://amphibiaweb,org/decline/HabFrag.html

Atedhor GO, Odjugo PAO, Uriri AE (2011). Changing Rainfall and Anthropogenic-Induced Flooding: Impacts and Adaptation Strategies in Benin City, Nigeria. J. Geogr. Reg. Plan. 4(1):42-52.

Chukwuocha AC (2012), GIS Based Drainage Network design for Owerri, South East Nigeria", A Ph.D Dissertation, Nnamdi Azikiwe University Awka, Nigeria.

Dieye A (2010), Overview of flood situation in W est Africa in 2010: the role of spatial information management, United Nations Office for the Coordination of Humanitarian Affairs, Regional Office for W est and Central Africa (UNOCHA/ROW CA) Federal Ministry of W ater Resources and Rural Development [Nigeria] (Undated), Sustainable W atershed Management.

Geoeye Inc. (2011). Geoeye and Ikonos Feature comparisonhttp://www.geoeye.com/CorpSite/products-and-services/imagery- sources/Comparison.aspx.

Ginkel HV (2008), Terms, Images and Realities: The future of Urbanization. United Nations University. Hosted at www.merit.unu.edu/archive/docs/.../200905_20090414_vanginkel.pdf

Gironas J, Andrieu H, Roesner L (2007). Alterations to natural catchments due to urbanization, a morphologic approach. http://documents.irevues.inist.fr/bitstream/handle/2042/25294/119_027gironas.pdf?sequence=1.

Hanski I (1999) Metapopulation Ecology. Oxford University Press, Oxford.http://www.un-spider.org/book/5088/4c-challenge-communication-coordination-cooperation-capacity-development

Integrated Regional Information Networks, IRIN, (2009), Burkina Faso: Coping with Urban Flood-Displaced" http://www.irinnews.org/report/87206/burkina-faso-coping-with-urban-flood-displaced.

Karley NK (2009). Flooding and Physical Planning in Urban Areas in W est Africa: Situational Analysis of Accra, Ghana, Theoretical and Empirical Researches in Urban Management Number 4(13) / November 2009, http://um.ase.ro/no13/2.pdf.

Koenig D (2009). The Challenges of Urban Growth in W est Africa: The Case of Dakar, Senegal, Center for African Studies Area Studies, University of Mumbai Vidyanagari, Santacruz (E) Mumbai www.mu.ac.in/arts/social_science/african studies doloreswp .pdf.

LAND INFO W orldwide Mapping, LLC (2010). W orldView-2 High-Resolution Satellite Imagery http://www.landinfo.com/W orldView2.htm

Mapmart (undated), WorldView-1 Imagery, http://www.mapmart.com/Products/SatelliteImagery/W orldView1.aspx?_kk=worldview%20imagery&_kt=4a3df3e7-e137-4887-9874- bf84fadfb8e9&gclid=COyB582ao6oCFQJO4QodrFZwXg

Odufuwa BO, Adedeji OH, Oladesu JO, Bongwa A (2012). Floods of Fury in Nigerian Cities, Journal of Sustainable Development. 5(7) http://www.ccsenet.org/journal/index.php/jsd/article/view/14435.

Tang Z, Engel BA, Lim KJ, Pijanowski BC, Harbor J (2005). Minimizing The Impact of Urbanization on Long Term Runoff (Paper No. 040103). J. Am. Water Resour. Association.https://engineering.purdue.edu/ABE/People/.../minimizing.pdf - United States.

Williams RA (2000). Environmental Planning For Sustainable Urban Development. Proceedings of The Caribbean W ater and W astewater Association 9th Annual Conference and Exhibition at Chaguaramas, Trinidad, October 2000 http://www.bvsde.paho.org/bvsaidis/cwwa9/will.pdf.