# Dynamics in the Landscape and Ecological Services in System I Drainage Area of Lagos

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**Abstract**

*The study examines the implications of urban land uses on hydrological processes and ecological services in system I (OdoIyaAlaro Channel) of the Lagos Drainage Master Plan. Aerial Photography (1965) and Ikonos 2 Imageries (2008 and 2014) were used to assess the land use and land cover changes in a GIS environment. A field survey was carried out to identify plant and fish species within the wetlands. Land use-land cover changes for1965, 2008 and 2014 show that about 80% of the area has been built-up. Based on environmental change projections using precipitation and land use drivers, it is expected that runoff and peak flow will increase by 6.34, 14.24, and 20.36% for a 50 year medium climate change, a 50 year high climate change and a 100 year high climate change respectively. Some of the flora expected to be lost from the wetlands and creeks based on land use changes include Thuja sp and Ficus sp. This would affect some of the ecological services offered by these plants. Effluent discharge from industries is also putting the fish supply at risk, as species such as Sarotherodo nmelanotheron and Liza falcipinnis are reducing. The study advocates a conservation approach for sustainable urban land use.*

**Keywords**: Land Use-Land Cover Change; Wetland; Ecosystem; Urbanisation; Watershed

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## INTRODUCTION

Lagos is one of the fastest growing cities in the world. According to Agboola and Agunbiade (2009), the population of Lagos grew from 1.4 million in 1963, to a total of 3.5 million in 1975. Assessing world urbanization trend for urban agglomerations with more than 5 million inhabitants, the United Nations (2014) put the population of Lagos for 1990 at 4, 764,000. For 2014 the population of the city was estimated as 12, 614,000 while the population projection for the year 2030 was put at 23, 239,000 inhabitants. Similarly, the average annual growth for the period 2010 to 2015 was put at 3.9 percent.

Like the rest of the Lagos metropolis, the catchment of the System I Drainage Basin which is the study location has also experienced a high level of urbanisation as manifested in rapid population growth and increasing economic development within the catchment. The population for Ikeja Local Government Area which makes up a greater proportion of the landmass of the catchment increased from 79,079 in 1931 to 112, 879 in 1952 (Odumosu, 1999). By 1991 the population had increased to 203, 383 inhabitants, while in 2006 the total population had increased to 2006 (National Bureau of Statistic, 2010).

In response to intense urbanisation within the catchment, there has been a significant change in the pattern of land use and land cover in the area. This trend has culminated in a significant reduction in vegetal cover, especially in the extent of the ecologically sensitive wetlands that made up a significant proportion of system I watershed.

Judging by current developmental trends, the remaining wetlands within the drainage area would be subjected to a number of changes. Firstly, the ecological character of the wetland would undergo a number of modifications, including the modifications of some hydrological functions such as runoff, groundwater recharge and discharge, residence time and turn over period (Hollis, 1998, Mitch *et al*., 1994). Secondly, important ecosystem services including provision of medicinal plants, fishes/other aquatic foods, wood for construction purposes, habitats provision and buffer against urban flooding, provided by the wetlands would be adversely affected (Millennium Ecosystem Assessment, 2005). Furthermore, increased hydrological fluxes brought about by intense urban land use change may result in flooding, especially in the face of unguided developments as revealed by the extent of imperviousness within different watersheds in Lagos (Odunuga *et al*., 2012).

Within the study watershed, increased imperviousness driven by land use and land cover changes has resulted in about 18.34 % of the total landmass being used for industrial purposes. Due to the high concentration of industries in this area including Oregun Industrial estate, Ikeja Industrial estate, WEMABOD Industrial area and Agidingbi Industrial area, high volumes of inadequately treated industrial effluent are discharged into System I (Soneye, 2004). The myriad of chemicals introduced into the water body could have negative consequences for the ecosystem services provided by the stream. These may include impaired ability to retain, transform and process organic matter entering the stream (Gibson and Meyer, 2001), and changes in the biotic community structure and functions of the aquatic ecosystem (Emmanuel *et al*., 2008).

Also, a number of studies have demonstrated the dwindling wetland extent in Lagos, especially with respect to land use and land cover changes. Adepoju *et al* (2006) analysed the extent of land use and land cover changes in metropolitan Lagos between 1984 and 2002. The study revealed that while built-up area increased from 47,728 ha in 1984 to 64,656 ha in 2002, forest and agricultural land use decreased from 32, 865 in 1984 to 13, 856 ha in 2002.

In a similar study, Abiodun *et al* (2011) analysed the land use changes in Lagos State for the periods 1984, 2001 and 2005. Their study showed that built-up area increased from 770, 613, 896 $m^2$ to 942, 856, 236 $m^2$ and 974, 725, 556 $m^2$ in 1984, 2001 and 2005 respectively. Extent of vegetal cover declined from 1, 968, 779,938.26 $m^2$ in 1984to 1, 806, 364, 142 $m^2$ in 2001 and 1, 774, 943, 270.10$m^2$ in 2005.

Akpomrere and Nyorere (2012) showed that Ikeja Local Government Area where a larger portion of the watershed lies has undergone a significant level of change. The study showed that in the 1962 the area of vegetal cover was 3, 100.89 ha. By 1994 it had reduced to 305.66 ha, while the 2004 it had further reduced to 283.76 ha. Conversely, built-up area increased from 311.27 ha in 1962, to 3,037.71 ha and 3,232.08 ha in 1994 and 2004 respectively.

Tejuoso (2006) investigated the dynamics of wetlands in the Lower Ogun River Basin. The study showed that between 1986 and 1994 forested wetlands and non-forested wetlands reduced by 3.591 $km^2$ and 0.063 $km^2$ respectively. Between 1994 and 2000, forested wetlands reduced by a further 7.139 $km^2$, while non-forested wetlands decreased by 0.461 $km^2$. Furthermore, the extent of built-up area increased by 2.925 $km^2$ between 1986 and 2004, while between 1994 and 2000 the built-up area grew by 41,113 $km^2$.

Due to the integral role that land cover plays in controlling the hydrologic response of the system I watershed, and the role that land use modification could play in the degradation of ecological services provided by these wetlands, this study examined the implications of urban land use on hydrological processes and ecological services within the drainage System. The study adapted from Odunuga *et al.* (2012) the extent of land use and land cover changes between 1965 and 2008 and assessed the impact of this environmental change on the ecosystem services provided by this urban wetland.

## STUDY AREA

### Location and Extent

The System I Drainage Channel (otherwise known as the Odo-IyaAlaro Channel) is one of the six systems of drainage and flood channels in the Lagos metropolis. The Odo-IyaAlaro Stream is the main natural drainage within the area. The System I Drainage Area (Fig.1) occupies a landmass of about 4235.7ha. Geographically, it extends from about Latitude $6^0$ 33′ 40″N to $6^0$ 36′ 48″N and Longitude $3^0$ 21′ 02″E to $3^0$ 24′ 12″E. The rainfall regime of the study area is bimodal. The first maxima occur between June and July, while the second maxima occur between September and October. Annual precipitation is about 1,800mm. (Odumosu, 1999; Odunuga, 2010).The wetland located within the gorge between Ojota and Maryland is a freshwater wetland (inland wetland) associated with the system 1 drainage area. Generally the relief ranges between 5m amsl and 20m amsl.

The drainage channel traverses Agidingbi, Obafemi Awolowo Way, Oregun Link Road, and Ogudu Bridge. Storm water runoff and wastewater from the channel discharges into the Ogudu Creek, where it eventually empties into the adjourning Lagos Lagoon. The drainage channel is served by eight tributaries and de-floods several places which include Agidingbi, Oregun and environs, Mobolaji Bank-Anthony Way, Ikeja, Allen Avenue, Onigbongbo, Opebi, Ilupeju, Ojota, Maryland, Anthony Village, Mende, Bariga and Pedro..

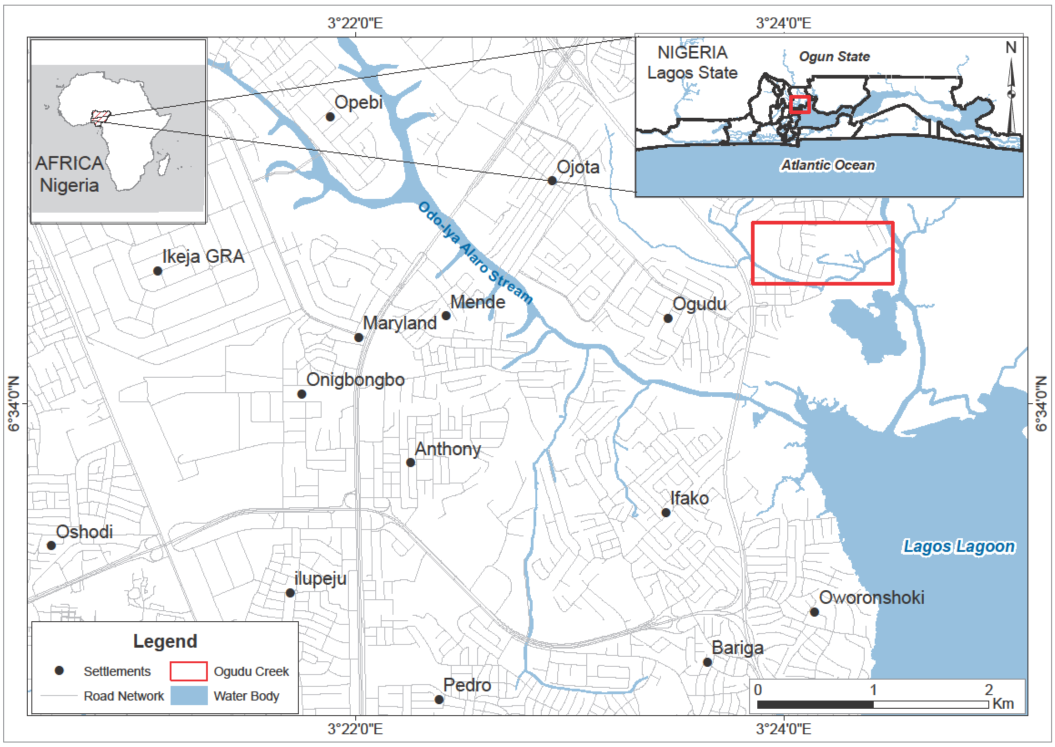


Fig 1: System I Drainage Area of Lagos Metropolis.

## METHODOLOGY

### Land Use and Land Cover Mapping

The study applied remote sensing and GIS tools to conduct urban land use change analysis for the system 1 watershed. Table 1 shows the data sources and their characteristics.

Since the study is on hydrological response and ecological services, land use analyses focused on imperviousness of the land area rather than detailed classification of urban land use change. Also, the period between 1965 and 2008 was not analysed. This is due to high cloud cover for available remote sensing data for the 80s and 90s. However, the trajectory of change in this period was complemented with in-depth discussion with residents who had a long history of residency in the area.

The maps/images for mapping the watershed as it was in 1965, 2008 and 2014 were created from mosaics of sheets of aerial photographs of 1965 and Ikonos 2 imageries of 2008 and 2014 respectively. The overlapping aerial photographs were arranged (mosaic) in a contiguous manner such that the 60% side overlap and 40% end overlap were achieved. This provides a continuous representation of the watershed as it was in 1965.

Table 1: Data Sources and their Characteristics for Land use / Land cover.

| Data Type | Date | Scale / Resolution | Identification | Acquisition Source |
|---|---|---|---|---|
| Aerial Photograph | 1965 | 1:40,000 | | Federal Survey |
| Topographic Map | 1985 | 1:25000 | Ilaro Sheet 279 SE.3 | Lagos State Survey of Nigeria |
| Ikonos Imagery | 2008 | 1 meter | Ikeja / Ketu /Alapere/ Maryland (Lagos) | Geography Department, University of Lagos |
| Ikonos Imagery | 2014 | 1 meter | Ikeja / Ketu /Alapere/ Maryland (Lagos) | Geography Department, University of Lagos |

The aerial photographs were scanned as grey shade to capture the tonal variation and imported into the GIS environment. Geo-rectification and ground truthing of the scanned mosaic aerial photographs to *UTM* zone 31 were conducted using established control points within the Lagos Metropolis Area. In addition to the use of two established control points, readings from an already geo-rectified IKONOS 2 imageries used to map 2008 and 2014 scenarios were also complementarily used for ground truthing. This was achieved by generating several readings of known point features such as channel/stream confluence and road junctions identifiable on both the satellite image and the aerial photographs.

Using the image elements such as tone, texture, shape, association, site, size, pattern (Odunuga and Oyebande, 2007) as well as the local knowledge of the environment, the 1965 aerial photographs as well as the 2008 and 2014 Ikonos satellite imagery were interpreted and vectorized using on-screen digitization in the Arc GIS environment. The zooming facility of the arc GIS allows for in-depth visual expression at a reasonably large scale (Omojola, 1997). Constant scales of 1:5000 were maintained during the mapping exercise for 1965, 2008 and 2015 scenarios. Both the map and distance unit of the arc GIS were set to metre during the exercise. Through these activities, the land use and land cover features of system 1 for 1965, 2008 and 2014 were accomplished. Apart from area calculation of the land use/land cover (LU/LC) for the three scenarios (1965, 2008 and 2014) to generate trend and rate of change, overlays of the generated land use of the period interval (1965-2008) and (2008-2014) were also conducted. This provides information in matrix format on a specific point by point change detection procedure that generates the nature, location and magnitude of the changes.

## Environmental Change Projections

The environmental change projections adopted a simple rainfall-runoff-landuse change relationship approach using the Precipitation Water Inundation Model (PWIM) (Odunuga, 2010, Odunuga *et al*., 2012). PWIM is a simple model that uses an accounting method to determine loss due to infiltration (landuse) changes, the runoff volume and the peak discharge during a storm event. The attractiveness of PWIM stems from its simplicity and parsimony (in terms of the number of parameters), both of which make it a practical rainfall-runoff tool for urban catchment and wetlands. The PWIM has three major components: (1) an Infiltration Component based on Horton's approach (Horton, 1939) which determines the rainfall loss due to infiltration during a storm; (2) a Runoff Component which determines the excess rainfall (i.e., runoff) and peak flow during a storm; and (3) a Digital Surface Component which calculates the surface area within the watershed over which the peak runoff is spread. Using the Runoff Component, the Peak flow was stimulated using PWIM on four rainfall events with total amounts exceeding 45mm, with an intensity of not less than 20mm/hr between June and July 2008. The projection estimated how the hydrological fluxes, especially the peak flow event for the same rainfall characteristics (amount, intensity and duration) will change under different landuse scenarios.

The increment in urbanisation driver was adopted from Odunuga's (2010) analyses of land use changes in the Lagos drainage system. The study investigated urban land use change and developmental activities in central Lagos between 1965 and 2003. A follow up study by Odunuga (2009) reveals that only a marginal increase in imperviousness will be recorded in most parts of central Lagos. This study, however, adopted Odunuga *et al*. (2012), multiplying factors for land use increments in Lagos. Based on the expected marginal increase, multiplying factors for the contribution of the urbanization driver to transforming storm runoff into flood in central Lagos were determined using trend analysis (Odunuga *et al*., 2012). Table 2 shows the multiplying factors for Urbanization drivers in future flood generation in Lagos based on trend analysis of land use developments. For instance, 0.05 (50 years) for a scenario (High) means that flooding emanating from rainfall of the same characteristics will increase by 5% in the next 50 years when compared with the 2008 base year. The increment is a result of an increase in area impervious due to urbanization.

### Identification of Flora and Fauna

A field study was conducted to take an inventory of the different plant species available in the wetlands of the gorge located between Mende, Maryland and Ojota. The plant species were photographed and collected for proper identification in the laboratory. Information on the available species of fishes and other aquatic life within the System I were obtained over a period of one month through observations of catches and interviews with artisanal fishermen. Interviews were conducted with 20 of the fishermen in the form of focus group discussions. This was done with the assistance of community members, who themselves are also involved in the fishing industry.

Table 2: The Multiplying Factor for Urbanisation Drivers (Imperviousness):

| Scenario | 50 years | 100 years |
|---|---|---|
| **High** | 0.05 | 0.75 |
| **Medium** | 0.01 | 0.025 |

## RESULTS AND DISCUSSION

### Land Use and Land Cover Changes

As earlier stated, the land use analyses focused on the extent of built-up and wetland areas. As at 1965, the extent of imperviousness (Built-Up Area) was 321.06ha (7.57%), while the extent of inland wetlands and coastal wetlands was 1840.41ha and 2074.22ha respectively. By 2008, the extent of imperviousness had increased to 3346.20ha, while the extent of inland and coastal wetlands had reduced to 222.37ha and 667.12ha respectively. The increase in the extent of imperviousness is indicative of the conversion of wetlands in the study area to other uses. Table 3 shows the land use analyses of System I of Lagos metropolis while figure 2 shows 2014 land use of the watershed.

Table 3: Land Use Analysis for System I in Lagos

| | **Static Land Use 1965** | | **Static Land Use 2008** | | **Static Land Use 2014** | |
|---|---|---|---|---|---|---|
| Land Use Type | Area (ha) | % Total | Area (ha) | % Total | Area (ha) | % Total |
| Built-Up | 331.06 | 7.58 | 3356.2 | 79 | 3405.23 | 80.39 |
| Inland Wet-land | 1840.41 | 43.45 | 222.37 | 5.25 | 203.9 | 4.82 |
| Coastal Wet-land | 2074.22 | 48.97 | 667.12 | 15.75 | 626.56 | 14.79 |
| Total | 4235.7 | 100 | 4245.7 | 100 | 4235.7 | 100 |

Between 1965 and 2008, the extent of imperviousness increased at an average rate of 70.12ha per annum, while inland wetland and coastal wetland decreased at a rate of 37.62ha per annum and 32.72ha per annum respectively. Also, between 2008 and 2014 there was a further marginal increase of built up area and a continuous reduction in both inland and coastal wetlands was recorded. Table 4 shows the change statistics of land use in the System I Drainage Area of Lagos. In all, the roof cover (built-up area) dominates the spatio-temporal land use distribution of the study area. However, in-depth discussion with residents that have lived in the area for decades shows that the bulk of conversion took place in the 70s and 80s while recent conversion has been marginal.

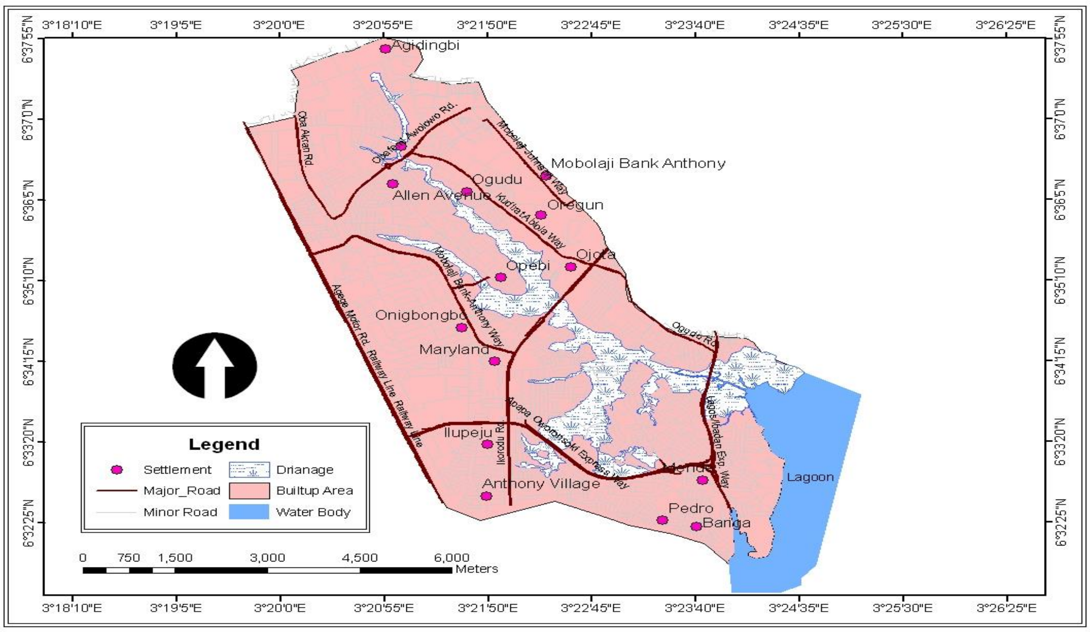


Fig. 2: Landuse at System I Drainage Area of Lagos for 2014

Tables 5 and 6 show the change matrix that describes the nature of land use and changes in land cover between the periods 1965 to 2008 and 2008 to 2014 respectively. The figure, along the diagonals of the tables, represents the areas of land use/land cover classes that have remained in the same locations (representing the relative stability of those classes); all figures along the rows (excluding those along the diagonal) represent losses to land use/land cover classes; and those along the columns are gains to land use/land cover classes.

Table 4: Change Statistics for System 1 in Lagos

| | **Change Statistics** | | **Change Statistics** | |
|---|---|---|---|---|
| Land Use Type | 1965-2008 Area (ha) | Annual Rate of Change | 2008-2014 Area (ha) | Annual Rate of Change |
| Built-Up | 3015.14 | 70.12 | 59.03 | 9.84 |
| Inland Wetland | -1618.04 | -37.62 | -18.47 | -3.08 |
| Coastal Wetland | -1407.1 | -32.72 | -40.56 | -6.76 |
| Total | - | - | - | - |

Table 5: Land Use and Land Cover Change Matrix in System 1 for 1965 and 2008

| Landuse Classes for 2008 | **Landuse Classes for 1965** | | | | |
|---|---|---|---|---|---|
| | | Built Up Area | Inland wetland | Coastal Wetland | Total |
| | Built Up Area | 331.06 | 1618.04 | 1407.1 | 3356.2 |
| | Inland wetland | | 222.37 | | 222.37 |
| | Coastal Wetland | | | 667.12 | 667.12 |
| | Total | 331.06 | 1840.41 | 2074.22 | **4245.69** |

Table 6: Land Use and Land Cover Change Matrix in System 1 for 2008 and 2014

| Landuse Classes for 2014 | **Landuse Classes for 2008** | | | | |
|---|---|---|---|---|---|
| | | Built Up Area | Inland wetland | Coastal Wetland | Total |
| | Built Up Area | 3356.2 | 18.47 | 40.56 | 3405.23 |
| | Inland wetland | | 203.9 | | 203.9 |
| | Coastal Wet-land | | | 626.56 | 626.56 |
| | Total | 3356.2 | 222.37 | 667.12 | **4245.69** |

These results, however, show a general lack of regard for wetlands' fragility and their eco-system services during developmental activities. Also, reduced interception as a result of the removal of vegetal cover, compaction of soil and increase in storm water runoff as a result of increased imperviousness portends negative consequences for the area's hydrology. With respect to the potential impacts on the remaining wetlands, increased storm water runoff, which is a major hydrologic stressor, can lead to a number of conditions, including increased ponding within the wetland, increased water level fluctuation (hydroperiod) and flow constrictions. Increased ponding and water level fluctuation have been shown to aid conditions that contribute to the spread of invasive wetland and dominance of invasive species due to their level of tolerance of hydrologic change, loss of sensitive species and loss of species richness (Azous et al., 1997; Chow-Fraser et al., 1998; Wright et al., 2006, Odunuga, 2010).

## Environmental Change Projections

An earlier study by Odunuga et al. (2012) shows that runoff and peak flow are expected to increase under different environmental change scenarios due to increased imperviousness in Lagos metropolis, including area covered by System I. The projected future impervious areas for different climate change Scenarios are presented in Table 7, while the results of peak flow, based on the integration of precipitation and increase in urbanisation drivers using PWIM, are presented in Table 8. As shown in Table 7, the extent of impervious area will continue to increase, from 3356.20ha in 2008 (the base year) to 3663.88ha under the 100 years High Climate Change (HCC) scenario.

Table 7: Projected Future Impervious Area for Different Climate Change Scenarios

| Drainage Area (ha) | Impervious Area (ha) | | | | |
|---|---|---|---|---|---|
| | 2008 | 50 Years Scenario | | 100 Years Scenario | |
| | Base Year | High | Medium High | High | Medium High |
| 4235.7 | 3356.20 | 3557.99 | 3388.56 | 3663.88 | 3452.10 |

Source: Odunuga *et al*., (2012).

An increase in the Total Impervious Area (TIA) signifies a concomitant increase in the runoff coefficient of the watershed. It has been observed that urbanisation generally increases storm runoff response to rainfall as a result of higher stormwater peaks generated by impervious surfaces. Depending on the extent of imperviousness within an urban watershed, peak flows may increase by a factor of 3 to 8, and runoff volumes by 2 to 2.5 above pre-urbanised conditions as urbanisation progresses (Oyebande, 1990).

Furthermore, peak flow generated as a result of increased and continuous increase in imperviousness within the drainage area is expected to have significant impacts on the hydraulic and ecosystem of receiving water bodies within the watershed. In the case of system 1, frequent high flows within the stream may lead to bank and bed erosion.

Similarly, increased TIA may further increase the vulnerability of watershed to more degradation and the urban stream syndrome. This is because pollutants and suspended matter in the storm water generated in the Contributing Drainage Area (CDA) is likely to change the substrate within the stream, threatening aquatic life forms and modifying or altering biodiversity.

The results of the PWIM peak flows and area inundated for different areas presented in Table 8 show that runoff and peak flow will increase by 6.34%, 14.24%, and 20.36% for 50 years Medium Climate Change (MCC), 50 years HCC and 100 years HCC respectively. On average, area inundated will increase by 2%, 3% and 4% for 50 years MCC, 50 years HCC and 100 years HCC respectively.

A sustained increase in runoff and peak flow as presented in Table 8 portends an increased risk of flooding, especially flash floods within the CDA. A recent example is the 16 hour rainfall event of July 10, 2011, in which some communities around the Mende area of Maryland were inundated and properties worth millions of dollars were destroyed. Under the different scenarios in which runoff and peak flows were simulated, flooding events would be aggravated as a result of lack of maintenance of drainage facilities due to the clogging of drainage systems, and sediments and solid wastes or debris transported with storm water.

Loss of riparian vegetation along system 1 will further worsen flooding in some localities such as Arowojobe within the drainage area. This is because the high hydraulic roughness and flow resistance of riparian vegetation has contributed to the dissipation of kinetic energy of floods. These scenarios also have negative implications for biodiversity in the watershed as flooding and water logging may change habitat conditions for biodiversity, potentially leading to changes in species composition within the remaining wetland area.

Table 8: PWIM Simulation of Peak Flow and Area Inundated for Different Scenario on System I

| **2008 Situation** | | | | **50 yrs HCC** | | | **50 yrs MCC** | | | **100 yrs HCC** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | PWIM RO (mm) | PWIM PF ($m^3/s$) | PWIM AI (ha) | PWIM RO (mm) | PWIM Peak ($Qm^3/s$) | PWIM AI (ha) | PWIM RO (mm) | PWIM Peak ($Qm^3/s$) | PWIM AI (ha) | PWIM RO (mm) | PWIM Peak ($Qm^3/s$) | PWIM AI (ha) |
| 3/6 | 1650.37 | 194.37 | 1150.43 | 1885.60 | 221.87 | 1172.04 | 1754.97 | 206.50 | 1164.58 | 1986.46 | 233.74 | 1179.71 |
| 7/6 | 2345.62 | 276.00 | 1168.73 | 2679.94 | 315.34 | 1194.67 | 2494.29 | 293.49 | 1185.71 | 2823.30 | 332.21 | 1203.86 |
| 13/7 | 4131.00 | 486.08 | 1223.63 | 4719.77 | 555.36 | 1262.54 | 4392.81 | 516.89 | 1249.10 | 4972.26 | 585.07 | 1276.33 |
| 21/7 | 2251.12 | 264.88 | 1157.75 | 2571.97 | 302.64 | 1181.09 | 2393.80 | 281.67 | 1173.03 | 2709.55 | 318.82 | 1189.37 |
| *RO-Runoff; PF-Peak Flow; AI- Area Inundated | | | | | | | | | | | | |

Adapted from Odunuga *et a*l. (2012)

## Ecosystem Services

## Wetlands

An inventory of plant species within the wetland of Ojota-Maryland gorge and the wetland of Ogudu foreshore indicated that the wetlands consist of a variety of flora. The inland freshwater wetland of Ojota-Maryland consists of *Carica papaya, Luffa cylindrica, Ipomoea involucrate, Mariscus alternifolius, Ficus Specie, Eclipta prostrate, Sacciolepis africana, Amaranthus spinosus, Thuja Specie, Musa sapientum and Elaesisguineesis*. The mangrove wetland of Ogudu foreshore consists of *Rhizophora racemora, Avicennia nitida, Cyperus articulates, Cyperus papyrus, Paspalum vaginatum, Achrosticum Specie, Marsilea Specie, Cyclosorus Specie, Ceratopteris Specie, Pandanus candelabrum, Raphia hookeri and Phoenix reclinata.*

The provisioning services rendered by the different species of plants at these wetlands include food, fibre and fuel, biochemical and genetic materials. Details on the ecosystem services provided by individual plant species are presented in Table 9.

Table 9: Ecosystem services of Plant Species

| **Ojota- Maryland Wetland** | | | |
|---|---|---|---|
| **S/N** | **Scientific Name** | **Common Name** | **Ecosystem Services** |
| 1. | *Carica papaya* | Pawpaw | **Medicinal uses**:<br>**Leaves**- used in treatment of ailments such as dengue fever and menstrual pain<br>**Fruit**- laxative and remedy for indigestion<br>**Seed**- used for liver detoxification and treatment of ailments such as pile and typhoid<br>**Latex**: used in intradiscal injection and lowering of blood pressure<br>**Roots**- cure for urinary ailments, dyspepsia and worm expeller<br>**Culinary uses**:<br>**Leaves**- used as meat tenderiser<br>**Latex**- used as meat tenderiser<br>**Cosmetics uses**:<br>**Peel**- sunscreen, anti-dandruff and smoothing salve<br>**Latex**- used in shampoo and face lifting operations<br>**Industrial uses**:<br>**Latex**- used for the treatment of commercial beer in the brewery industry; used for de-gumming of natural silk in the textile industry |

| | | | |
|---|---|---|---|
| 2. | *Luffa cylindrica* | Sponge Gourd/Vegetable Sponge | **Medicinal uses**:<br>- Natural remedy in the treatment of degenerative disorders such as inflammatory disorders and liver diseases<br>**Nutritional/Dietary uses**:<br>-Eaten as edible vegetable<br>**Domestic uses**:<br>-Used as bath and kitchen sponge, shoe mats<br>**Wastewater treatment**:<br>-Serves as adsorbent for the removal of heavy metals;<br>Serves as immobilisation matrix for plant, algae, bacteria and yeast<br>**Other uses**:<br>-Packing and sound-proof linings |
| 3. | *Ipomoea involucrata* | Morning Glory Weed | **Medicinal Uses**:<br>**Sap**- stimulant and remedy for gonorrhoea<br>**Leaves**- treatment of jaundice, localisedoedema, filarial infection, headache and dysmenorrhoea |
| 4. | *Mariscus alternifolius* | Mother Grass | **Medicinal Use**:<br>-Treatment of gonorrhoea<br>**Culinary use**:<br>-Rhizome edible after cooking |
| 5. | *Ficus Specie* | Figs | **Medicinal uses**:<br>-Treatment of ailments such as gastrointestinal problems, asthma, diarrhoea, haematuria |
| 6. | *Eclipta prostrata* | False Daisy | **Medicinal uses**:<br>-Treatment of asthma, body pains, bronchitis and pneumonia, burns, gingivitis |
| 7. | *Sacciolepis africana* | Purple Swamp Grass | Animal forage |
| 8. | *Amaranthus spinosus* | Thorny Amaranth | **Medicinal uses**:<br>-Used as anti-inflammatory, anti-malarial, anti-bacterial, anti-diuretic and anti-viral agent<br>**Nutritional/Dietary uses**:<br>-Serves as vegetable and grains in human nutrition, used forage for livestock |
| 9. | *Thuja Specie* | Giant Cedar | **Construction uses**:<br>-Manufacture of shingles and deck boards, construction of canoes, furniture, ceiling panelling, roof tiles, interior walls<br>**Other uses**: |

| | | | |
|---|---|---|---|
| | | | -Ornamental trees, guitar sound boards |
| 10. | *Musa sapientum* | Banana | **Nutritional/Dietary uses**: -Consumed as desert, vegetable and made into various confections **Energy use**: -Peel used in the making of banana charcoal |
| 11. | *Elaesis guineensis* | African Oil Palm | **Industrial uses**: -Fatty acid derivative used in the production of bactericides, cosmetics, pharmaceuticals and water treatment products; - Used as oleochemicals in the production surfactants, personal care products, cosmetics, agrochemicals, lubricant grease, toilet soap, industrial cleansing, printing ink, polyols and polyurethane; -Biomass (oil palm shells, mesocarpfibres, empty fruit bunches from mills, oil palm fronds and oil palm trunks from field during replanting) serves as raw materials for medium density fibre board, particle board, pulp and paper, plastic composites, bio-compost, used as animal feed, fertilizer, briquettes and feedstock for the production of biodiesel **Culinary uses**: Used as cooking and frying oil and production of shortenings, margarine and confectionary fats |
| **Ogudu Mangrove Wetland** | | | |
| **S/N** | **Scientific Name** | **Common Name** | **Ecosystem Services** |
| 12. | *Rhizophora racemosa* | Red Mangrove | **Environmental Protection/Habitat Provision**: Shoreline protection; enhancement of nearshore environments; soil stabilisation; provides wind break along coastal margins; serves a habitat for a wide range of terrestrial and arboreal wildlife; serves as part of the life cycle of many fish species; plays host to marine species such as periwinkle (Tympanotonuefuscatus), Oysters (Crassostreagasar), Swimming Crabs (Callinenectes Specie), Cockles (Anadarasenilie), Whelk (Thais coronta), and Clams (Tagelusadansornia) **Medicinal uses**: Used for the treatment of angina, boils, and fungal infections, leaves and barks are used as antiseptic and in the treatment of diarrhoea, dysentery, fever, malaria and leprosy **Construction uses**: Used for structural components of traditional houses, cabinet works, tool handles, boat anchors and raft making **Other uses**: Used as animal fodder; wood is used as fishing stakes, spears, copra huskers to use as a source of chips for pulp production; bark and hypocotyls are used to make tannin or dye used in the tanning of leather |
| 13. | *Avicennia nitida* | Black Mangrove | **Medicinal uses**: Bark and leaves are used as a cure for thrush; Resins and seeds are used in the treatment of tumours and ulcers |

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|---|---|---|---|
| 14. | *Cyperus articulatus* | Jointed Flatsedge/ pri-prioca | **Medicinal use**:<br>used as abortifaciant, anti-convulsant, anti-epiletic, antivenin, carminative and contraceptive<br>**Other uses**:<br>Pest control and insect repellent |
| 15. | *Cyperus papyrus* | Papyrus Sedge, Paper reed, matting plant, Nile Grass | Used in the production of ancient writing material; useful in wastewater treatment, roots used as food, fuel and making of utensils, culms or stalks used in early architecture for shelter, boats, sails, mats, baskets, clothes, sandals, cordage, food , in-cense, medicinal ash; flowering heads used as garlands |
| 16. | *Paspalum vaginatum* | Seashore Paspalum, Biscuit Grass | Used for sand dune stabilisation and erosion control in envi-ronmentally sensitive sites; wetland restoration and site rec-lamation on oil and gas well sites; commercial and residential landscaping and sports turf; bioremediation of unproductive soils and forage for cattle and horses |
| 17. | *Achrosticum Specie* | Golden Leather Fern | **Medicinal uses**:<br>Used as antihelmintic and stypic in traditional medicine; used as worm remedy and astringent in haemorrhage |
| 18. | *Marsilea Specie* | European Water Clo-ver | **Medicinal uses**:<br>Relieves ailments like hypertension and infantile diarrhoea<br>**Nutritional/Dietary uses**:<br>Bread making and other culinary uses |
| 19. | *Cyclosorus Specie* | None | **Medicinal uses**:<br>Treatment of ailments like cough, malaria, sores and burns<br>**Other uses**:<br>Used as soap and sponge substitute |
| 20. | *Ceratopteris Specie* | Water Sprite/Water Lettuce, | Fronds are used as vegetable |
| 21. | *Pandanus candelabrum* | Pandanus Palm/Screw Pine/Pandan | **Medicinal uses**:<br>**Bark**- used in the treatment of sore throat, diarrhoea, dysen-tery and enteritis<br>**Leaves**- used in making mats, oil prepared from young leaves used in treating burns<br>**Roots**- treatment of Leucorhoea, abbess, oedema and preven-tion of miscarriage<br>**Other uses**:<br>**Fibres**-used in making cords and brushes |
| 22. | *Raphia hookeri* | Raffia Palms | **Leaves**- used for shelter<br>**Stem**- produces palm sap which is drunk as a beverage<br>**Trunk**- serves as firewood<br>**Ripe Mesocarp**- yields edible oil |
| 23. | *Phoenix reclinata* | Wild Date Palm, Sen-egal Date Palm, | **Construction uses**:<br>**Trunk**- serves as poles for buildings |

| | | | |
|---|---|---|---|
| | | Swamp Date Palm, False Date Palm | **Leaf Rachis**- used as wattle for constructing mud houses<br>**Leaflets**- used for building ties<br>**Leaves**- used as door entrance and covers<br>**Other uses**:<br>**Leaf Rachis**- used as fish traps and hand brooms<br>**Leaves**- serves as fans for stoking fires and fanning insects, sleeping and prayer mats, ornamentation<br>**Leaflet**s- used for protecting or curing diseased mango trees<br>**Roots**- used as insect larvae for fishing |

Agricultural benefits are also derived from these wetlands. At the Mende area of Maryland, the wetlands are used for the cultivation of different crops. A field visit to the area revealed the wetlands are used for the cultivation of different staples, fruits and vegetables including Cocoyam (*Colocasia esculenta*), Plantain (*Musa sapientum var paradisiacal*), Banana (*Musa sapientum*), Sugar Cane (*Saccharum officinarum*), Bitter Leaf (*Vernonia amygdalina*), Red Spinach/Plumed Cock's Comb/Silver Cock's Comb, locally called Soko (*Celosia argentea*), (Fig. 3), and West African Mallow Leaves, locally called Ewedu (*Corchorus olitorius*).

The ecosystem services provided by these wetlands are however being threatened by an increased rate of changes in land use and land cover, as well as global climate change. According to the Millennium Ecosystem Assessment (2005), climate change will not only further worsen the loss and degradation of many wetlands and cause the extinction of or decline in their species, but the human populations that are dependent on their services will also be negatively impacted. Based on the Reactive Global Orchestration and Order from Strength scenarios of the Millennium Ecosystem Assessment (2005), the degradation of these wetlands is expected to increase while the extent of the wetlands is expected to decrease due to increases in human population.

Fig 3: Cultivation of Plumed Cock's Comb at Mende, Maryland Wetlands.

Furthermore, encroachment on or loss of these remaining wetlands would result in the loss of refugia for the biotic communities inhabiting the wetlands. Sedell *et al* (1990) defined refugia as habitats or environmental factors that convey spatial and temporal resistance and/or resilience to biotic communities impacted by biophysical disturbances. Loss of the refugia provided by these wetlands would result in the loss of shelter from fast moving currents, loss of hiding place from predators, and loss of reproduction site (spawning and nursery sites) for aquatic, amphibian and terrestrial life forms. Loss of these wetlands would also mean the loss of an important role of providing refugia for recovery from natural hazards such as floods.

## Fish Supply

Fish supply is an important provisioning service offered by Ogudu creek. The Creek and the adjoining wetlands serve as important fishing source and bird nesting sites. The availability of different species of fish (Table 10) within the Creek is also of immense socio-economic value as these serve as a source of livelihood for artisanal fishermen as well as fish mongers.

Table 10: Fish Species within Ogudu Creek

| Family | Species | Common Name |
|---|---|---|
| Cichlidae | *Tilapia dageti* | - |
| Cichlidae | *Tilapia mariae* | Spotted Tilapia |
| Cichlidae | *Sarotherodon melanotheron* | Blackchin Tilapia |
| Cichlidae | *Chromidotilapia guentheri* | Gunther's cichlid/ Gunther's Mouth-brooder |
| Mugilidae | *Liza falcipinnis* | Sickle fin Mullet |
| Eleotridae | *Kribia Kribiensis* | - |
| Citharinidae | *Citharinus latus* | Moon Fish |
| Monodactylidae | *Psetias sebae* | - |
| Mochokidae | *Synodontis ocellifer* | Ocellated Synodontis |
| Bagridae | *Chrysichthys aluuensis* | - |
| Elopidae | *Elops lacerta* | West African Lady Fish |

Source: Field Survey

Interviews conducted at the Ilaje fishing community (at Ogudu) where most of the fishermen are resident revealed that most of the community members are engaged in the fishing industry. The men are mostly fishermen, while the women are mostly fish mongers. Average daily catch of fish is reported to vary according to the type and size of fish caught. Based on interviews conducted with the fishermen, a small sized basket of *Sarotherodon melanotheron*

(Blackchin Tilapia), (Fig 4) which weighs between 6 and 7kg is sold for a dollar equivalent of between $15. 15 and $21.21, while a big basket is sold for an equivalent of $48.48.

Fig 4: Blackchin Tilapia from Ogudu Creek.

Responses from the fishermen revealed that there has been no extinction of any fish species in the creek. Rather, there has been a decline in the quantity of different species of fish caught over the years. Another complaint of the fishermen is that their fishing nets sometimes get entangled by water hyacinth and debris from refuse dropped in the creek.

The biotic integrity of this aquatic ecosystem is however being threatened by different anthropogenic activities, especially the discharge of industrial effluents from nearby industrial establishments and domestic waste and sewage from settlements along the creek. This situation renders the fish species within the creek vulnerable to bioaccumulation and biomagnification of pollutants such as heavy metals and synthetic organic contaminants that might be present in the industrial effluents, rendering them unsafe for human consumption. The polluted status of the creek is evident in the proliferation of water hyacinth (*Eichhornia crassipes*) and other floating aquatic weeds such as *Pistia* and *Vossia cuspidate*. Indiscriminate discharge of improperly treated industrial effluents has the potential to adversely affect the survival and physiological activities of fishes and other aquatic organisms (Baby et al., 2010). Similarly, changes in water quality as a result of pollution may lead to loss of fish species, which could result in significant shifts in the ecosystem dynamics (UNEP GEMS, 2008).

## RECOMMENDATIONS AND CONCLUSION

The study has brought to the fore the implications of urbanisation and environmental change on the hydrological processes and ecosystem services provided by the System I Drainage Area of Lagos metropolis. In the light of the changes that have taken place in the area, there is a need for a review of the Lagos Master Plan to promote environmental and natural resource conservation. The remaining inland wetland should be gazetted as a conserved urban ecosystem that should not be developed. With regards to the adverse hydrological impacts of urbanisation, a multi-disciplinary approach via the integration of structural and non-structural measures is strongly recommended. The drainage design should take into cognizance anticipated peak flow as computed using the PWIM for different scenarios under climate and land use dynamics. Furthermore, the expected increase in runoff and peak flow under the different climate change scenarios calls for the maintenance and improvement of the existing drainage system. The use of wetland for urban agriculture as identified in the study should be sustained and encouraged. Due to observed decline in quantity of fish caught, sustainable fishing practices including wetland fish breeding and other innovative technologies should be adopted. This will further enhance the wetland ecosystem services without damaging the tangible and intangible environmental values of the wetlands. Also recommended is an awareness campaign and education on the hydrological and ecological benefits of wetlands as well as the implications of wetland conversion into built up area. Lastly, there is a need for the strict enforcement of policies including those protecting wetlands in Lagos.

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