Suitability Analysis of Waste Collection Sites in Port Harcourt Metropolis, Nigeria

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Abstract

The suitability of waste collection points in the wake of increased population and the proliferation of waste collection point is of concern to residents of Port Harcourt metropolis and centred to this research. The Global positioning System unit was used to collect the coordinate of all waste collection point across the study area. The waste collection points were buffered using defined factors such as distance of waste collection points from population, water bodies, the location of these points on soil types, and the manoeuvrability of waste collection trucks. The waste collection coordinate points were overlaid for the locations suitability which is tied to the sensitive environment guided by base maps, imageries retrieved from Landsat and google image. Findings revealed that the location of waste collection points across the study area is random and occurred indiscriminately exposed to sensitive environment such as water bodies, permeable soil, and denser population. The study therefore recommends that evacuation of waste from the locations should be done within munities to avoid percolation in to the ground water. Perforated surfaces to collect waste should be encouraged across the study area to contain the aesthetic degradation caused by locating waste collection points on crash barrier and minimise the risk of seepage and infiltration of pollutants from the deposited waste into ground water. Finally, sorting of waste should be encouraged at source of generation to minimise the deposition of toxic or potential toxic waste on the soil which could result in seepage, infiltration and flow as overland flow in to water bodies.

Keywords: *suitability, waste, sensitive, environment, pollutants*

I. INTRODUCTION

Policies for the sustainable management of solid waste have been a challenge for the metropolitan areas of developing countries, especially in terms of the management of space for a long time. Characteristics of the urban spatial structure includes increasing rural-urban migration, limited road access, unplanned settlements and high density, which makes the problem of spatial municipal structure arise [4]. To ensure good health and a reduction in mineral exploitation, solid waste treatment and recycling is advocated. In return jobs are created which sustains the urban population.

Since the advent of human civilization, man has not only introduced unwanted materials and removed materials indiscriminately from the surrounding environment, but has succeeded in entangling mankind in the whole confusion caused by human race, because mankind wants to triumph in the field of technological development at the expense of the endangered environment. As population increases, so also the rate of waste generation increases and this is due to the increased rate in product consumption and package with which it is associated. Heaps of municipal waste along major roads, stream channels, river banks and in the open spaces are very common in Nigeria [13]. The [20] stated that since the year 1950 man has used up services and goods that exceed the ones used by man since he was created. Wastes have for so long, since the great industrial revolution which occurred in Great Britain, grown practically, in every urban settlement worldwide. This makes for an increase complexity in the composition of waste since then many cities are no longer monobound, but none prepared for what lies ahead 'an avalanche of change that roped the fabric of urban life in cities adapting to the mushrooming of factories and supply facilities, the expansion of transport systems, and the construction of tenement for the growing labour force. Most human activities give rise to residual material which is not of immediate use where they arise. These residual materials may be recycled, reclaimed or reused otherwise they constitute waste, which will ultimately be released into the environment [2].

Currently, the system of the management of solid waste existing in the study environment shows deficiency in organised outline for proper gathering stations and motor passage ways evacuating the waste. The existing system seems to be largely based on experience, convenience to the refuse dumper which leads to indiscriminate disposal of waste as shown in plate 1.1 and 1.1b.

Plate 1.1 Refuse Dump along major Road

Plate 1.1B Indiscriminate Refuse Dump in Study Area

Even though there has been an increase in awareness of waste as a severe challenge to the environment which needs fast action. Methods adopted so far to curb the situation seems to have placed activities around waste generation and management static beyond the means of the authorities to collect and effectively dispose waste that originates from the area of study. Nowadays disposal of waste represent a major headache for many municipalities. Quick relief does not seem to be in sight because waste represents the true residual of our civilization and its imposition reflects our style of living and technological development [15]. Until recently, the study area which is found in Port Harcourt, usually called the garden city, attributed by how neat the city was the presence of green and flowering plants has marked much reversal as the case is now because waste is now littered in every nook and cranny of the city.

Wastes produced from homes, industries, office and other establishment in the study area has been a great challenge to all its dwellers. This challenge of waste disposal has posed enormous and serious problems that require strategic planning in other to overcome the menace. In the wake of the above, there is need to take very seriously the threat of massive amount of waste we put in to the environment every day going by the dustbin, the sight of dirt flowing into the road and the smell arising from it. Seeing that the strong smell and irritable sight is a common sight round the city with the all too familiar sight and smells of a crowded city there is need to optimize waste collection and disposal in our urban centers.

II. STUDY AREA

The area of study is Port Harcourt Metropolis see figure 2 comprising two Local Government Areas of Obio Akpor and Ikwerre Local Government of Rivers State see figure 1. The Niger Delta region houses the area of study, which is low lying along the tributaries in the east of the Niger River 66 km upstream from the Gulf of Guinea. The study area host varying land use activities ranging from educational, residential, commercial, industrial, and agricultural. The Local government areas have been engulf into the Port Harcourt metropolitan city making the study area to be highly congested in terms of population density.

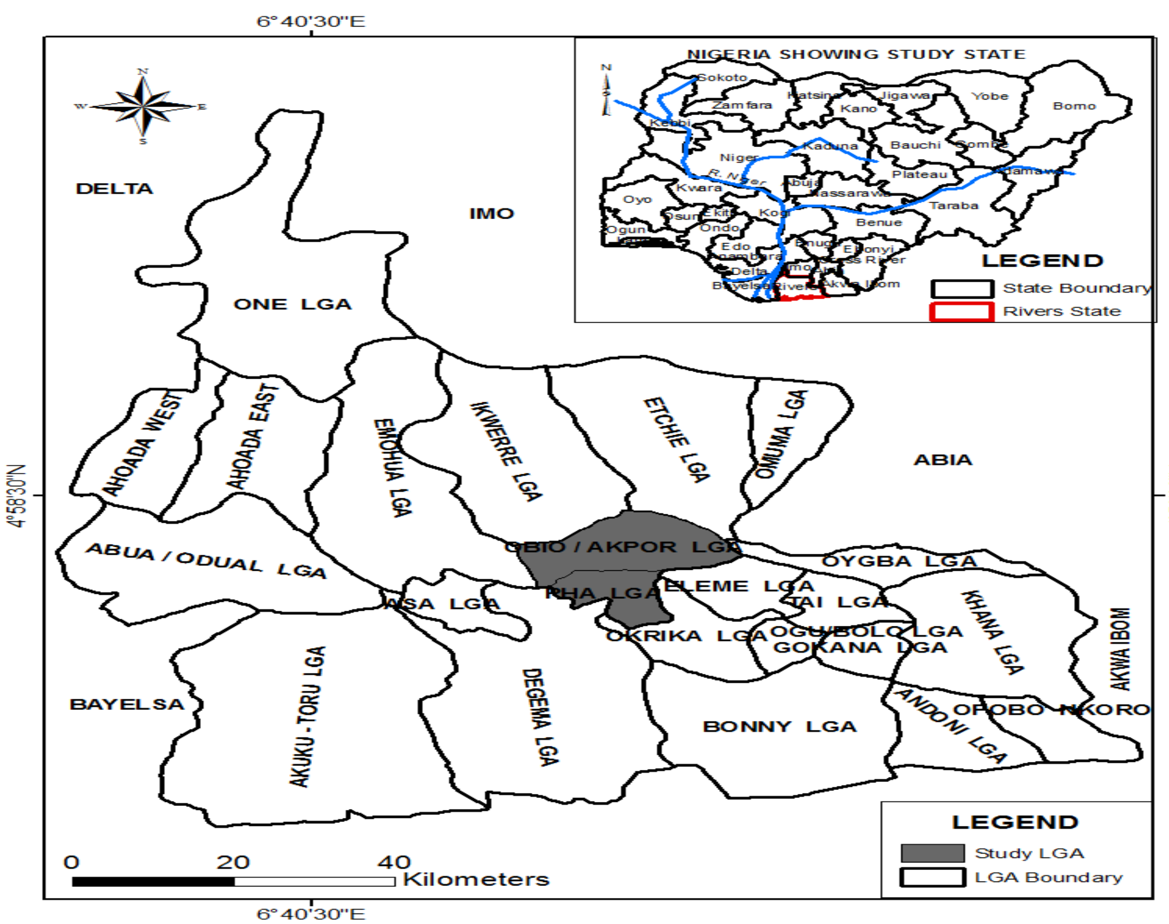


Figure 1. Rivers State Showing Study LGAs

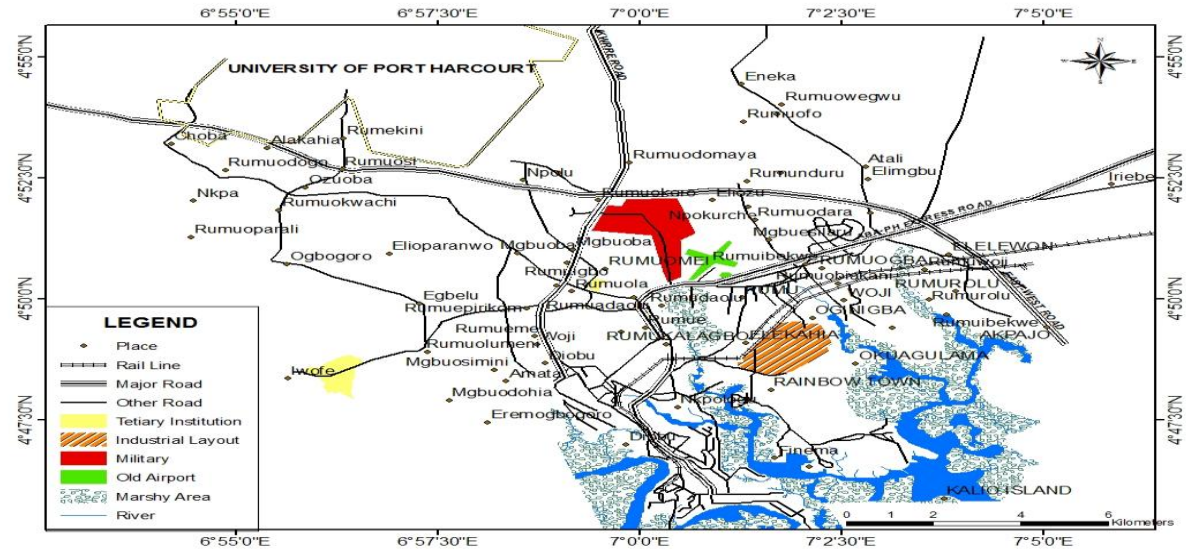


Figure 2 The Study Area Showing Communities with insert Rivers State

III. ECONOMIC ACTIVITIES

Initially the people of the study area are known to be primarily fishermen and farmers owing to the availability of the Rivers and vast uncultivated land before the emergence of industrialization. Today the study area is an institutional and industrial center which hosts numerous businesses and firms.

The economic activities of the area include food processing, manufacturing of paper products, paints, petroleum facility servicing, agricultural production, training institutes, metal works, road construction, and soap making. Engineering, Educational, medical, hospitality, and legal services are all rendered here.

IV. POPULATION AND LAND USE

The population of the study area was put at 100,998 people as at 2006. This is broken down into gender as 519,634 females and 481,252 males according to the National Population Commission [12]. The landcover and land use map of Port Harcourt metropolis which was obtained since the year 1986 showed the area of land surface built up was about 16, 25km^2 only see figure 3 and 4.

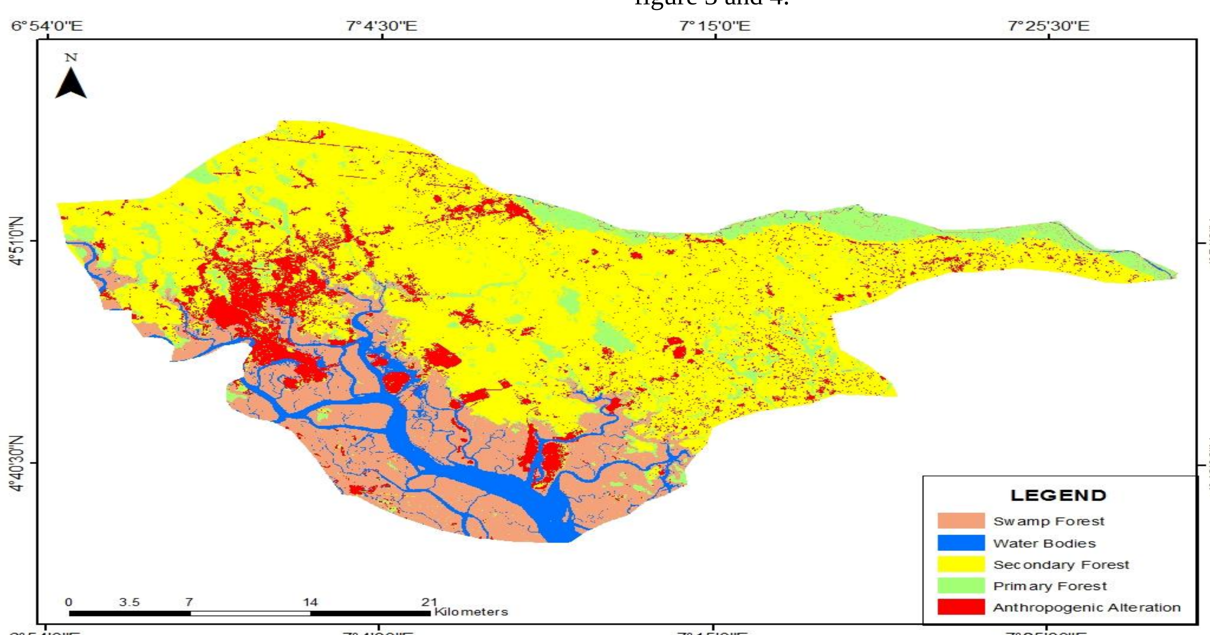


Figure 3. Landcover man of study area (1986)

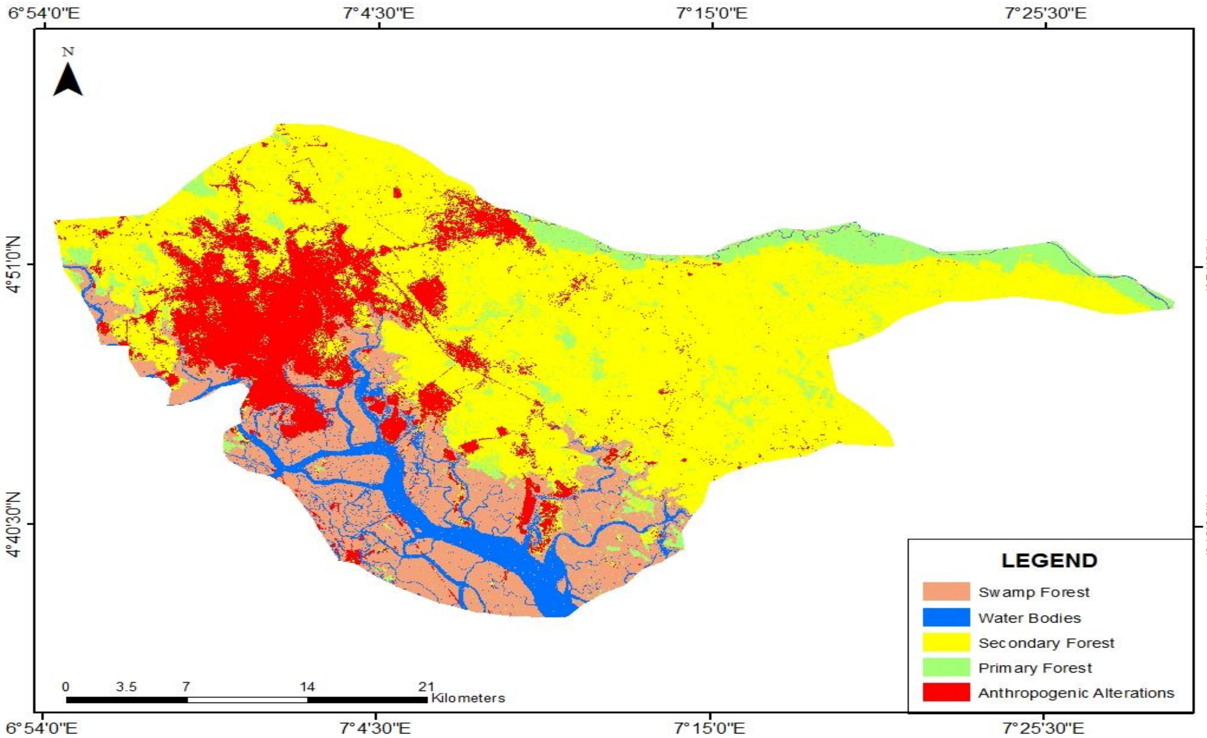


Figure 4. Landcover man of study area (2000)

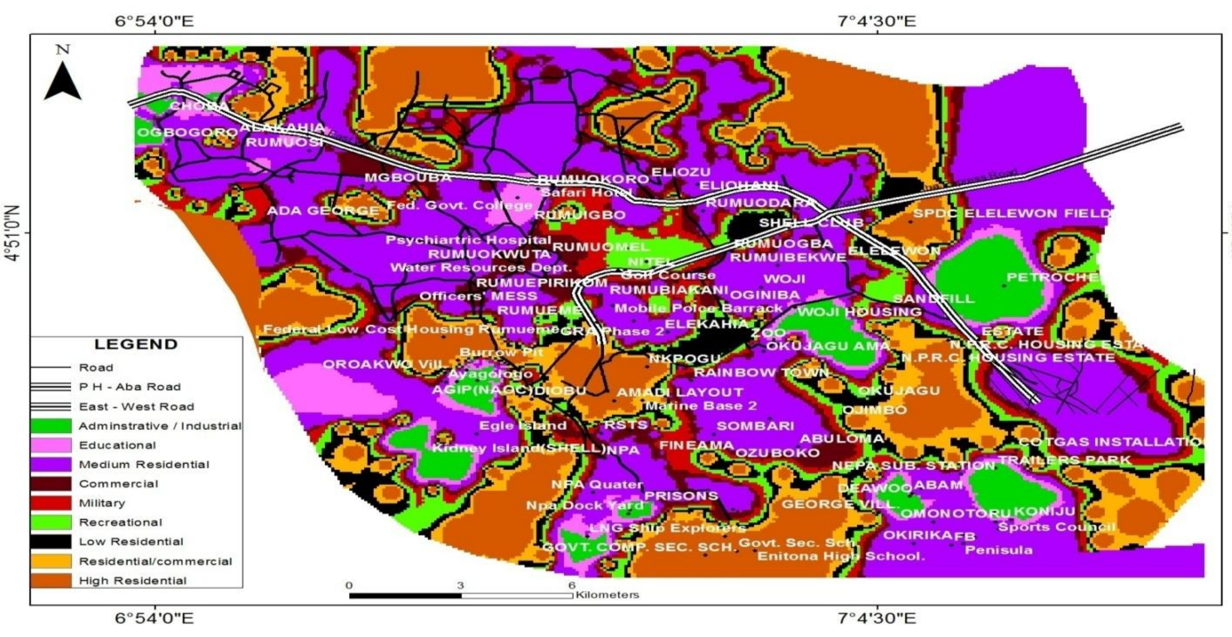


Figure 5. Landuse map of the study area

In the year 2000, an updated version of the map of the same area was digitises, 14 years later, a land area 282,25km^2 was built up. This shows an increase of over 17 times of the 1986 map [15]. This has engulfed the study area resulting to an unprecedented growth in the population and built-up size in the study area. Thus, as there is increase in land use activities in the study area, so also will there be an increase in waste generated.

V. MATERIALS AND METHODS

A. Nature and Type of Data

The nature of data collected for this research is mainly primary and secondary. The primary data was collected through the use of imagery, survey, and photographs. Secondary data was obtained from existing literatures, Rivers State Environmental Sanitation Authority, and Ministry of Environment. The type of data used for this study include, information on the population within the study area, the location of waste collection point, the land use type of each area sampled, the road network of the area studied. This enabled an understanding of the current trend in waste generation and disposal in the study area to make for the optimization of the collection of waste and of its disposal in the study area.

B. Method of Data Collection

The Global Positioning System (GPS) equipment was used to collect the current location of each waste collection point in the study area to understand the spatial pattern of waste collection and disposal in the study area and was analyzed in the ArcGIS environment. The actual location of each waste collection point (coordinate) as collated using the GPS was dropped in to the base map to show the number of waste collection point in each grid in relation to the entire community and study area. The area of each waste collection point was measured in meters using the metric tape and surveying technique to make for proper understanding of the size of collection point at each location in relation to land use types and population. Population information for each grid cell was collected in raster format from the world pop dataset and computed in accordance to waste collection points in communities to generate population of area hosting waste collection points. This made for easy correlation of population at the grid size in relation to number of waste collection or drop sites per grid area and community/land use of the study area. Base map of the study area was used in the analysis to create a sensitivity map which provided a guide for proper decision making in respect to optimizing waste collection point in the study area in line with basic sustainable measures such as location of waste collection points should be

1. Located at distance away from residence
2. Easily accessed by collection vehicles
3. Not located at road junctions
4. Centripidal to residents
5. Not along or on drainage path

C. Method of Data Analysis

Simple statistical method was used to analyse the data obtained whereby percentages was employed calculated, and used for the explanation.GIS aided output maps were created to generate the sensitivity map of the study area to guide in the optimization of waste collection points across the study area. Also, inferential statistical methods was used for relationship analysis hence, the spatial pattern of waste collection points across the study area was examined using the spatial clustes analysis in the Arc GIS environment. Thereafter the relationship between population and proliferation of waste collection point in the study area was examined using correlation analysis to check for relationship between population, size and proliferation of waste collection points per grid area among communities in the study area.

V. RESULTS AND DISCUSSION

A. Spatial Pattern of Waste Collection

Waste collection spots across the study area were collected using the Global Positioning System (GPS GARMIN etrex 10). The data collected was used to show the spatial trend of waste collection spots in the metropolis as shown in figure 6

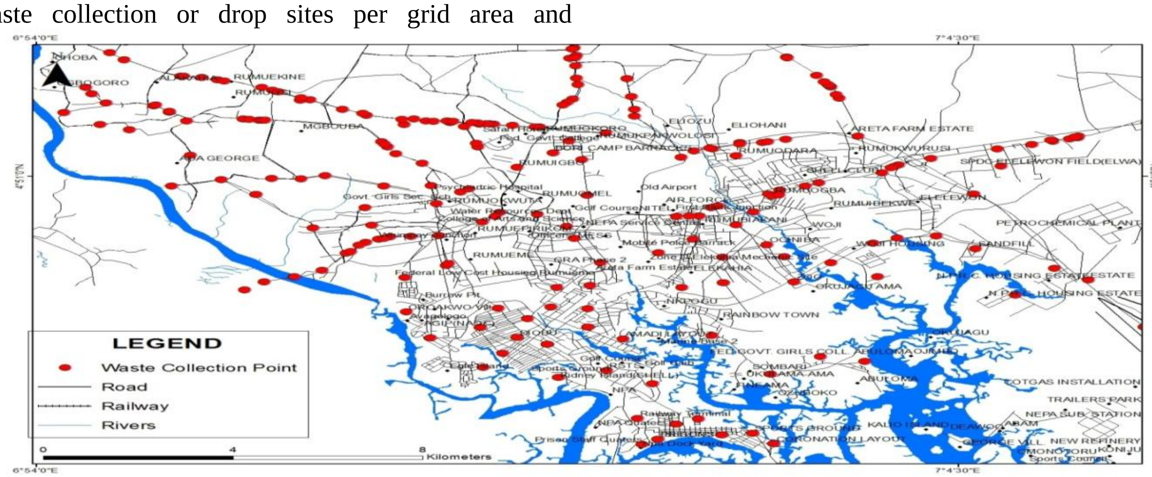
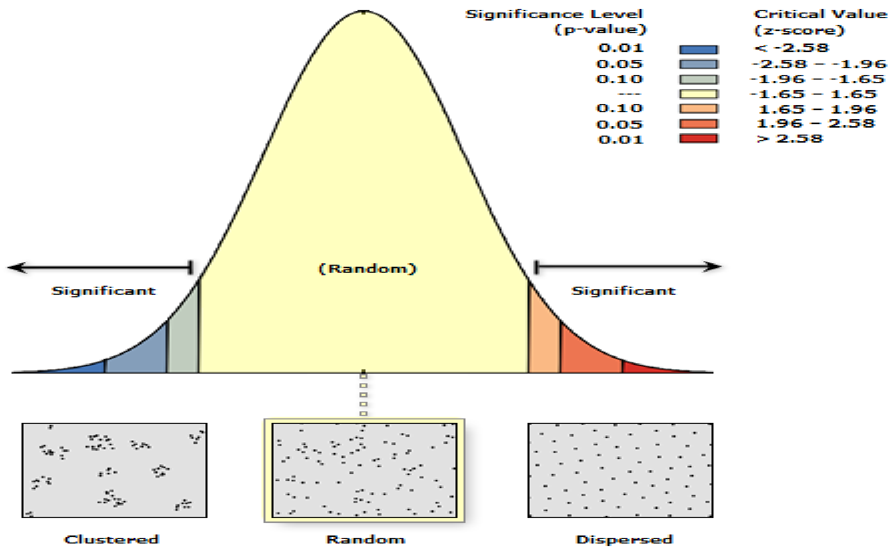


Figure 6 Spatial Pattern of Waste Collection across the Study Area.

The figure 6 shows the spatial trend of waste collection spots across the study area. From the figure, it is obvious that waste collection spots are linear around the middle roads (Paved Crash Barriers). This is because most waste collection spots in the study area are located at the middle of the road using the paved crash barrier as the platform of its location. This development is aimed at making the collection of waste easier for the waste truck drivers maneuvering of the truck in the course of waste collection. The examination of waste collection point's spatial pattern using the Nearest Neighbour Analytical tools gave a Nearest Neighbour Ratio of 1.011003 with a z-score of 0.340726 and a p-value of 0.733310 as shown in figure 7



Given the z-score of 0.340725550591, the pattern does not appear to be significantly different than random.

Figure 7 Nearest Neigbourhood Test for Spatial Trend of Waste Collection Site

Figure 7 shows the Spatial pattern of waste collection points across the study area. From the analysis, it is obvious that the location of waste collection point across the study area is randomly distributed and the randomness of these distributions is not by chance.

B. Optimizing Waste Collection

In order to optimize the location of waste collection point across the study area, several factors were incorporated to measure the sensitivity of locations where wastes are left for collection. The factors looked into for the purpose of this study were access for easy maneuvering of collection trucks, population density, drainage and soil.

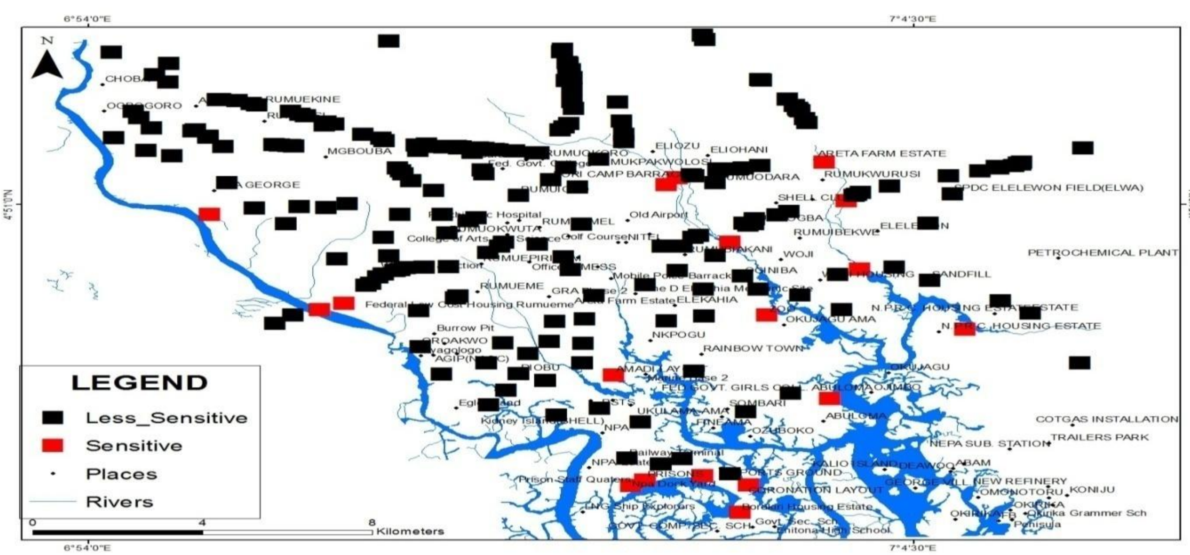


Figure 9Sensitivity Based on the Truck Ability of Maneuver

Figure 9 shows sensitivity of waste collection points based on the ability of collection trucks to maneuver and collect the waste. A 20m shoulder space for vehicle maneuvering during ingress to and egress from service point was buffered across all collection points to derive the sensitivity map of all collection points. This is subject to the concept of least effort in executing works therefore where the truck drivers would find it difficult to collect their waste may result to the abandonment of the waste at such location. These actions of truck drivers will automatically convert the waste collection locations to permanent dump site. The sensitivity of this point was derived directly from field observation across the locations and further categorization in the GIS platform into sensitive and less sensitive points of collection based on maneuvering and access to waste collection points by waste truck drivers. Upon this, the dots coloured black are collection points that are less sensitive to collection while the points coloured red are sensitive to collection by the waste trucks based on the accessibility to the waste collection points.

C. Influence of Population Density and Proliferation of Waste Collection Points

The influence host population on the location of waste collection points was considered. This is aimed at understanding the spatial trend of waste collection point in relation to population density of areas, ranging from high to medium and sparse population density.

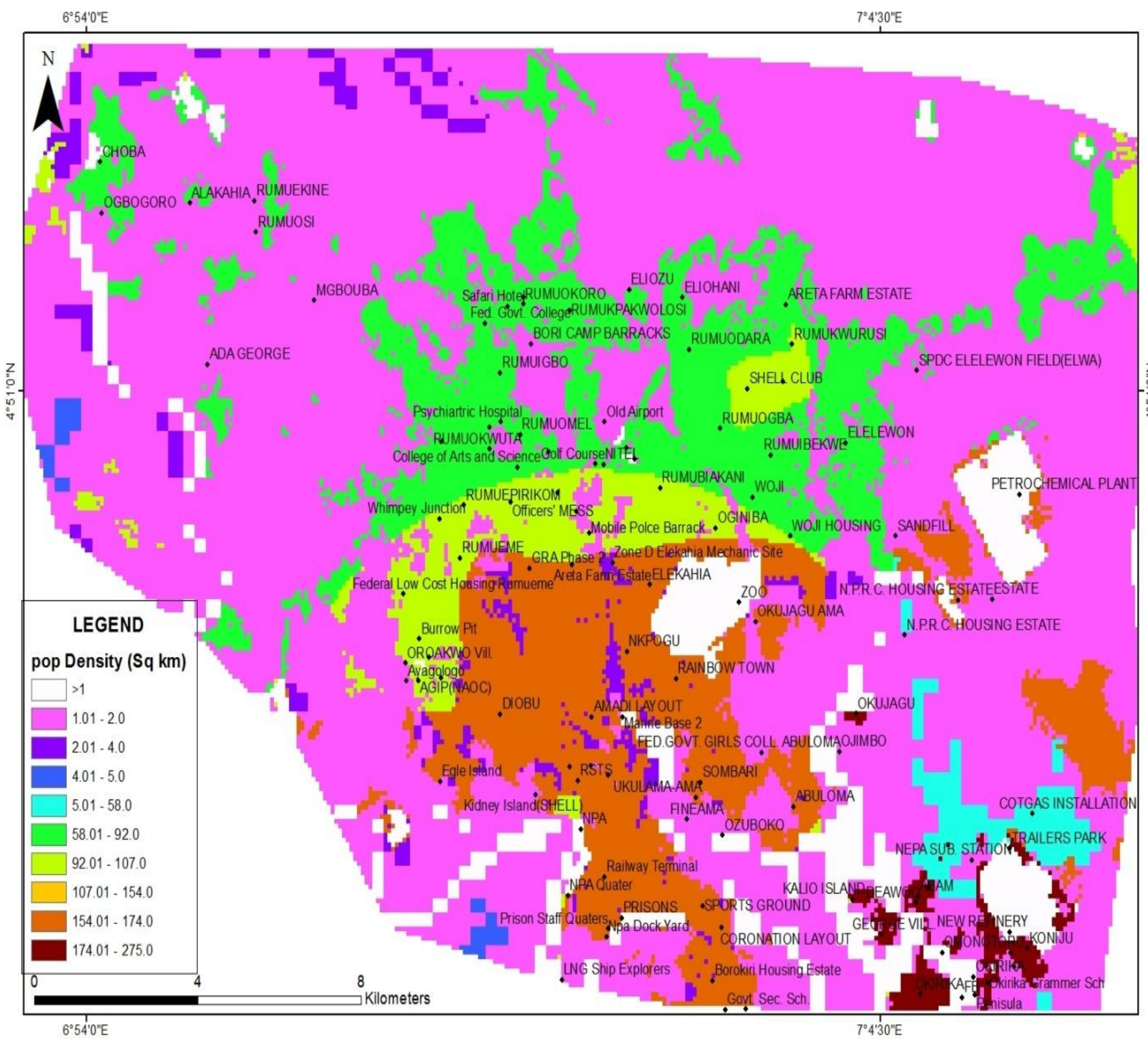


Figure 10 Population Map of the Study Area

The figure 10 shows the population map of the study area in raster format which was used to classify the area based on the population figure of each cell unit derived. The dark brown areas are areas of high population while the green areas are areas of medium population and the area coloured white are area of sparse population in square kilometers.

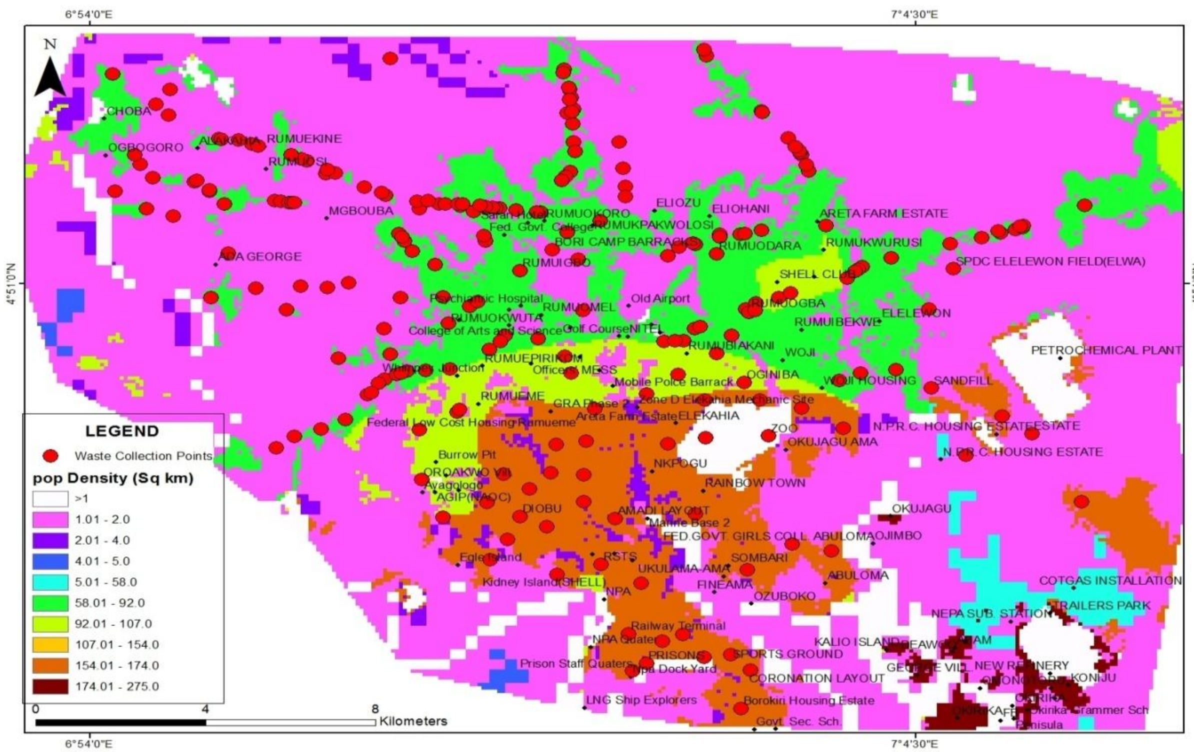


Figure 11 Spatial Trend of Waste Collection Based on Population

From the analysis in figure 11, waste collection points retrieved across all the location in the study area was overlaid on the population map of the study are. The overlay reveals the spatial trend in relation to the population of the places. From the analysis waste collection is noticed across areas of dense to medium population while the areas of sparse population had very little and in some places no collection points located on them. Based on sensitivity of waste collection to population, waste should be located in areas with sparse population rather than in dense population.

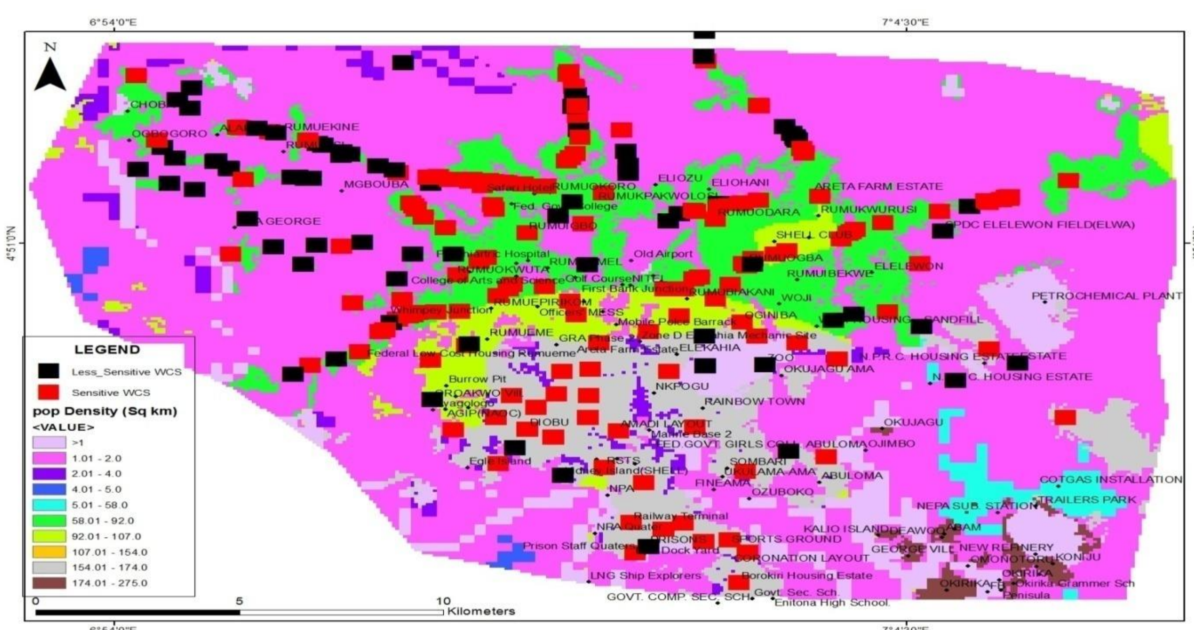


Figure 12 Sensitivity upon Population Density

The figure 12 reveals sensitivity based on population density across the study area. The overlay of waste collection points on the population map of the area allowed for the extraction of the population figure around the cell on which the waste collection lay. This is to ensure a buffering of 30 meter distance from dense or medium population. From the analysis the waste points coloured black are less sensitive to population that are dense or medium while the collection point coloured red are very sensitive to population hence waste collection points in such areas should be discouraged

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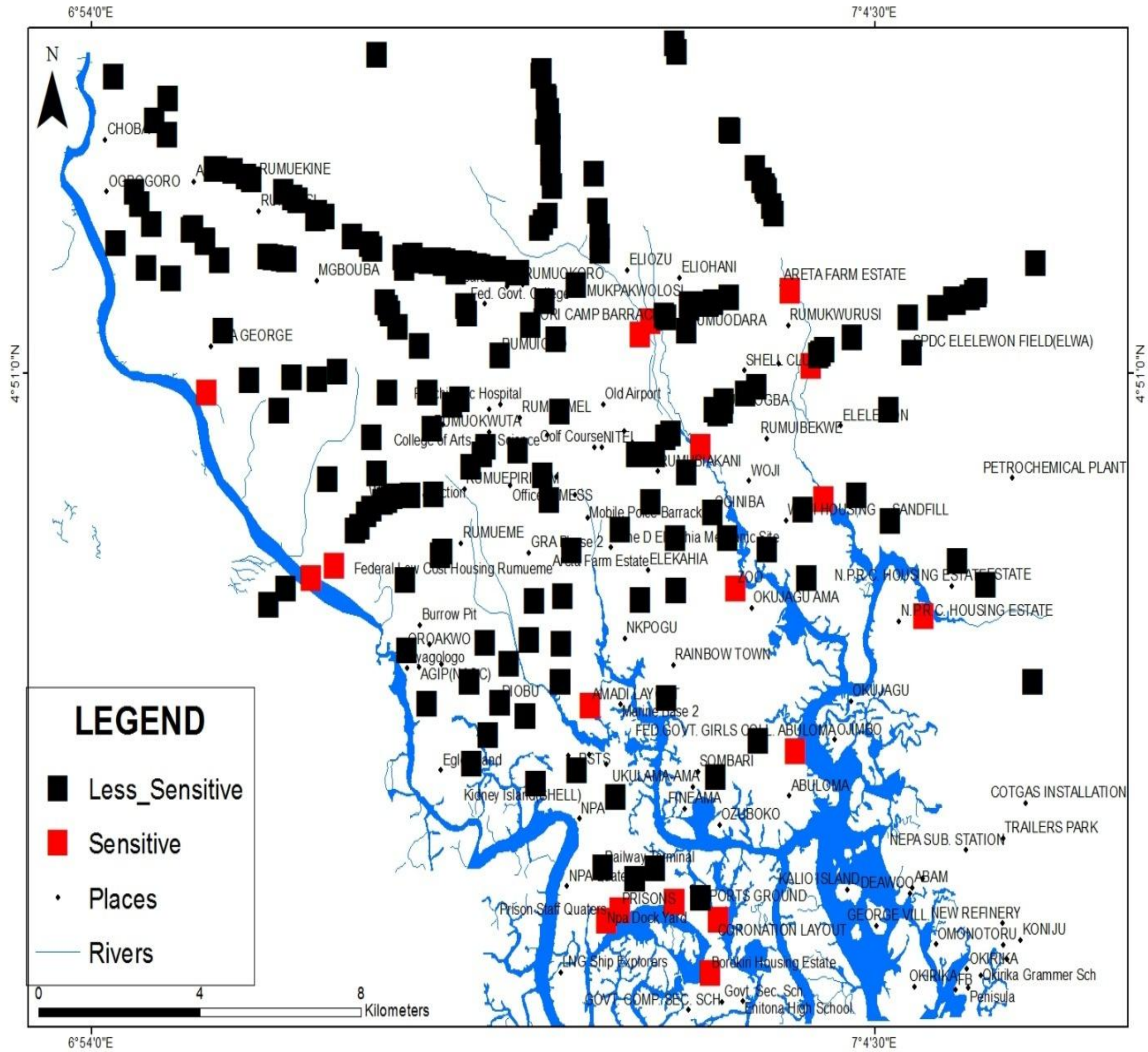

Figure 13 Sensitivity to Water Bodies

The figure 13 was derived from the analysis to attain sensitivity based on 300m distance away from environmentally sensitive areas such as rivers and streams. Each rivers and stream were buffered using a ring buffer of 30 meters to create a sensitivity map of sensitive and non sensitive waste collection points.

From the analysis, the black coloured points reveals waste collection points that are above 300 meters from sensitive environments such as water bodies. Hence in case of flow in to major water bodies' movement of pollutant can be restrained by natural and anthropogenic factors.

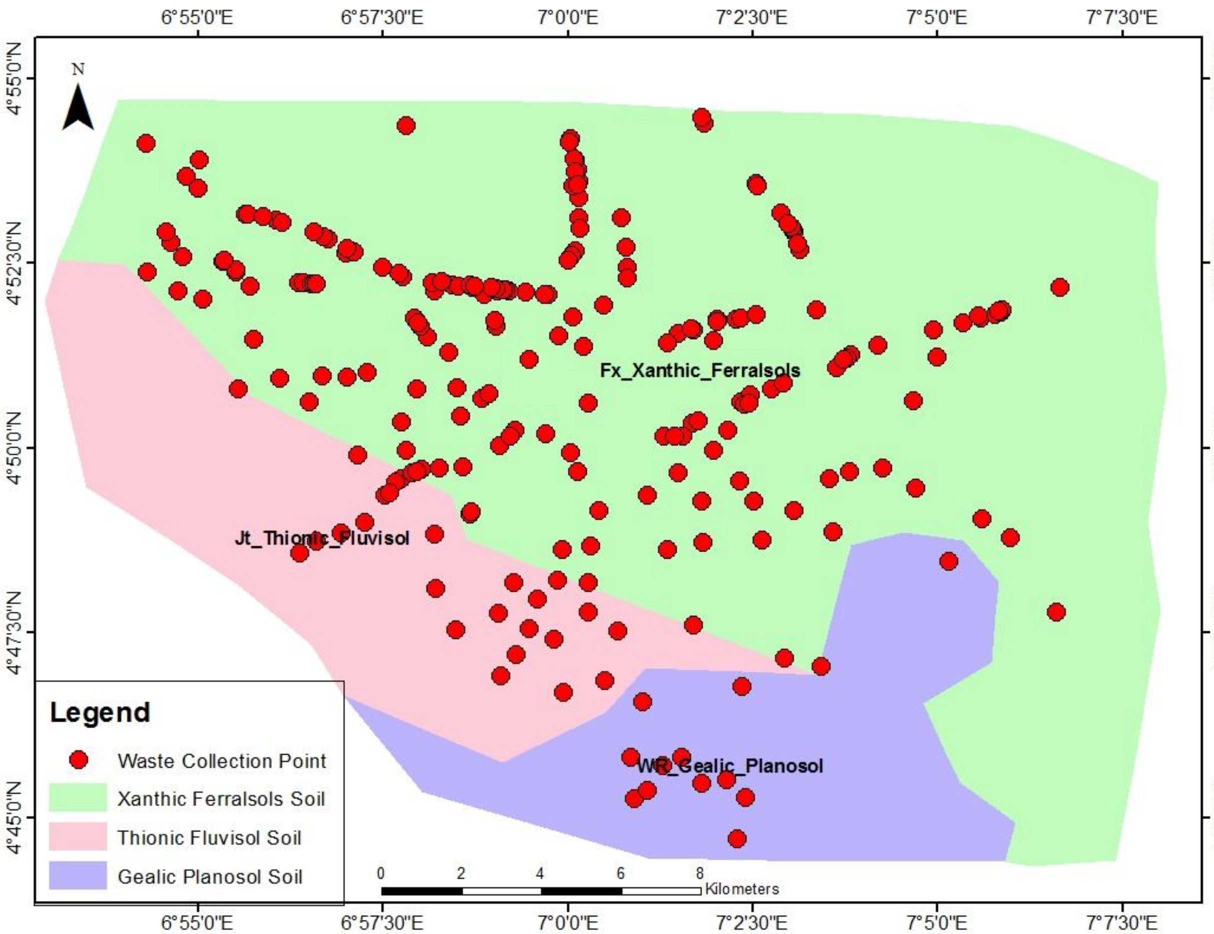

Figure 14 Sensitivity Based on the Soil type of the Region

Environmental sensitivity of waste collection points based on soil types was also don't to ensure the location of waste collection on soil that favours such. This premised that permeability of soils varies from one soil type to another. Therefore the less permeable the soil is the most appropriate for the location of waste collection site in order to avoid the percolation of pollutants into the soil and thereby the ground water as a result of waste derived and deposited for collection within the locality.

From the vector analysis conducted over the region from base vector maps of the region, it discovered that there are three most dominant soil types in the region which are the Xanthic soil, Flouisol Soil and the Planosi Soil as shown in the figure 14. from the analysis most of the waste collection sites are located in the Xanthic, Flouisol Soil types which are both highly permeable allowing much percolation of surface water., hence locating waste collection site on this soil types would not be favourable to the people as it is exposed to sensitive environment such as ground water.

D. Optimized Locations for Waste Collection

The location of waste collection points within the study area is randomly located. This location enables the waste generator to empty their waste can or containers and await the arrival of waste collectors to collect the waste for disposal. The GIS platform provided for the sensitivity analysis of each location across the study area and other locations that are less sensitive to include the location not enlisted presently for waste disposal for collection by service men or trucks. To ensure easy maneuvering of truck in the course of waste collection, area of less impact on communities or populations, maximum proximity to water bodies and location on soil that are less permeable, sensitive and less sensitive waste collection points where derived from the analysis. Hence, the location of waste on the area of less sensitive will enhance environmental friendly location for waste collection from the population. As a result of these preferred locations of less sensitivity, evacuation of waste from the locations should be done within munities to avoid percolation in to the ground water.

VI. CONCLUSION

The analysis on the spatial trend of waste collection site across the study area reveals that waste collection site in the study area are randomly distributed across space in the metropolis. The suitability of waste collection site in reference to the ability of collection truck to maneuver and collect the waste reveals that most of the waste collection sites are less suitability especially in the Northern port of the study area. This could be attributed to the fact that most waste collection sites are located on top of the crash barrier build at the middle of the road. Making it very easy for collection trucks to drive in and collect the waste.

Suitability in relation to population density revealed that most of the waste collection sites are very suitability across the study area as they are mostly located in areas of very high to medium population density. Therefore the location of waste in these areas will expose majority of the population to the effects of waste on health and other human related concerns. Waste collection points at the southern part of the study area eposes the suitability environment to pollution from waste deposited as a result of the drainage network crisscrossing the study area (southern part). Finally, based on the soil classification of the study area, the soils in the Northern part of the study area are very porous and would encourage seepage of liquid derived from the waste deposit. These pollutants may seep into the ground water of the surrounding environment resulting in the pollution of ground water which the people depend for drinking and other domestic purposes.

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