LAGOS

The Lagos Megacity

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CHAPTER 1
Introduction

Geography

Lagos State is located on the south-western part of Nigeria on the narrow coastal flood plain of the Bight of Benin. It lies approximately between longitude 2° 42’ E and 3° 22’E and between latitude 6° 22’N and 6° 42’ N. It is bounded in the North and east by Ogun State of Nigeria, in the West by the Republic of Benin, and in the South by the Atlantic Ocean. It has five administrative divisions of Ikeja, Badagry, Ikorodu, Lagos Island and Epe which were subdivided to 20 Local Government Areas (LGAs) during the creation of States and LGAs in Nigeria in 1999. Presently, there has been a creation by the State Government of 37 Local Council Development Areas (LCDA) in addition to the 20 LGAs making a total of 57 Local government administrative units. Territorially, Lagos State encompasses an area of 358,862 hectares or 3,577 sq.km which is about 0.4 percent of the total land area of Nigeria (Figure 1).

Lagos State has a coastline 180 km long. Underlain by sedimentary rocks; it is on a coastal plain characterized by predominantly flat terrain, with an average elevation of less than 15m above sea level. The land slopes gently from the interior to the sea. Water bodies and wetlands cover over 40% of the total land area of the State with lagoons and creeks consisting 22% of its area. An additional 12% is subject to seasonal flooding. The coastal areas consist of lagoons, creeks and swamps separated from the open sea by a strip of sandy land that varies in width from two to sixteen kilometres. The entrance into Lagos Lagoon is the only major outlet through which the lagoons and creeks drain into the sea (BNRCC, 2012).

The dominant vegetation of the State is the tropical swamp forest consisting of fresh water and mangrove swamp forests both of which are influenced by the double rainfall pattern of the State, which makes the environment a wetland region, hence, the reference to Lagos as an environment of aquatic splendour. Its wetland environment is characterized by rich alluvial and terrallitic red-yellow soil, on which would be found dense luxuriant undergrowth, climbers, epiphytes and tropical hard woods (LASG, - www.lagosstate.gov.ng –Information for Visitors).
History

Lagos State was created on 27 May 1967 by virtue of Decree No. 14, which restructured Nigeria’s Federation into 12 States. Prior to this, Lagos Municipality had been administered by the Federal Government through the Federal Ministry of Lagos Affairs as the regional authority, while Lagos City Council governed the city. Equally the metropolitan areas (colonial province) of Ikeja, Agege, Mushin, Ikorodu and Epe were administered by the Western Region. The State took off as an administrative entity on 1 April 1968, with Lagos Island serving the dual role of State and Federal Capital. However, with the creation of the Federal Capital Territory, Abuja in 1976, the capital of Lagos was moved to Ikeja. Equally with the formal relocation of the seat of the Federal Government to Abuja on 12 December 1991, Lagos ceased to be Nigeria’s political capital. Nevertheless, Lagos remains the nation’s economic and commercial capital.

Demography

The population of Lagos State by the 2006 National Census conducted by the National Population Commission was 17,552,942. The initial discrepancy between the Federal and State Governments has been harmonized through appropriate legal adjudication. Going by a population growth rate of 3.2 percent, the projected population for the State in 2015 is 23,305,971 (Bureau of Statistics, 2013).
Megacity: A mega-city by definition is a continuous urbanized area with population of at least 10 million people (UNCHS, 1996). Development in Lagos State is so rapid that the metropolitan area has expanded and absorbed the once rural communities. Hence Lagos can be best described as a City – State. The population of the State has been above 10 million people since the 2006 National census. Lagos State therefore qualifies to be called a megacity - a Lagos megacity. Some four LGAs of Ogun State, adjoining Lagos State have fused in to Lagos State forming Lagos Megacity Region (LMCR). In terms of water issues – water supply, waste water and storm water, these four LGAs have a lot of impact on Lagos State. In this monograph, the Lagos megacity not the Lagos megacity region will be the bone of discussion.

Lagos megacity contains urban, semi–urban and rural communities, though rapid expansion and development is changing the distribution rapidly. Urban areas are those with a population greater than 20,000, semi-urban areas are those with a population of between 5000 and 20,000 while rural areas are those communities with a population of less than 5000. Figure 2 shows the classification of communities in Lagos megacity in 2011. It shows 32.5 percent of the communities to be urban areas.

**Figure 2: Classification of Communities in Lagos Megacity, 2011**

![Figure 2: Classification of Communities in Lagos Megacity, 2011](image)

Source  Digest of Statistics, 2013
CHAPTER 2
Water Resources

Institutional framework

Nigeria is a Federation with 36 States and the Federal Capital Territory. Water comes under concurrent legislation. Institutional arrangement as emphasized by the National Water Policy responds to the vision of equal distribution of water resources between consumers without compromising the environmental requirements and those of future generations. A major institutional approach in Nigeria is that of co-operative governance which recognizes that while many governmental functions are undertaken on national, state and local levels, there must be a commitment to co-operation between each level.

The institution responsible for water resources management at the Federal level is the Federal Ministry of Water Resources (FMWR). Other Ministries and Agencies of the Federal Government have some form of involvement or the other in the sector.

In Lagos State, the Water Sector is guided by the Lagos Water Sector Law (2004) and Lagos State Water Sector Policy (2013). The Lagos State Water Sector, as with other Sectors, has a Governance framework that stands on a tripod in accordance with the Principles of Integrated Water Resources Management and international best practice. These are:

- Policy development, formulation review, monitoring, and evaluation,
- Service Provision; water supply and sanitation/wastewater management and
- Regulation.

These three activities though related and intertwined, are actually independent and are the responsibilities of separate and identifiable Ministries, Departments and Agencies (MDAs) of Government. While the State Ministry responsible for the Environment is responsible for Policies and all matters relating thereto, Lagos Water Corporation (LWC) and the Lagos Wastewater Management Office (LSWMO), other State Agencies and the Private Sector undertake Service Provision while the Lagos State Water Regulatory Commission (LSWRC) is responsible for Regulation. Regulations are rules made by a Government Authority to control conduct either by prescription or directive to achieve a stated objective. Rural water supply is the preview of the Ministry of Rural Development.
Regulation of the Sector

The Lagos State Government has identified the need to institutionalize a Regulatory framework to create governance for ordering activities in the State Water and Sanitation/Wastewater Sector. The overarching Objectives of regulating the Water and Wastewater Sector Include:

- Production efficiency and minimized costs
- Allocation efficiency and prices reflect costs
- Sustainability and cost recovery/return on capital, reliability and availability
- Fairness and level playing field (one regulatory regime for public and private providers)
- Improved access to Service for all and sustained development.

Ground water is unregulated in Nigeria. Boreholes are therefore drilled indiscriminately, with inadequate data collection and storage, and no limits to amount of water to be extracted. The Federal Ministry of Water Resources in conjunction with the Standards Organization of Nigeria (SON) has drafted a Code of Practice for Water Well Construction in Nigeria (SON, 2010). The code is yet to come into operation. Lagos State Water Regulatory Commission has also produced a Lagos State Groundwater Development Regulations - DRAFT – whose implementation is about to commence.

History of Institutional History of Water Development and Management in Lagos (LWC, 2011, Jideonwo, 2014)

- Potable water supply in Lagos started in 1910 with Iju water Waterworks (capacity of 9160 m³ per day) plus ND 700mm trunk main “A” commissioned in 1915 to serve Lagos Island
- Iju upgraded to 27,277 m³ per day with trunk main “B: ND 600 mm to serve Lagos Island, Apapa and Ebutte-Meta.
- Further expansion of Iju works in 1954 to 50,007 m³ per day with third trunk main “C”, ND 1050 mm constructed in 1962 expanding coverage to residential/industrial areas of Ikeja, Ikorodu Road via east of metropolis.
- Iju modernization in 1982 to 204,574 m³ per day to boost pressure in existing mains with additional 10 mini waterworks (Capacity 11,183 m³ per day)
- Isashi waterworks commissioned in 1977 to serve west of metropolis – Isashi, Satellite Town to FESTAC town.
- Adiyan Phase 1, constructed and commissioned in 1992 under the Lagos Water
Supply Expansion project with 80 km trunk mains and other secondary and tertiary mains and connections.

- 12.15 MW Independent Power Plant for Iju, Adiyan and Akute.
- Construction of Micro Waterworks

Alongside these since 1980 have been provision of water schemes by the construction of boreholes through National -, and State programmes and others such as the Millennium Development Goals, Constituency Projects of Legislators at National and State levels, Local Governments and Private Companies and individuals

**Climate**

Lagos has a tropical wet and dry climate. It experiences two rainy seasons, with the heaviest rains falling from April to July and a weaker rainy season from September to November. There is a brief relatively dry spell in August and a longer dry season from December to March.

Rainfall varies from one location to the other in Lagos Megacity. Data obtained at six different locations in the megacity in Table 1 illustrates the variation. The average rainfall for the years 2000 to 2012 is shown in Figure 3 (from www.worldweatheronline.com/lagos-weather-averages/lagos/ng.aspx)

**Figure 3**

![Average Rainfall (mm Graph for Lagos)](image)
TABLE 1: RAINFALL IN LAGOS STATE IN 2013.
(Lagos State Ministry of Environment)

<table>
<thead>
<tr>
<th>Month</th>
<th>Alausa, Ikeja</th>
<th>Meran</th>
<th>Badagry</th>
<th>Igbonla, Epe</th>
<th>Badore, Lekki</th>
<th>Igbogbo, Ikorodu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>JAN</td>
<td>45.21</td>
<td>46.23</td>
<td>17.018</td>
<td>17.02</td>
<td>21.08</td>
<td>17.02</td>
</tr>
<tr>
<td>FEB</td>
<td>74.17</td>
<td>31.24</td>
<td>12.95</td>
<td>59.18</td>
<td>32.77</td>
<td>36.58</td>
</tr>
<tr>
<td>MAR</td>
<td>118.62</td>
<td>76.45</td>
<td>39.12</td>
<td>19.56</td>
<td>16.76</td>
<td>14.73</td>
</tr>
<tr>
<td>APR</td>
<td>209.80</td>
<td>104.65</td>
<td>97.03</td>
<td>79.50</td>
<td>111.00</td>
<td>78.23</td>
</tr>
<tr>
<td>MAY</td>
<td>139.19</td>
<td>138.43</td>
<td>126.49</td>
<td>57.66</td>
<td>99.57</td>
<td>60.71</td>
</tr>
<tr>
<td>JUN</td>
<td>435.10</td>
<td>305.56</td>
<td>261.62</td>
<td>144.02</td>
<td>182.37</td>
<td>124.97</td>
</tr>
<tr>
<td>JUL</td>
<td>525.53</td>
<td>384.30</td>
<td>284.48</td>
<td>201.68</td>
<td>312.67</td>
<td>221.74</td>
</tr>
<tr>
<td>AUG</td>
<td>132.59</td>
<td>254.25</td>
<td>135.38</td>
<td>75.69</td>
<td>52.32</td>
<td>50.29</td>
</tr>
<tr>
<td>SEPT</td>
<td>101.09</td>
<td>70.61</td>
<td>256.54</td>
<td>43.69</td>
<td>46.23</td>
<td>96.01</td>
</tr>
<tr>
<td>OCT</td>
<td>36.07</td>
<td>14.48</td>
<td>176.53</td>
<td>48.01</td>
<td>23.37</td>
<td>71.88</td>
</tr>
<tr>
<td>NOV</td>
<td>65.28</td>
<td>43.43</td>
<td>52.07</td>
<td>54.36</td>
<td>56.13</td>
<td>29.46</td>
</tr>
<tr>
<td>DEC</td>
<td>44.20</td>
<td>45.21</td>
<td>26.16</td>
<td>24.89</td>
<td>76.45</td>
<td>26.92</td>
</tr>
<tr>
<td>TOTAL</td>
<td><strong>1926.84</strong></td>
<td><strong>1514.86</strong></td>
<td><strong>1485.39</strong></td>
<td><strong>825.25</strong></td>
<td><strong>1030.73</strong></td>
<td><strong>828.55</strong></td>
</tr>
</tbody>
</table>

Highest value of 1926.84 mm was obtained at Alausa, Ikeja with the least value of 825.25 mm being obtained at Igbonla near Epe.

With its high mean annual rainfall, Lagos Megacity has abundant water resources in the form of surface water (rivers, lagoons, lakes and creeks) and groundwater. The major surface water bodies are the Lagos-, Ologe – and Lekki - lagoons. Others are Kuramo Waters and Badagry-, Five Cowries- and Omu -Creeks. The major rivers are Ogun, Yewa, Aye, Owo, Oworu and Osun (Figure 4).
The groundwater is contained in four aquifers in the sedimentary basin: the first and shallow aquifer, is the Recent Sediments along the Atlantic Sea coast and along river valleys. It is used for very small private domestic supplies through dug wells and shallow boreholes. The second and third aquifers are in the Coastal Plains Sands Formation. They are exploited through dug wells in places, shallow - and deep - boreholes (maximum depth of 300 m at the coast). These aquifers provide substantial quantities of water for private-, public- and industrial–water supplies. This is the main aquifer exploited in Lagos megacity. The fourth aquifer is the deep and highly productive Abeokuta formation. Only a few boreholes located mainly in Ikeja industrial area, extract water from the fourth aquifer. The water from this aquifer is hot with temperatures as high as 80 °C recorded in a few of the boreholes (Coode Blizard Ltd et al, 1966). This aquifer is undergoing massive development in adjoining Ogun State in recent times where it is encountered at shallower depths of between 300 to 550 m. Figure 5 is a north – south geologic cross-section showing various Formations in the sedimentary basin. In Figure 6, a hydrogeologic cross-section from west to east along
the coast shows both the lithologic and water quality variations in the Coastal Plains Sands and Recent Sediments.

Figure 5: North – South Hydrogeologic Cross – Section of the Benin Sedimentary Basin;
The estimated available water resources in Lagos Megacity are given in Table 2.
CHAPTER 3
Infrastructure

Water Supply

Public water supply in Lagos megacity is undertaken by the Lagos Water Corporation. In rural areas of the city as well as peripheral areas, the Ministry of Rural Development provides water from boreholes mainly through standpipes and to a lesser extent piped distribution. The water supply equation is completed with inputs from Federal Government of Nigeria and its agencies, the LGAs / LCDAs, Corporate bodies through their Community Assistance Programmes (Corporate Social responsibility) and Private

<table>
<thead>
<tr>
<th>S/N</th>
<th>Type</th>
<th>Quality of Water</th>
<th>Source</th>
<th>Safe Yield (Mm³/d)</th>
<th>Surface Area Km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Surface Water</td>
<td>Fresh</td>
<td>Ogun River</td>
<td>2.092</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>Oshun River</td>
<td>0.207</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>Yewa River</td>
<td>0.1889</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>Aye River</td>
<td>0.11271</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>Owor/Solodo</td>
<td>0.0944</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Brackish</td>
<td>Lagos Lagoon</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>Badagry Creek</td>
<td>200</td>
<td>(part in Benin Repu.)</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>Lekki Lagoon</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td>Ologe Lagoon</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Ground Water</td>
<td>Fresh</td>
<td>Groundwater</td>
<td>Modeled aquifer through put</td>
<td>650,000 m³</td>
</tr>
</tbody>
</table>
Individuals. In Lagos, the total water demand is estimated at 2.452 million cubic metres per day (Mm$^3$/d) using per capita water demand at 0.136 m$^3$/d. Water production by the Lagos Water Corporation is 0.9534 Mm$^3$/d (LWC, 2011). The demand gap of 1.498 Mm$^3$/d is met by individuals mainly through dug wells and boreholes (Table 3). Industrial water supply demand and to a lesser extent agricultural demand are not included in this estimate. Industrial water supply is predominantly if not fully from groundwater. The water from the Lagos Water Corporation is of good quality and conforms to the Nigerian Standard for Drinking Water Quality (NSDQW) for potable water at the point of production. Quality impairment does occur as the water goes through the transmission system and usage (home –point of usage).

**Table 3: Lagos Megacity Water Supply Baseline Data - 2010**

<table>
<thead>
<tr>
<th>S/N</th>
<th>Parameter</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Population</td>
<td>18 million</td>
</tr>
<tr>
<td>2</td>
<td>Production</td>
<td>0.9534 Mm$^3$/D</td>
</tr>
<tr>
<td>3</td>
<td>Water Demand</td>
<td>2.5416 Mm$^3$/D</td>
</tr>
<tr>
<td>4</td>
<td>Demand Gap</td>
<td>1.4982 Mm$^3$/D</td>
</tr>
</tbody>
</table>

From LWC, 2011.

Production of potable water by the Lagos Water Corporation is mainly from the surface water sources as shown by the data for 2012 (Bureau of Statistics, 2013)

**Figure 7: Average Daily Water Production by LWC in 2012**

Spatially however, more people depend on groundwater than surface water in Lagos megacity. This is illustrated by 2010 survey data on the predominant source of potable water supply in the whole megacity.
In order to meet the demand gap, Lagos Water Corporation has developed a Lagos Water Supply Master Plan (2010 – 2020) which outlines into the short, medium and long term infrastructure development programme (Table 4) to address:

Development of new schemes

- Sustaining current operational assets with a sustainable management plan.
- The goal stated in the Master Plan is to supply water to all residents of the Megacity by December 2020.

Table 4: Water Supply Sector Realities (LWC, 2011)

<table>
<thead>
<tr>
<th>S/N</th>
<th>ITEM</th>
<th>QUANTITY (Mm³/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Operates 11 Service Arena</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3 Major Water Works</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i. Adiyen</td>
<td>0.324</td>
</tr>
<tr>
<td></td>
<td>ii Iju</td>
<td>0.218</td>
</tr>
<tr>
<td></td>
<td>iii Ishashi</td>
<td>0.218</td>
</tr>
<tr>
<td>4</td>
<td>24 Mini Waterworks</td>
<td>0.253</td>
</tr>
<tr>
<td>5</td>
<td>19 Micro Water Works</td>
<td>0.09</td>
</tr>
<tr>
<td>6</td>
<td>Transmission Mains (ND 2000 – 600 mm)</td>
<td>180 km</td>
</tr>
<tr>
<td>7</td>
<td>Distribution Mains (ND 500 – 75 mm)</td>
<td>2215 km</td>
</tr>
</tbody>
</table>
As a coastal and highly industrialized State, water resources in Lagos megacity faces huge pollution challenges. Two of these are from:

**Salt water intrusion**

Salt water occurs in the lagoons and during the dry season extends considerable distance in to the rivers flowing in to the lagoons. This necessitated the construction of a weir on the Ogun River near the intake of the Lagos Water Corporation at Akute in Ogun State. Salt water also occurs all along the coastline and has caused many boreholes and wells to be abandoned. Salt water intrusion in aquifers is not restricted to the coastline but goes far inland in the valley of the River Ogun (Oteri, 2013, AGR and GWD & ENG LTD, 2011). Figures 5 and 6 above illustrate the variation of saline water in the Coastal Plains Sands aquifer. Water supply in the coastal belt including highbrow areas of Ikoyi, Apapa, Victoria Island and parts of Lekki Peninsular is adversely affected as most inhabitants cannot afford to drill deep boreholes in to the fresh water aquifer underlying saline water aquifers. A 30 m deep borehole at Agiliti in Kosofe LGA of Lagos (sample 14, Table 5 below) shows the chemical analysis data. The water is brackish and the borehole was abandoned. They are therefore restricted to the shallow fresh water aquifer overlying the saline zone which is polluted by soakaways, septic tanks and contaminated water in drains. Climate change will adversely enhance saltwater intrusion in to surface – and ground – water

**Oil Pollution**

Pollution of groundwater from underground storage tanks in petrol stations and storage tanks in factories and homes has been reported in Nigeria in general and Lagos in particular. Leakage which is thought to be mainly due to vandalism of the petroleum product pipelines from Atlas Cove at the sea coast to the Nigerian National Petroleum Corporation pipeline Depot at Mosimi Ogun State has given and is giving rise to extensive contamination of groundwater along the pipeline route. At Baruwa, groundwater pollution of the aquifer occurred in 1994 affecting an area of 81.4 hectares (AGR, 2005). The maximum thickness of floating hydrocarbon on water was 0.65 m. Figure 9 shows samples of products recovered from dug wells in Baruwa.
One and half kilometres to the south of Baruwa is another groundwater hydrocarbon pollution plume at Diamond Estate, on LASU Road, Isheri–Olofin., which was first reported in 2010 (The Guardian, 2010). Hydrocarbon product floating on groundwater also occurs. In both cases, remediation is yet to be carried out. Many of the affected residents have no access to public water supply and cannot use their groundwater through dug wells or boreholes. Many of the affected residents have no access to public water supply and cannot use their groundwater through dug wells or boreholes.

**Waste Water**

Lagos has no main sewerage system apart from a few scattered treatment plants within its housing estates and at the Secretariat. This poor sanitation situation is compounded by the frequent and severe flooding affecting many areas (World Bank 2006). Sewage disposal from domestic sources in Lagos megacity is predominantly through the use of septic tanks as shown in Figure 10 from a household survey as published by the Lagos State Bureau of Statistics in 2013 but reported by Department of Water and Sanitation (LSMRD, 2015).
Disposal and management of waste water and sewage in Lagos megacity in the past was characterized by disposal of raw sewage into the Lagos lagoon and other surface water bodies (Awomeso et al, 2010). Waste water from industrial premises were sent into the drains without treatment or monitoring. All these have changed or are changing gradually. The Lagos State Waste Management Office (LSWMO) was excised from the Sewage department of the Office of Drainage Services, Lagos State Ministry of The Environment in 2010. Since then it has aggressively pursued the rehabilitation of old waste water treatment plants (WWTPs) and construction of new ones. The WWTPs at three Housing Estates have been rehabilitated while a new 25 million litters per day WWTP is being built at Odo Iya Ro near Ojota and eight more planned are for other Government Housing Estates. LSWMO also has gone into Public Private Partnership arrangement with some firms to construct and operate treatment plants. Many Private and Government organizations and companies have built or rehabilitated WWTPs. Aggressive public enlightenment on waste water disposal and construction of the best type of septic tank for differing terrain is on-going through radio and television. Overall, the total functional waste water infrastructure has increased from 0.04 to 6% due to the upgrade of existing Lagos Megacity owned WWTPs.

Regulation and monitoring of waste water from industries in Lagos megacity is under the preview of the Lagos State Environmental Protection Agency (LASEPA). The Agency is saddled with the responsibility of maintaining a healthy environment through adequate regulatory mechanism. These industries have been mandated by law to have preliminary treatment plants in their premises but a lot of them have not complied and those that have often bypass the treatment processes due to its high operation cost (LASG, 2013).
The pollution of surface water by industries in the past is illustrated by the case of Abuja / Igbo -Agbowa creek polluted by waste water effluent from a Textile factory.

Samples 1 – 3 in Table 5 illustrates the impact of the effluent on the water in the river. The effluent is coloured, acidic (low pH) and high value of electrical conductivity, total dissolved solids, biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Samples 4 to 7 show the chemical characteristics of waste water from some industries in Lagos. These are found to have low pH, high values of COD and Bod as well as higher than normal heavy metals.

**Solid Waste**

Solid waste management in Lagos has been the responsibility of the Lagos State Waste Management Authority (LAWMA) since 2005 with a significant upgrade of its mandate in 2007. Prior to 2007, the waste management operations were inadequate resulting in Lagos being one of the dirtiest cities in the world. The situation has drastically changed with good to very good refuse collection system in close to 70 percent of the Megacity. The megacity now wears a new look. By the statistics, 4,171,899 metric tons of solid waste were deposited in five landfill sites in Lagos Megacity in 2012. LAWMA also operates three (3) Transfer Loading Stations in addition to smaller satellite disposal sites. It has also gone into added services such as recycling of wastes and production of gas from the sites. However, the landfill sites are not sanitary landfills. Contamination of ground water has been detected in a number of the landfill sites such as Olusosun, Solous and Abule Egba. In a groundwater contamination studies carried out on the Solous dumpsites ( The Project Team, 2014), evidence of contamination by the leachate in the form of high values of Chloride, BOD, COD and heavy metals of private boreholes used for domestic water supply was found.
Table 5: Physicochemical Properties of Water around Lagos State

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Palapo</th>
<th>Abuja</th>
<th>Oripodi</th>
<th>Oba Akran</th>
<th>Adeniyi Jones</th>
<th>ACME</th>
<th>Odogunyan</th>
<th>Badagry</th>
<th>Ibeju</th>
<th>NBL PLC</th>
<th>Shomolu MWW</th>
<th>Eredo</th>
<th>Ikorodu</th>
<th>Agiliti</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ibeshe River, Ibeshe</td>
<td>Ikeja</td>
<td>Ikorodu</td>
<td>Dug wells Recent</td>
<td>CPS Aquifers</td>
<td>ABK Formation</td>
<td>Recent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source</td>
<td>Waste outlet</td>
<td>Discharge @ Lagoon</td>
<td>Waste Industrial Effluents</td>
<td></td>
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<td>1.61</td>
<td>5.95</td>
<td>6.30</td>
<td>5.2</td>
<td>5.85</td>
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<td>Temperature</td>
<td>28°C</td>
<td>28°C</td>
<td>28°C</td>
<td>28°C</td>
<td>31.5°C</td>
<td>30°C</td>
<td>35.35°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity</td>
<td>µS/cm</td>
<td>170</td>
<td>305</td>
<td>540</td>
<td>18.65</td>
<td>32.23</td>
<td>349</td>
<td>24.2</td>
<td>109.5</td>
<td>190.</td>
<td>90.9</td>
<td>65.2</td>
<td>105.5</td>
<td>410</td>
<td>2338</td>
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<tr>
<td>TDS</td>
<td>mg/l</td>
<td>80</td>
<td>155</td>
<td>60</td>
<td>18.65</td>
<td>32.23</td>
<td>349</td>
<td>24.2</td>
<td>109.5</td>
<td>190.</td>
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<td>65.2</td>
<td>105.5</td>
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<td>44</td>
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<td>68</td>
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<td>96</td>
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<td>150</td>
<td>1034</td>
<td>642</td>
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<td>Chloride</td>
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<td>Copper</td>
<td></td>
<td>0.23</td>
<td>0.26</td>
<td>4.5</td>
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<td></td>
<td></td>
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</tr>
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<td>Lead</td>
<td></td>
<td>0.05</td>
<td>0.5</td>
<td>0.5</td>
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<td></td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td>11.93</td>
<td>5.22</td>
<td>3.41</td>
<td>1.25</td>
<td></td>
<td></td>
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<td>Total Iron</td>
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</tr>
</tbody>
</table>


CPS – Coastal Plains Sands Aquifer, ABK – Abeokuta Formation, Recent – Recent Sediments. TDS – Total Dissolved Solids, DO – Dissolved Oxygen
COD – Chemical Oxygen Demand, BOD – Biochemical Oxygen Demand.
Samples 1 – 3: Surface water samples, Samples 4 – 7: Industrial effluents, Samples 8 – 14: Groundwater samples
Storm Water

Most parts of Lagos megacity are low lying with high water table which in some areas along the coast less than 0.15 m below ground level. In 2011, Lagos was submerged in flood due to water released through the Ogun and Oyan Rivers in Ogun State into Lagos megacity as well as unprecedented rain intensity which combined to flood many parts of City (Aderogba, 2012). Some of the causes of floods here are:

- Blocked canals
- Inadequate drainage canals
- Non-compliance with environmental laws
- Planlessness
- Encroachment on drainage channels
- Maintenance of drains
- High tide and Ocean/ Lagoon surges
- Photographs of some of the storm water drainage channels taken in September 2015 are shown below:

![Figure 12: Photographs of storm drainage channels in Lagos.](image)

The Ministry of The Environment is making serious efforts at effective flood management.
Economy

Nigeria is Africa's most populous country with a population of over 170 million. Lagos megacity is the nation's economic nerve centre with over 2,000 industries. 65% of the country's commercial activities are carried out in the megacity. Two of the nation's largest seaports - Apapa and Tin-Can Ports are located in Lagos megacity and a new one is planned for the Lekki Free Zone. The Business News (2014) stated that Lagos Megacity is arguably the most economically important State in the country. Research has proved that Lagos megacity is set to become the continent's 13th biggest economy, with a per capital income set at about $2,900 which is currently double the amount of the national average of $1,700. According to the Punch Newspaper (2015), the GDP of Lagos megacity is estimated at $91bn. The Executive Governor of Lagos State Mr Akinwunmi Ambode, is reported to have in August 2015 declared that the GDP of Lagos State has hit US131bn, which is per capita of US$5620.87 (Ayinla, 2015).

Lagos megacity has as many as 200 different slums with two out every three people living in slums (Jideonwo, 2014, Akanda and Hossain, 2012, Lawanson, 2008). Monthly Household income brackets in Lagos are as follows (1 US$ = N198.54)

- Low Income - Less than N50,000
- Middle Income - N50,000.00 to N100,000.00
- High Income - Above N100,000.00

From a survey of three Local Government Areas, Oloke et al (2013), found 49 percent were Low income earners, 28 percent were Middle income earners with 23 percent were High income earners.

The Lagos Water Corporation charges a very low tariff, much lower than what is charged by the Cross River State Water Board Ltd, which operates a Public Private Partnership and much lower still than Private Water Supplies in Lagos Megacity. Table 6 compares the tariffs charged by the different organizations (LWC, 2011, ORTECH, 2007)
Table 6: Comparison of Water Tariffs Charged (1 US$ = N198.54)

<table>
<thead>
<tr>
<th>ORGANIZATION OR AGENCY</th>
<th>UNIT</th>
<th>COST PER UNIT</th>
<th>COST PER LITRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagos Water Corporation</td>
<td>m³</td>
<td>50 Naira (N)</td>
<td>0.05 Naira (N)</td>
</tr>
<tr>
<td>Cross River State Water Board Ltd (Nigeria)-Industrial</td>
<td>m³</td>
<td>150 Naira (N)</td>
<td>0.150 Naira (N)</td>
</tr>
<tr>
<td>Cross River State Water Board Ltd (Nigeria)-Domestic</td>
<td>m³</td>
<td>100 Naira (N)</td>
<td>0.10 Naira (N)</td>
</tr>
<tr>
<td>Private</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ikeja</td>
<td></td>
<td>30 litres</td>
<td>50 Naira (N)</td>
</tr>
<tr>
<td>Ikorodu</td>
<td></td>
<td>30 litres</td>
<td>30 Naira (N)</td>
</tr>
<tr>
<td>Baruwa</td>
<td></td>
<td>30 litres</td>
<td>30 Naira (N)</td>
</tr>
<tr>
<td>Victoria Island</td>
<td></td>
<td>25 litres</td>
<td>70 Naira (N)</td>
</tr>
</tbody>
</table>

Main Trends and Forthcoming Issues

Water issues (water supply, waste water and storm water) have experienced upward trend in the last 16 years and the prospect are that advancement will continue to be recorded in tackling the challenges and meeting set targets. Many of the problems bedevilling the sector have been identified and development being pursued aggressively. Public enlightenment is in top gear.

In water supply, short-, medium-, and long-term infrastructure development programmes in the Lagos Water Supply Master Plan (2010 – 2020) have been outlined and are being pursued. However, for this to be successful the issues of management structure of the Lagos Water Corporation and water tariff among others will have to be tackled. The over-reliance of the future water sources on surface water especially desalination of brackish water, with regards to energy shortfall and cost in Nigeria are other concerns. The Lagos Water Corporation has a poor record of operating and maintaining groundwater schemes in an environment where most Industries and Private Housing Estates exploit groundwater for their water supply. The record of groundwater schemes by other government Ministries, Departments and Agencies (MDGs) is worse than that of the Lagos water Corporation.
Waste water treatment and central sewage facilities are still rudimentary. The Lagos State Waste Water Management Office is aggressively developing and running this sector. New laws are now in place for Estates and big establishments to build and operate WWTPs. It is unlikely that a central sewage system can be constructed covering large percentage of the megacity in the next 10 to 20 years.

Though Lagos is a low lying city with high water table especially along the coastal belt that is prone to flooding, a lot has been achieved by the Government in the last few years. Drainage master plans have been produced for most of the city and efforts enumerated above are being vigorously pursued to ensure flood – free megacity.

Two issues that can throw the spanner in the works in the development and management of water issues in Lagos megacity are:

1. Climate change – Climate change in form of rising sea level, and or higher rainfall as well as higher sea surges can have a negative impact on water issues in Lagos megacity especially water supply and flooding.

2. Development in Ogun State – Ogun State surrounds Lagos megacity in the north and east. All the rivers coming in to Lagos megacity come through Ogun State. Very rapid urban development is going on in Ogun State. Factories, Housing estates and towns are springing up whereby forests in recharge areas of the aquifers exploited in Lagos are being turned to paved cities and roads. Uncontrolled drilling and exploitation of the aquifers is going on in Ogun State and these could negatively affect Lagos megacity. There is a need for both States to work together in developing and sustainably managing the water resources in the two States.

On the positive side, development, both industrial, agricultural and urban are increasingly taking place in Ogun State. Unfortunately, planning is absent in this development.

The Role of Civil Society Organizations

The Role of Civil Society Organizations (which includes Women, youth groups) is well articulated in section 4.2.6 of the National Water Supply and Sanitation Policy (2000), which stipulates that NGOs shall make use of their presence and acceptability in the community to complement government efforts in promoting sanitation programmes especially health and hygiene education. In particular, the NGOs shall be involved but not limited to the following:
1. Advocacy and mobilization

2. Health, hygiene education and sanitation promotion in the community

3. Development of community sanitation programme

4. Training & capacity building of the community

5. Developing communication materials that are easily understood and accepted by the community

6. Sourcing and providing necessary finance for projects

7. Bridging existing gaps between government and communities

8. Working with lead government agencies to ensure generation and consolidation of relevant data
Part B

Water Specific Problems in Lagos Megacity

Water specific problems in Lagos megacity include the following:

A. Water Supply
   i. Poor water infrastructure and utility performance – This involves the production of insufficient quantity of water by the Lagos Water Corporation (LWC).
   ii. Quality impairment due to unplanned layout of most consumers to the distribution network necessitating the running of water distribution pipes along gutters and drainage channels over long distances from the consumers’ houses to LWC network.
   iii. Many of the mains pipes are old and rusty.
   iv. Unreliable power supply
   v. Inadequate and poor water storage and supply infrastructure
   vi. Low tariff charges
   vii. Poor operation and maintenance culture

   These issues have been fully discussed by LWC, 2012; Oyegoke et al, 2012; Jideonwo, 2014 and Ohwo, 2014.

B. Waste Water.
   i. Very poor sewage and sanitation infrastructure
   ii. Ensuring proper treatment and disposal of industrial effluent from both major and small industrial enterprises before being released to the drains and surface water sources 24/7
   iii. Proper maintenance and operation of waste water treatment
   iv. Public awareness of need for proper disposal of domestic waste water
v. Availability of land for provision of waste water treatment infrastructure
vi. High operational and maintenance costs

Vii Technical under capacity and Lack of lending facilities to investors coupled with high investment costs.

Figure 13 is a photograph showing the Alausa State Secretariat Wastewater Treatment Planted upgraded in 2010.

**Figure 13: Alausa Ikeja Upgraded Wastewater Treatment Plant**

C. Storm Water
   i. Blocked and Insufficient number of drains
   ii. Maintenance of the drainage system
   iii. Planning – Land use planning eg establishment of industries like Abattoirs and building on River floodplains

**Climate Change and Lagos Megacity**

Lagos State is likely to experience significant negative impacts as a result of climate change. The risks are particularly high as a result of its long coastline, flat topography, high water table, growing population and a heavy concentration of gross domestic
product (GDP) generating industry and infrastructure near the coast. In addition, sea-level rise and repeated storm surges will worsen the problems of coastal erosion that are already a menace in the Niger Delta, while the associated inundation will increase problems of floods, intrusion of sea-water into fresh water sources and destroying such stabilizing system as mangrove, and affecting agriculture, fisheries and general livelihoods (LSMOE, 2012). Likely impacts of climate change are:

i. Projections of climate change suggest that Lagos State will experience a slight increase in rainfall, a slight increase in rainfall variability and a temperature rise of about 3° C by 2100 (Triple “E” Systems and Pennsylvania State University, 2010).

ii. Similar studies by the Climate Systems Analysis Group of University of Cape Town and commissioned by the Building Nigeria’s Response to Climate Change (BNRCC, 2011) indicates a 2° C increase by the year 2065 and of 3.5 ° C by the end of the century for southern Nigeria. Rainfall increases are also projected, with a peak increase of about 2 mm/day in monthly rainfall in the 2046-2065 period in various communities throughout Lagos State, which means that they will be more affected if the quantity and quality of water and/or its accessibility change as a result of climate change.

iii. In addition, some communities as a result of being low-lying, may be flooded and submerged thereby resulting to migration and food security.

iv. BNRCC (2011), also projected wetter rainy seasons (ie high intensity rainfall associated with flooding) and drier dry season (meteorological drought). Occurrence of more frequent intense floods will cause damage to water infrastructure.

v. Sea level rise of about 40 cm by the year 2050 in the Lagos area. Lagos State would be exposed to increased erosion, storm damage, inundation in low lying areas, and intrusion of salt/sea water into groundwater aquifers and estuaries.

vi. Over-abstraction of groundwater resources in some locations to meet the increasing demand of the rapidly growing population and industry are likely to lead to sea water intrusion and land subsidence.

Strategy to Combat Climate Change in Lagos Megacity

Lagos State Government has listed the key elements of the State’s existing strategy to combat climate change and are as follows (LSMOE, 2012):

1. Launching a public awareness and sensitization programme to educate Lagosians about the threat of climate change and what needs to be done to address it. In an attempt to catch them young and use them (i.e. school children) as agents of change in reaching out to the larger society”, the State has launched a School Advocacy
Programme in which climate change clubs have been established in some primary schools and post primary institutions in the State.

2. Launching a climate change mitigation and adaptation programme. Various measures have been put in place to mitigate climate change and its impacts and adaptations. These include:
   
   a) A tree planting campaign and criminalization of indiscriminate tree felling;
   b) Landscaping of virtually all open spaces, road verges and medians, and triangular lay-bys;
   c) Introduction of a mass transportation system, including the BRT (Bus Rapid Transit scheme, rail transport and water transport;
   d) Establishment of a waste-to-wealth programme.
   e) Rehabilitation of the drainage infrastructure in Lagos;
   f) Shoreline protection, especially at the Bar Beach on Victoria Island;
   g) Erosion control;
   h) Urban renewal programme;
   i) Engaging the mass media (radio, television and print) to deliver warnings and weather predictions to vulnerable communities;
   j) Organizing quarterly meetings of Community Development Associations (CDAs) and Community Development Committees (CDCs) to inform and sensitize the public on climate change threats;
   k) Cultivating the use of social networking platforms to communicate real-time climate related threats.

Sea level rise is likely to be the most significant impact of climate change in Lagos State in the long term and this will have adverse impacts on virtually every sector of the economy.

Therefore, it is recommended that the State, working with the Nigerian Institute for Oceanography and Marine Research (NIOMR) and the Federal Ministry of Works / Environment, should conduct a statewide sea level rise vulnerability assessment as a matter of urgency.

**Innovations in Technology, Management and Governance.**

Innovations in technology, management and governance that have been imagined as solutions or partial solutions to these problems are as follows (LSMOE. 2012)

i. **Water Supply:**
   The current status of public water supply in Lagos megacity is very poor. As stated above for the year 2012 for which production data has been published, production
from all the waterworks was 12 percent of domestic demand. Out of this 12 percent, a good percentage does not get to the consumers due to losses on the way. The Lagos Water Corporation (LWC) has come up with a Master Plan aimed at meeting the demand by 2020 through the planned construction of new Water Treatment Plants (WTP) and associated network. The WTP will include desalination plants of brackish water from the lagoons. However, it is debatable whether all the projects will be completed and be operational by 2020. The execution of the Master Plan is anchored on the involvement of Public – Private – Partnership. Unfortunately, Worker’s Unions in the Water Corporation and some Civil Society Groups are opposing the participation of Private enterprises in the water supply sector due to a fear of overpricing and denial of access to this essential commodity to the under-privileged (Ebosele, 2015 and Ezeamalu, 2015). Figure 14 shows a march against privatization of water.

Figure 14: Protest against privatization of water by the Public Unions and Civil Society Groups in 2015

Our assessment and recommendations are as follows: In Nigeria, The Cross River State Water Board Ltd had operated a form of public – private – partnership (PPP) from 2004 to 2015, with Ortech Nigeria Ltd as the Private organization. The achievement indicators for the project for the years are shown in Table 7 below (Ekabua, 2014). Water production increased by 270 percent while efficiency
increased by 18 percent. The number of connections increased by 1,113 percent. Most households had meters installed. PPP had obviously been a success in Calabar, Cross River State.

Table 7

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Unit</th>
<th>Baseline</th>
<th>Current figure (As at Date)</th>
<th>% change</th>
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<tbody>
<tr>
<td>Water production in millionMP</td>
<td>Million m³</td>
<td>2.102</td>
<td>7.764</td>
<td>270</td>
</tr>
<tr>
<td>Total length of Distribution network rehab/Constructed</td>
<td>Km</td>
<td>596</td>
<td>805.6</td>
<td>35</td>
</tr>
<tr>
<td>No of connections</td>
<td>No</td>
<td>3.441</td>
<td>41,719</td>
<td>1,113</td>
</tr>
<tr>
<td>Population served from the systems under rehabilitation</td>
<td>No x 10⁶</td>
<td>0.112</td>
<td>0.95</td>
<td>748</td>
</tr>
<tr>
<td>Efficiency</td>
<td>% Billing</td>
<td>50%</td>
<td>59%</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>% Collection</td>
<td>66%</td>
<td>78%</td>
<td>18</td>
</tr>
<tr>
<td>Total cost of production in =N=million.</td>
<td>=N=million</td>
<td>550.00</td>
<td>865.00</td>
<td>57</td>
</tr>
<tr>
<td>Revenue from Water sales in =N=million.</td>
<td>=N=million</td>
<td>45.62</td>
<td>338.78</td>
<td>624</td>
</tr>
<tr>
<td>Cash operating ratio</td>
<td>Ratio</td>
<td>9%</td>
<td>39%</td>
<td>333</td>
</tr>
</tbody>
</table>

In Lagos Megacity, Private operators are involved in the collection of refuse with the Lagos State Waste Management Board. This has contributed greatly in moving Lagos from one of the dirtiest cities in the World to a pretty clean city, though much still needs to be done. The telecommunications sector and more recently the Power sector have been unbundled with private companies taking over from State Authorities – NITEL /MTEL and PHCN respectively. Improvements have been recorded in both sectors with the participation of the private sector. Jideonwo (2014) also recommended privatization of the water supply sector in Lagos in her thesis.

Involvement of private sector alone will not change radically the poor water supply except other changes are made. Some operators in the water industry are of the opinion that one agency in charge of water supply for over 23 million inhabitants is not –sustainable. It is the opinion that the PHCN model may be better applicable to the water sector.
ii. **Storm Water**

The reasons espoused by Aderogba (2011) in his paper are very much with us. Climate change will lead to a worsening of the flooding in Lagos megacity. Apart from the impact from higher amount of rain and its intensity, as well as storm surges from the ocean, the rapid urban development in Ogun State will mean more run off into the rivers which all flow to Lagos. Lagos State Government has produced drainage master plans as well as designed implementation strategy. However, a solution to flooding in the city rests in well-known solutions - which are:

- Keeping the drainage channels clean and ensuring they are not blocked by any refuse or structure at any time through constant and regular maintenance at the various levels of governance.
- Enforcing planning regulations – both individuals and even government agencies build on drainage floodplains. In essence, the wetlands should be preserved as they serve as withholding reservoir during peak flood.
- Public awareness – through radio jingles, drama, electronic and print media, town hall meetings et al
- Legislation – applying penalties to offenders

iii. **Waste Water**

The Lagos State Waste Water Management Office is on the right track in mounting enlightenment campaigns through Radio, Television and Stakeholders meetings educating the populace on waste water and sanitation with a view to changing the bad habits in the society.

The Federal Government and its agencies have many waste water treatment facilities in Lagos megacity which are not functioning. There is a need for cooperation between the two levels of Government so that they can work in tandem.

Issues of availability of land to construct waste water facilities need urgent attention of Government. The agencies of the State Government responsible for waste water management in Lagos – Lagos State Environmental Protection Agency (LASEPA) and Lagos State Waste Management Office (LSWMO) need
to redouble efforts especially in ensuring that waste water treatment plants are of the right design, work 24/7 and are utilized. Therefore, due to land economy in the State and the current use of septic tank as treatment option by a majority of the populace, the option of decentralization and co-treatment of sewage and septic tank liquor (fecal sludge) should be explored.
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