Disposal Sites and Transport Route Selection Using Geographic Information System and Remote Sensing in Abeokuta, Nigeria

ACHI Harriet Amaka[1]

[1] Federal University of Agriculture, Abeokuta.

Abstract

Waste management problems result from indiscriminate waste disposal which stems from Inadequate planning and implementation. This fact led to the present study which applied the Techniques of gis and rs to disposal sites and transport route selection in the emerging Megacity of abeokuta. Spatial data such as land-cover types; road and drainage networks of the City were extracted from a geo-referenced high resolution satellite image through on-screen Digitizing using gis softwares such as arcview. The existing disposal sites were geo-located And added as a layer to the map of the city. The land-cover, drainages, and roads were buffered at 30, 160 and 200 meters respectively using preset criteria such as distance of site from a street at 30 m, surface water at 160 m, major roads at 200 m and absence of important economic or Ecological features; to determine candidate sites from the land-cover types. Four legal disposal Sites in saje, olomore, totoro and ita-oshin and patches of illegal disposal sites were identified. Gis analysis gave a total of nine sites out of which only four met the preset criteria. Saje, ita - Oshin, sam-ewang, and ita-ika areas were the most appropriate sites.

Index terms— Geographic Information System, Remote Sensing, Disposal site, Transport Route.

1 Introduction

he current global trend of waste management problems stems from unsustainable methods of waste disposal, which is ultimately as a result of inadequate planning and implementation. The practice of direct dumping of wastes into water bodies, open, abandoned lands and any other 3 "appealing" sites without proper treatment have led to serious environmental pollution and health-related problems.

Solid Waste according to The United State Environmental Protection Agency (USEPA, 2005) is defined as any garbage, refuse, sludge from a waste water treatment plant, water supply treatment plant or air dried material, including solid, liquid, semi-solid or contained gaseous material resulting from industrial, commercial mining and agricultural operations and from community activities.

Waste management issues should be confronted in a more generalized manner, which means that new strategies need to be designed for considering diverse and variable urban models. This fact demonstrates the necessity of developing integrated, computerized systems for obtaining more generalized, optimal solutions for the management of urban solid waste (Karadimas et al, 2004).

Geographic Information System (GIS) and Remote Sensing are such computerized systems which can be integrated to get optimal solutions for sustainable management and planning of solid waste.

Geographical Information System (GIS) is any system that captures, stores, analyzes, manages, and presents data that are linked to location(s). It allows users to analyze spatial information, edit data, maps, and present the results of any operations (wikipedia, 2011).

Remote sensing is the small or large-scale acquisition of information of an object or phenomenon, by the use of either recording or real-time sensing device(s) that are wireless, or not in physical or intimate contact with the object (such as by way of aircraft, spacecraft, satellite, buoy , or ship) **??**wikipedia, 2011).

This study emanated from the obvious problems of population and city expansion as a result of rural migration to urban centres; increase in solid waste generation as a consequence of overpopulation; distance of location of disposal sites from residential areas which encourages indiscriminate waste disposal at illegal locations; and insufficient disposal sites leading to a creation of patches of disposal sites all over the places.

The study focused on identifying the present locations of disposal sites and assessing their suitability; determining other locations best suited as disposal sites across the study area; and determining the most appropriate, efficient, and least-cost routes for transporting waste to landfills or recycling centres. Characterization of municipal solid wastes (MSW) are impacted by a number of factors, including climate, population, season, income level, social behaviour, the extent of urbanisation, effectiveness of recycling and the presence of industrial activity. Wastes from tropical areas generally contain a relatively high concentration of organic matter (Diaz et al, 2005).

Solid waste generation is a part of every human activity or process stream. Nigeria, having a population of 120 million (Adewumi et al., 2005), generated 0.58kg solid waste per person per day. Several factors influencing solid waste generation in Nigeria and the city of Abeokuta include the following: inadequate technology, facility for separation at source, strength of solid waste management policy and enforcement (Sridhar and Adeoye, 2003). Also are education, income and social status (Abel, 2009).

Disposal of solid waste generated in a community is the ultimate step in a solid waste management system. In the advanced technologies, disposal is preceded by engineering activities such as sorting, volume reduction and / or receding. The open dump method of solid waste disposal is considered as both naïve and dangerous. This is because of the leachate effect (i.e the chemical and biological contaminant in wastes) which could constitute a direct risk to human health (Lasisi, 2007). In some parts of Nigeria, refuse is generally buried, though some heedless burning is sometimes observed (Igoni, et al., 2007). ascertained that GIS is an ultimate method for preliminary site selection as it efficiently stores, retrieves, analyses and displays information according to userdefined specification.

To arrive at the selection criteria for choosing a site for landfill, relevant literature and decision makers' opinion should mostly be sought. Adeofun et al (2006) and Sani et al (2010) gave some specifications which were adapted in this study.

Designing short routes for waste collection is possible within a GIS system. The application of GIS in route planning and designation of collection points in some experiments has shown that GIS is capable and can help improve waste collection in residential neighbourhoods in urban areas.

Secondly, in order to have an efficient solid waste management system, GIS may be adopted because it is capable of handling both spatial and nonspatial data necessary for effective solid waste collection system.

Thirdly, solid waste collection contractors prefer routes which are short and cheap, with high rate of return within a short period. However, traditional methods of handling data are incapable of identifying the least cost routes for solid waste collection.

Fourthly, GIS has been proven to be a tool that provides the alternative method of minimizing operational costs for contractors (Kyessi and Mwakalinga, 2009).

2   II.

3   Materials and Method a) Description of Study Area

The study was conducted in Abeokuta, Ogun State. Abeokuta is both the capital and administrative headquarters of Ogun State situated in the South-Western part of Nigeria with coordinates between latitude 7° 09? N and 7° 19?N and longitude 30 29?E and 3041?E (Akanni, 2005

4   c) Data Analysis

Five major GIS spatial operations were performed to achieve the set of objectives for this research. These are digitizing, buffering, overlay, query and network analysis (Sani et al, 2010).

5   III.

6   Results and Discussion

7   a) Location of Existing Disposal sites in Abeokuta

The disposal sites in Abeokuta were located on a map in Figure 1. The legal disposal sites are located at Saje (Old Quarry Site) which happens to be the largest disposal site in Abeokuta; Olomore, Totoro and Ita-Oshin areas while the illegal disposal sites are arbitrarily located at any available space. Some of them as shown in

8   b) Road and Drainage Networks in Abeokuta

The road and drainage networks in Abeokuta were located on a map in Figures 2 and 3 respectively. The road network consists of the streets, major roads, railway and express road while the drainage network consists of the major river -Ogun River as it cuts across the study area and the surrounding tributaries.

9   d) Buffering Analysis

In determining the most appropriate locations for siting disposal sites in Abeokuta, a set of buffering analysis were performed on the drainages, land-cover and roads as depicted in Figures **??**, 6 The locations proposed as disposal sites in Abeokuta as shown in Figure **??** include Saje, Ilugun, Olomore, Ita-Oshin, Mokola, Ita-Ika, Onikolobo, Sam-Ewang and Kemta. The areas of the candidate sites are given as 12.06km2 for Saje being the largest site; 4.64km2, 2.66km2, 2.14km2, 1.47km2, 1.47km2, 1.44km2, 0.87km2 and 0.71km2 for Ita-Oshin, Mokola, Ilugun, Ita-Ika, Sam Ewang, Kemta, Olomore and Onikolobo espectively.

Figure Figure Figure

Saje, with an area of 12.06km2 and an indigenous residential area located far away from any resource of economical / ecological value, can be described as one of the most appropriate site. Ilugun has an area of 2.14km2 and is described as an undeveloped land. It is however situated some few kilometers near a railway station and is not readily accessible.

Olomore has a small area of 0.87km2 and overlaps the railway station, express road and the Ogun River and is described as "undeveloped land".

Ita-oshin with a fairly large area of 4.64km2 is described as a modern residential area and has a notable hospital. It is also overlapping the railway station, express road and the Ogun River which are resources of important economic / ecological value.

Onikolobo and Ita-Ika are areas described as 'undeveloped land' with areas of 0.71km2 and 1.47km2 respectively and located away from resources of economic importance.

Sam Ewang, Kemta and Mokola have areas of 1.47km2, 1.44km2 and 2.66km2 respectively and consist of indigenous and modern residential areas with no attachment to any resource of economic / ecological importance.

From the descriptions above, the most appropriate sites are given in Figure 10 as follows: Saje, Ita-Oshin, Sam-Ewang, and Ita-Ika. The total area of the four most appropriate sites is 19.64km2 out of a total area of 79.95km2 for the study area.

10   f) Determining the Shortest and Least Cost Routes

The proposed transport routes are depicted in Figure 11. These gave directions which are the shortest distances between the proposed disposal sites and are also cost-effective. It was found out that the first "stop"is Saje and it is cost-effective to travel through Ita-Ika and Sam-Ewang before making a final stop in Ita-Oshin and vice-versa if Ita-Oshin becomes the first stop.

The total cost for the "stop" routes which is the shortest route that connects the stops is 27.30km while the total cost to make a round-trip (Tour Route Cost) is given as 36.00km.

11   g) Discussion

The arbitrary and indiscriminate siting of disposal sites in Abeokuta has led to the creation of so many patches of unsightly mountains of refuse scattered around the city. Four major areas which are Saje, Olomore, Ita-Oshin and Totoro are currently regarded as legal disposal sites while the others are termed as arbitrary. Burning still remains the most Disposal Sites and Transport Route Selection Using Geographic Information System and Remote Sensing in Abeokuta, Nigeria applied method of waste disposal especially for the illegal disposal sites, because the frequency at which waste is burned is higher when compared to that of the legal disposal sites (Ogwueleka, 2009). The final selection of the disposal sites after various analyses in ArcView is influenced by several factors including the size (area) of candidate sites, nearness to resources havingecological / economical importance, accessibility to roads and type of development activities that have taken place in such a location (Adeofun et al, 2006;Sani et al, 2010 andSener, 2010).

Saje, one of the proposed sites, is preferred for its large size and distance from areas with important economical/ecological value; and will serve Ilugun and Mokola which were initially selected but later eliminated. Ilugun and Mokola were eliminated during the selection process because they were closely located to Saje which is large enough to serve the areas. Furthermore, Ilugun is overlapping the railway, Ogun River and express road and would not be large enough if any attempt is made to reduce it farther away from these obstacles; it is also not on the road network i.e. not currently accessible to other locations. Sam -Ewang is another proposed site lying between Onikolobo and Kemta which were both eliminated as well due to the clustered nature of their locations. It is therefore intended that Sam-Ewang will serve both locations as it lies in-between and is accessible from both locations. Ita-Oshin was favoured in the selection process even though it overlaps some obstacles because of its large area. It is therefore advised that about 1.5km -2km of its 4.64km should be carved out from the obstacles before siting the disposal site in the area. It will also serve Olomore area which was initially selected but later eliminated because of its nearness to resources of important value and very small size.

Determining transport routes for waste collection and transportation services is very essential in order to reduce travel costs and increase efficiency in transferring wastes to disposal sites (Ogra, 2003). The most appropriate route from the starting point, Saje, is through Ita-Ika, Sam-Ewang and finally to Ita-Oshin and vice-versa.

12   IV.

13   Conclusion/Suggestions

It has been demonstrated beyond every reasonable doubt that GIS is a very important tool for determining the most appropriate locations for siting disposal sites and finding the least-cost travel routes for waste transportation and disposal. Therefore, the proposed disposal sites should be considered as appropriate waste disposal / landfill sites and as such, approved for location. Locating disposal / landfill sites should not be arbitrary and its management should be deliberately planned and consistent to ensure a continuous and efficient waste management program. Transport routes should be short to allow for multiple trips, efficiency in waste collection and transportation and cost-effectiveness. Also, the following recommendations are made:

? Saje disposal site should be retained and considered a possible location for siting landfill. This page is intentionally left blank 2   [1] [2]
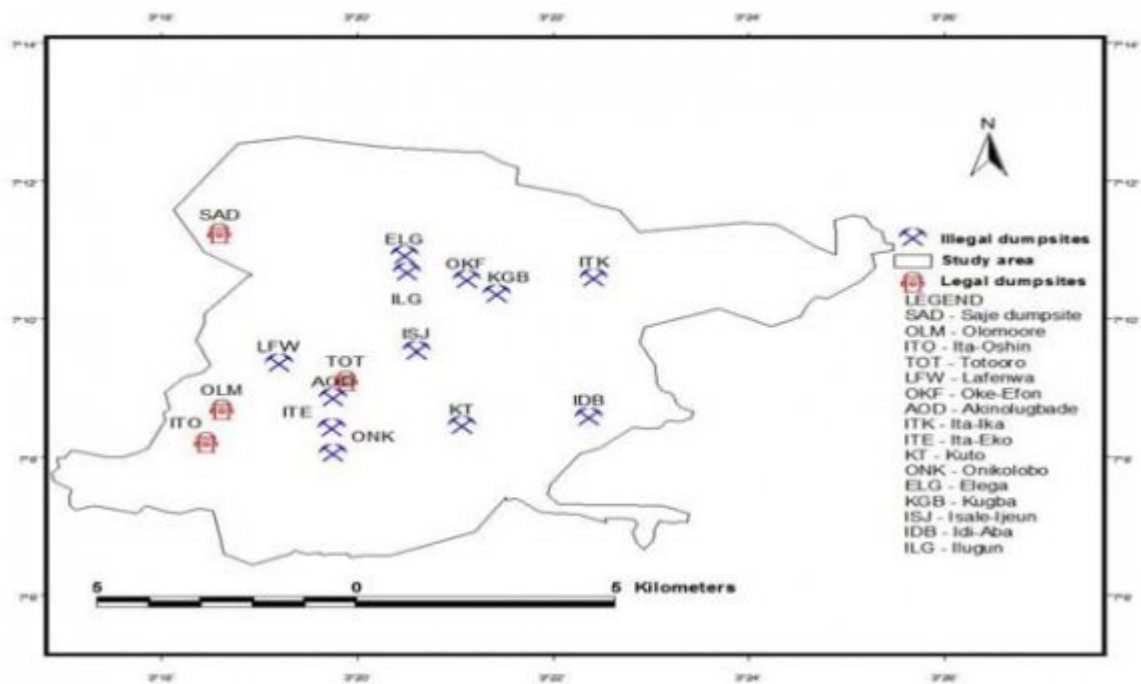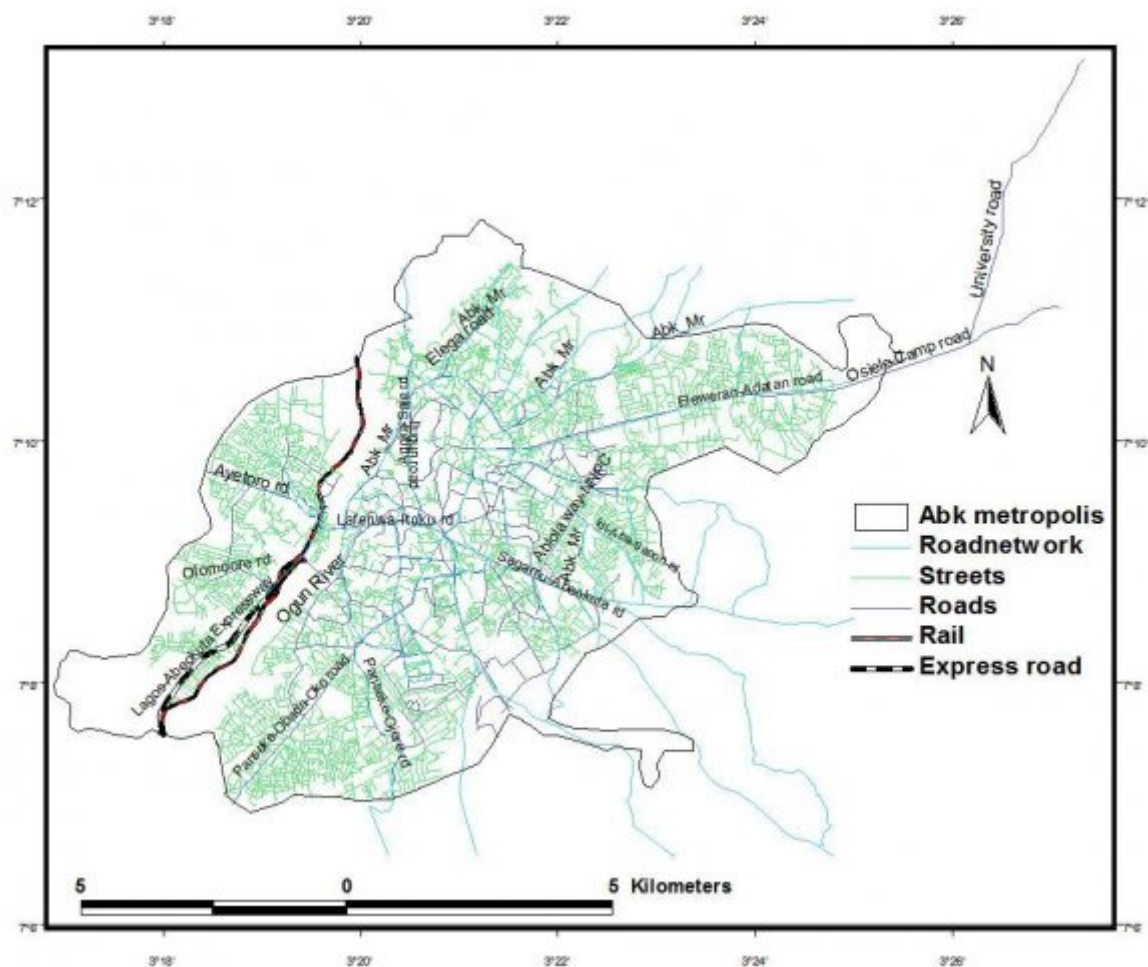

Figure 1:

Figure 2:
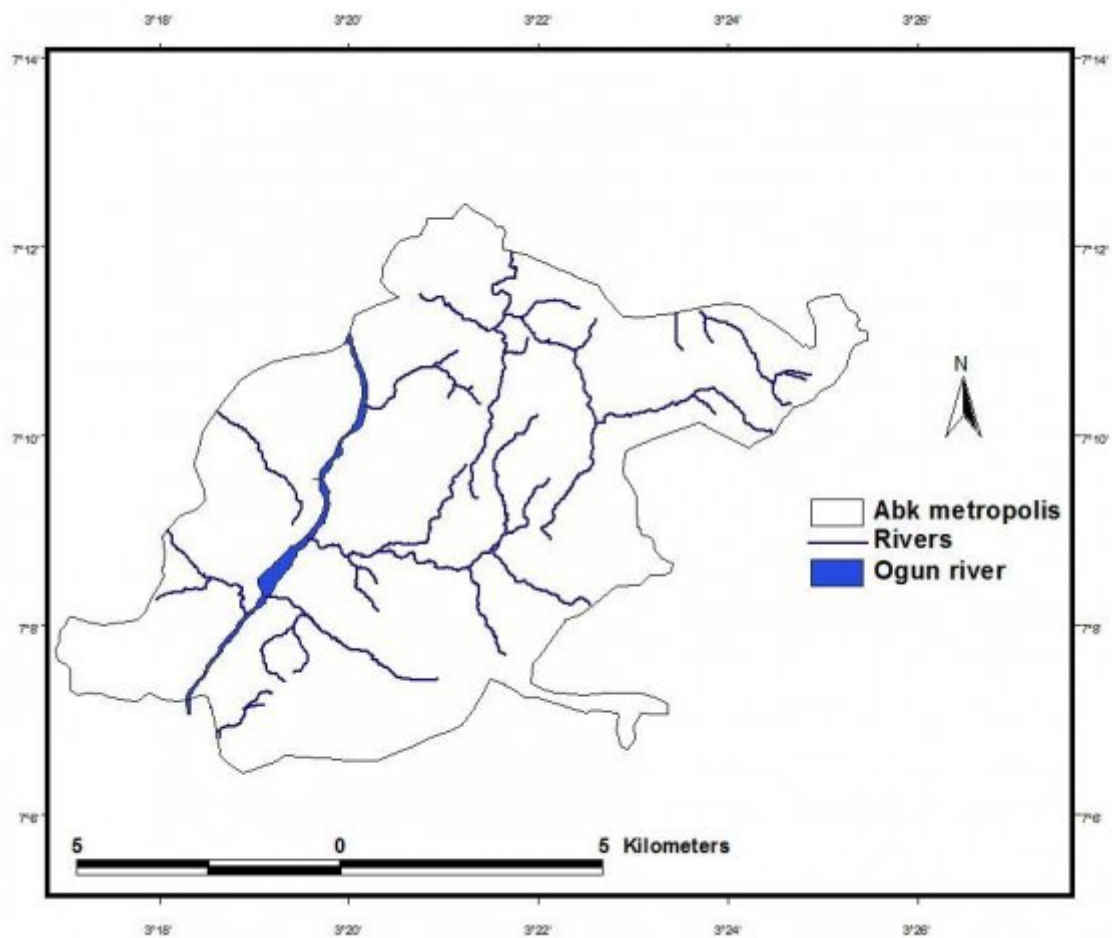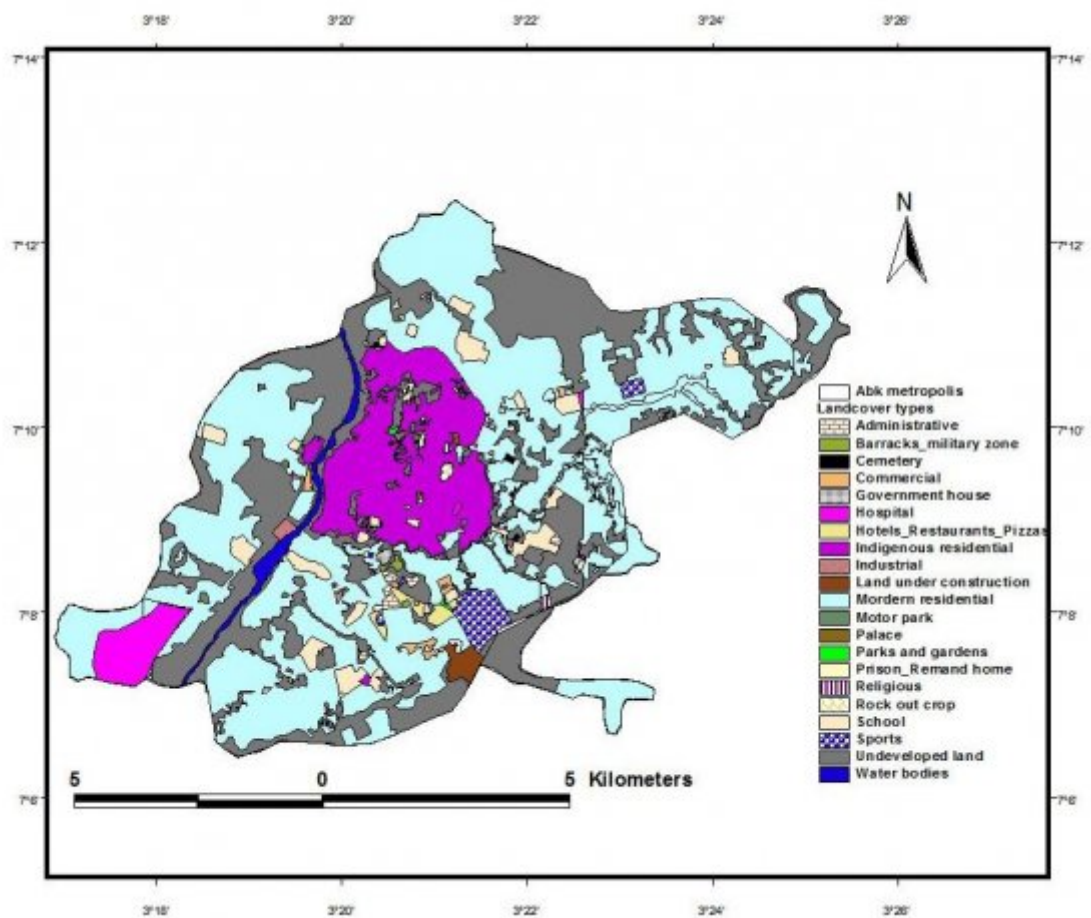
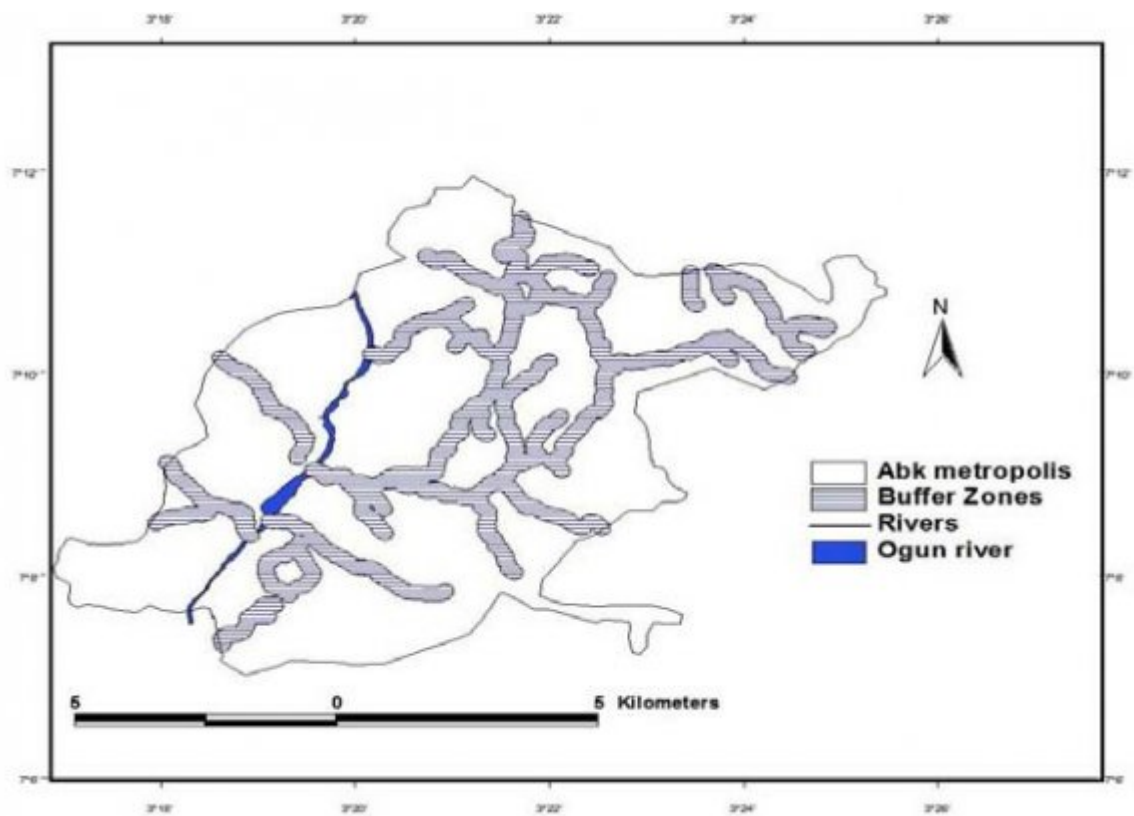Figure 3: Figure 1 :

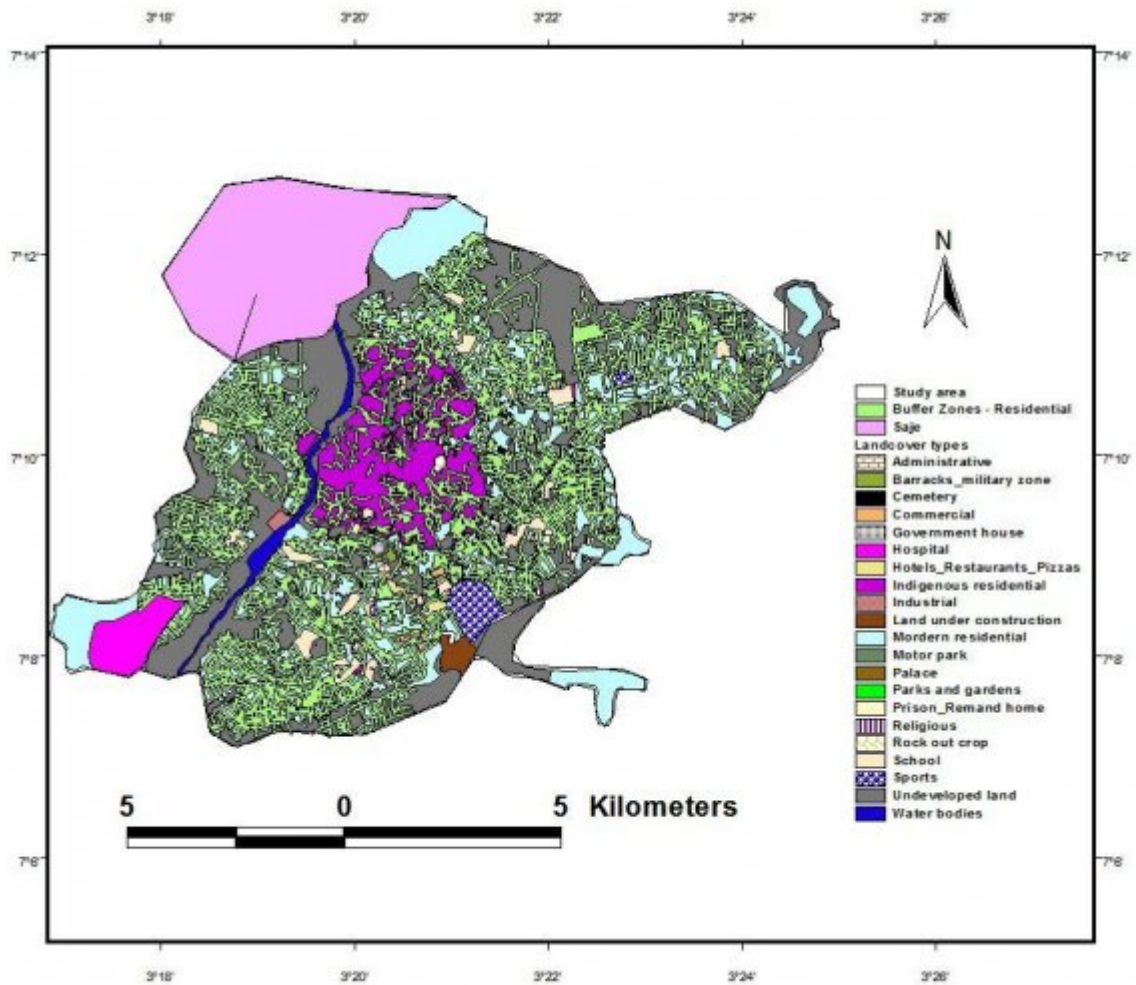**2**

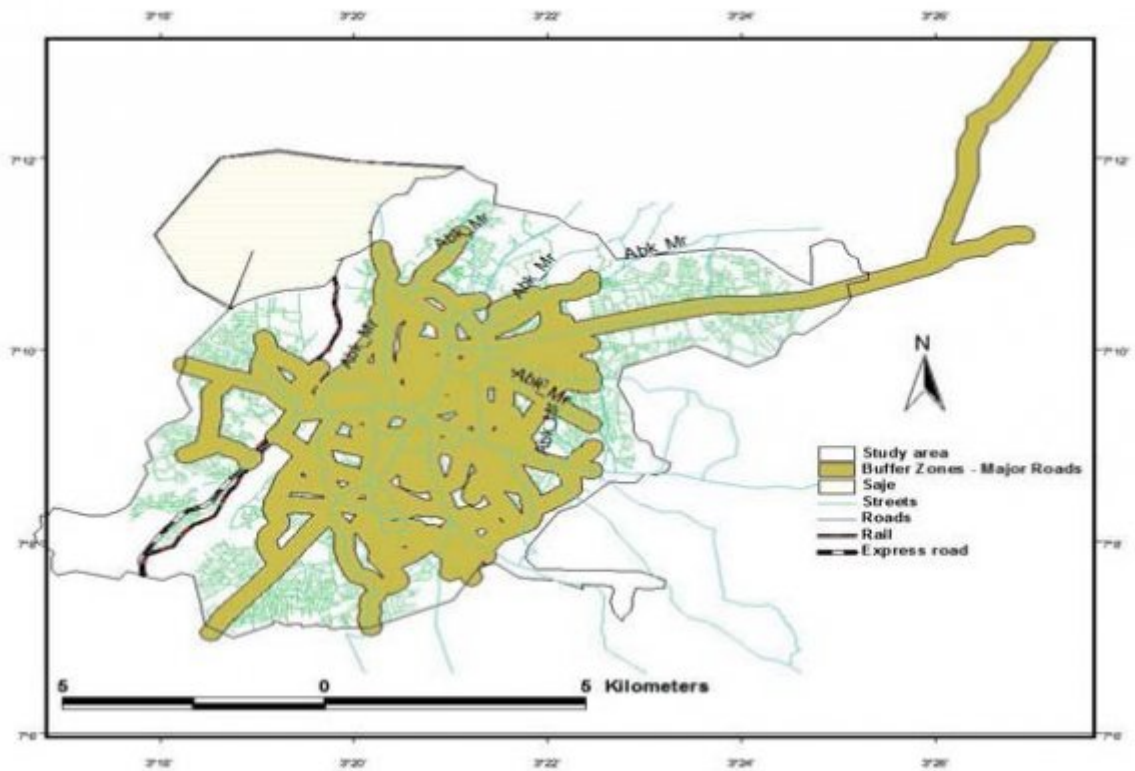Figure 4: 2 :

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Figure 5: Figure 3 :

Figure 6:

Figure 7:

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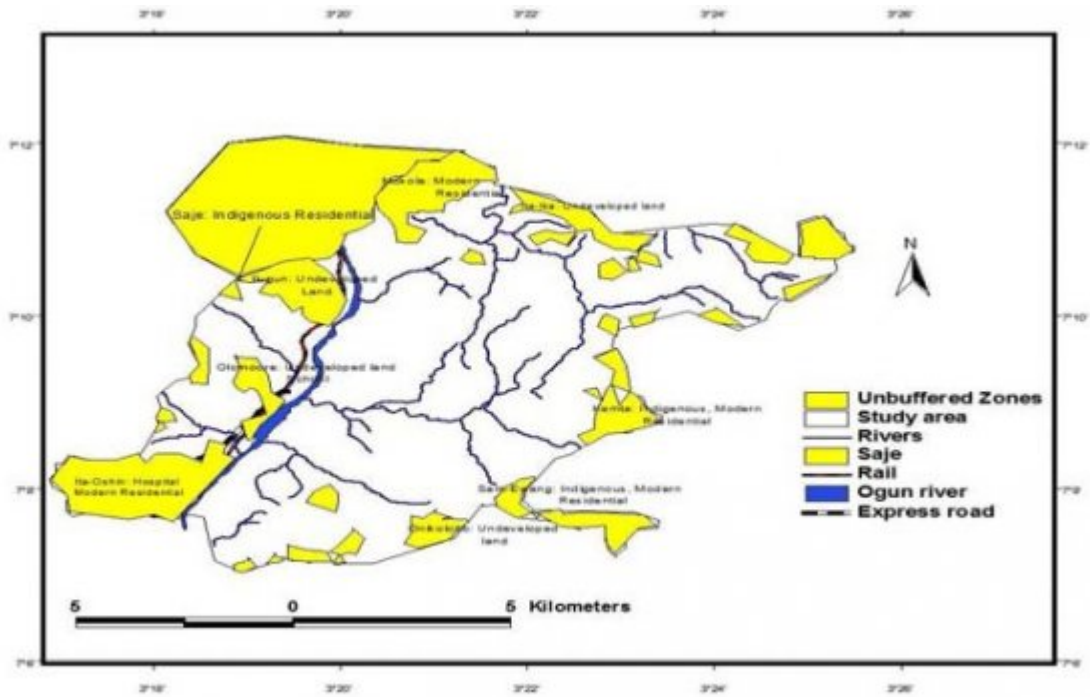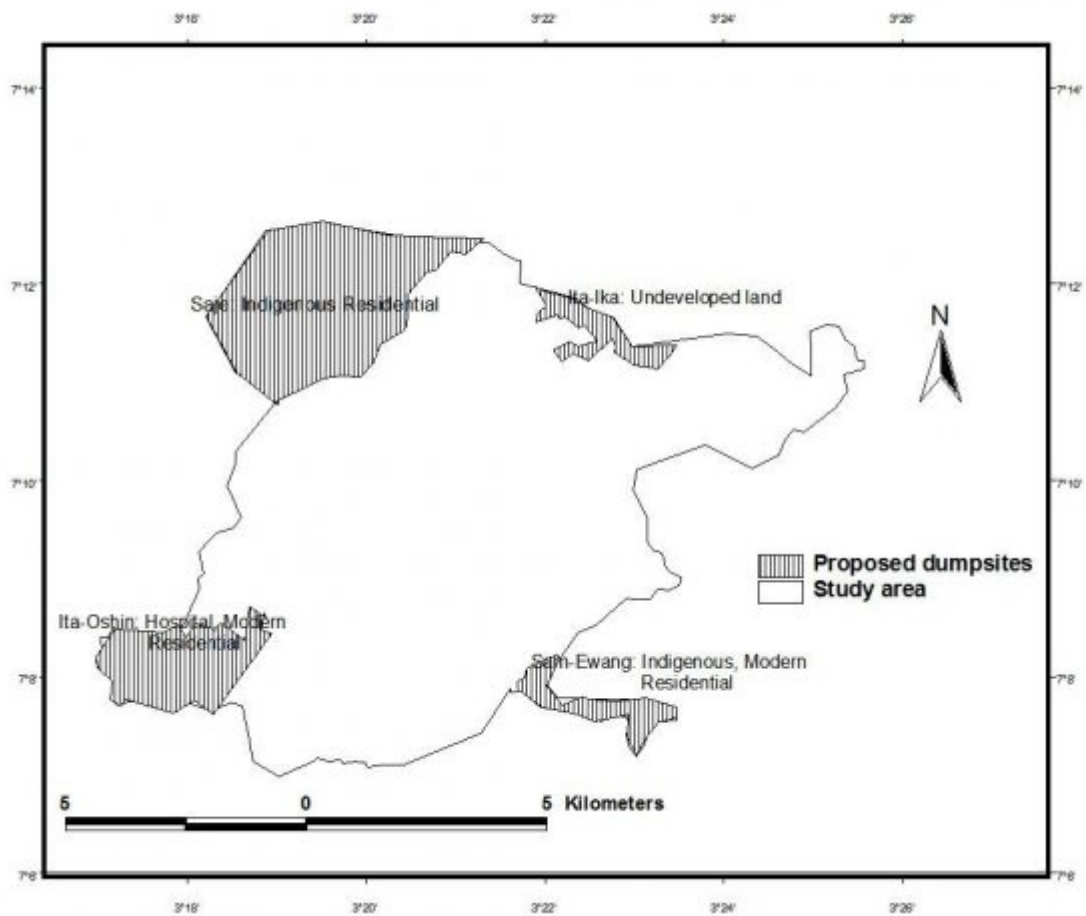
Figure 8: 4 :

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Figure 9: Figure 5 : 6 :
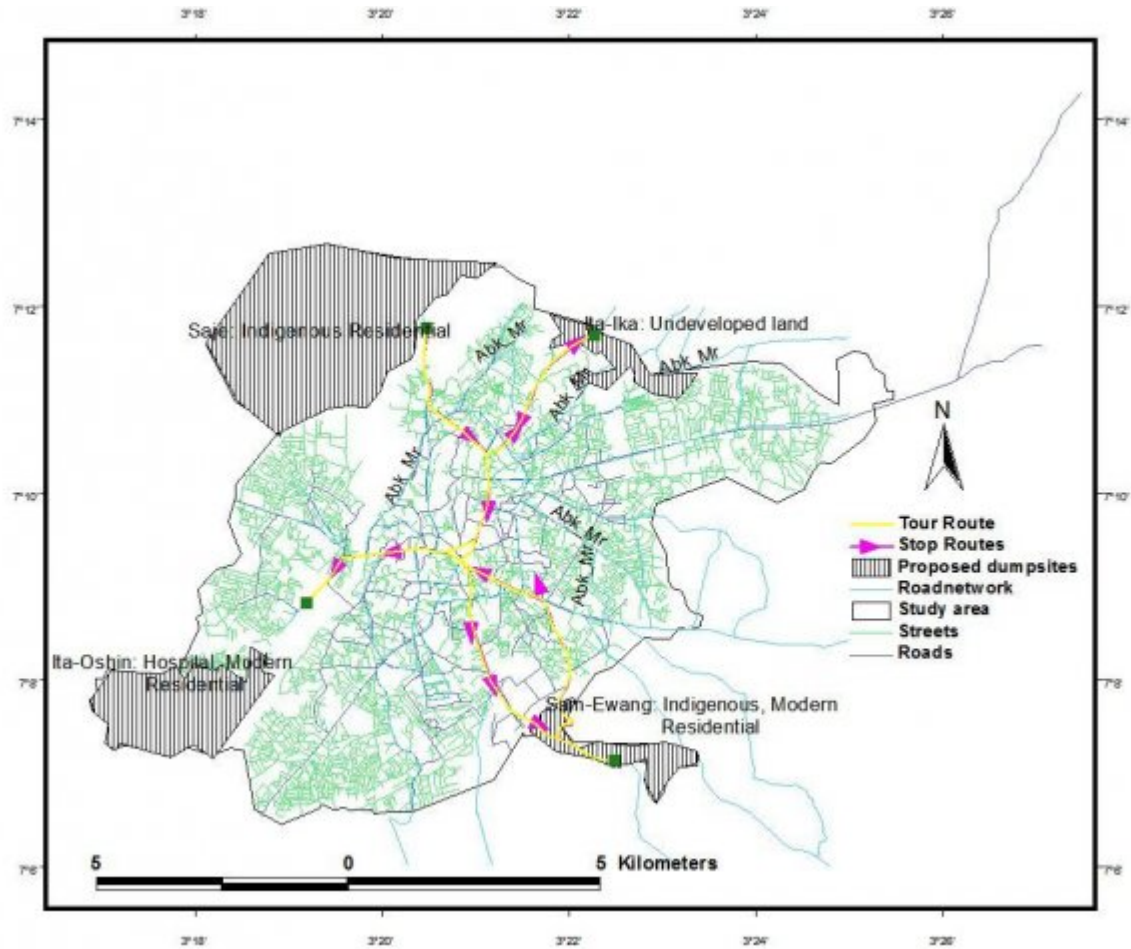
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Figure 10: Figure 8

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Figure 11: Figure 9 9 :

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Figure 12: Disposal 10 :

b) Data Collection
A Satellite Image (IKONOS, December 2006) of
Abeokuta metropolis was obtained from the GIS unit of
Institute of Food Security, Environmental Resources and
Agricultural Research (IFSERAR), University of
Agriculture, Abeokuta (UNAAB).
Land-use / land-cover map, road map,
topographic map, drainage map, and other relevant
maps were obtained from relevant agencies including
the Water, Environmental and Sanitation (WES)
department of the Local Governments, Cartography
Laboratory at the Department of Water Resources
Management and Agrometorology and the GIS Unit of
IFSERAR, UNAAB. Global Position System (GPS) device
was used to determine the coordinates of existing
disposal sites.

Figure 13:

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