FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 6 No. 4, August, 2022, pp 137 - 143
DOI: https://doi.org/10.33003/fjs-2022-0604-1058

ASSESSMENT OF LANDFILL SITES USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM IN ZARIA, KADUNA STATE, NIGERIA

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ABSTRACT
This study assessed the location of landfills in Zaria LGA of Kaduna State by the use of GIS and RS. Increase in population has brought rapid urbanization, which in turn accelerates the rate of waste generation. This caused indiscriminate disposal of waste in landfills within residential centers, which are not properly located; these are source of disease, pollution, and unaesthetic. Hence, all the landfills in the study area were identified (27 landfills) and their locations or spatial data recorded using a GPS. GIS was employed for mapping and spatial analysis using buffering of 500 meters' proximity to residential houses in order to designate the proper and improperly located landfills. Results of the GIS analyses indicated 2 landfills were properly located, while the remaining 25 were not. Based on the results of this study it is recommended that all the improper landfills should be abandoned and banned by the government; new landfills should be designated at outskirts of the town at distances of few kilometers from the residential houses; pickup points should replace the abandoned landfills, and new ones also be designated for efficient waste management.

Keywords: GIS, GPS, Landfill, Remote Sensing, Site Analysis

INTRODUCTION

Increase in population has brought rapid urbanization, which in turn accelerates the rate of waste generation, that is mostly dumped indiscriminately in landfills, causing serious environmental concerns that poses challenges to human health and general wellbeing (Rahman and Hogue, 2006; Babalola and Busu, 2011). In Zaria, there are concerns regarding the location of many landfill sites with respect to their nearness or proximity to the residential areas; hence their spatial positioning is amongst the important reasons for determining their site appropriateness (Zulu and Jerie, 2017). Public health could be in jeopardy, as people closer to the landfills are suspected to be more unwell than those farther away (Zaidu, 2008). There is concern for suitable locations of many landfills in the study area; regarding whether or not their proximities to the people are within acceptable and safe range in order to achieve healthy and vibrant environment (Zaidu, 2008; KEPA, 2014).

Moreover, the proximity of many of these landfills to the residential houses may have violated the standard threshold of more than 400m away from residential areas set by Kaduna State Environmental Protection Authority (KEPA, 2014). Hence, this study intended to assess the suitability of landfills in the study area based on the proximity criteria amongst the standards set by KEPA.

This is to be carried out through the use of Geographical Information System (GIS) and Remote Sensing (RS). Therefore, the use of GIS provides simple and fast solution to site location question, as it is equipped with in-built modules and tools for buffering, Euclidean distance, and modelling (EPA, 2006). By buffering around a landfill using a standard threshold distance, it easily shows whether it is properly sited or else (Ahire et al, 2022).

The role of GIS is much in solid waste management as many aspects of its planning and operations are highly dependent on spatial data (Zulu and Jerie, 2017; Ahire et al, 2022). In general, GIS plays a key role in maintaining data to facilitate collection operations, as it reduces time and cost of mapping the refuse landfill sites for efficient waste management (Chalkias and Lasaridi, 2011). GIS also provides a digital data bank for present and future monitoring program of the landfill sites site (Sumathi, 2008); and ArcGIS is a platform for spatial data analysis (Bombom et al, 2022)

GIS is an appropriate technique for landfill site analysis and mapping since it has the capability to manage large amount of spatial data that comes from various sources (Al-Ansari, 2013). The use of GIS and remote sensing in landfill and waste disposal issues as well as its management has been documented in many studies including Hassan (2004), Sumathi, (2008) Akpu et al (2011), Chalkias and Lasaridi (2011), Zulu and Jerie (2017), and Ahire et al (2022). Hassan (2004) studied problems associated with waste disposal and collection in Zaria Local Government Area, Kaduna State. The study identified many waste disposal sites were indiscriminately dumped very close to human dwellings causing pollution and diseases to the residents.

Akpu et al (2011) worked on the impact of the spatial distribution of solid waste dumps on infrastructural facilities in Samaru, Zaria, Kaduna State, Nigeria. The primary data sources were GPS survey, satellite imagery of Zaria and personal observation. Seven major dumpsites were identified, which were been dumped in drainages, road networks, schools, and near to residential buildings. This resulted in stagnated polluted water, causing malaria, cholera and typhoid fever as well as environmental degradation. The study recommended that dump sites should be located far away from infrastructural facilities; and that Remote Sensing and GIS be used in planning and monitoring of dump sites.

The aim of this study is to assess the spatial suitability of landfills sites in Zaria Local Government Area (LGA) of Kaduna State, with a view of designating as properly or improperly located for efficient refuse management and sound public health.

MATERIALS AND METHODS

The study area covered the whole of Zaria Local Government Areas, its located between latitude 11° 04′ 23″ and 11°04'23" north of the equator and 7°42′ 25 ″ and 7°42'25" east of the

Greenwich meridian respectively. Zaria LGA is in Kaduna north senatorial district and it occupies a total area of 563 square kilometers. Zaria LGA is bordered to the north by Sabon Gari LGA and to the northwest by Giwa LGA, to the south by Igabi LGA, and to the east by Soba LGA.

Reconnaissance was conducted by combing the area to identify the landfills (27 landfills in number), and was observed that many were too close to the residential areas. Decision was made on the type of instrument that was appropriate for the work, and the procedures and techniques to be employed were selected. A base map of the study area was developed in ArcGIS 10.5. This enables us to study the landfills sites. The instrument used for the include hand held (GPS), laptop computer, scanner and printer.

Field work was carried out using GPS to locate spatial positions (the coordinate) of the landfill. There are temporarily sites located by the roadside (known as pick points), as well as permanent landfill in some parts of the study area situated in gullies, eroded land, waterway and excavated area. Some of the government designated landfills are in filin mallawa, Galma near sectaria, Tukur-Tukur gonan ganye, Kasuwa Danmagaji.

The GIS work includes digitizing the base map of the study area from Google image. The landfills coordinate data were downloaded from the GPS and transferred to Microsoft Excel as points saved as Text (Space Delimited), and saved for further processing. The base map was scanned into the ArcGIS working environment, which was again converted into vector format through on screen digitizing. Scanning automatically captured map features, text, symbols as individual cells, or pixels and produces an automated image.

Digitizing the base map involved converting the analogue map into digital format by tracing the features in the ArcGIS 10.5 environment. During the digitizing process, features from the image are captured as coordinates in point, line or polygon format. ArcGIS interfaces to import satellite imagery as base layer. Alternatively, is by importing selected screenshots from Google Earth through navigating to the study area in Google Earth (Figure 1). Then, 4 control points were added on each corner of the image (Figure 2), then recording their latitude/longitude (coordinates), and exported the image as a jpg file, to complete the image registration.

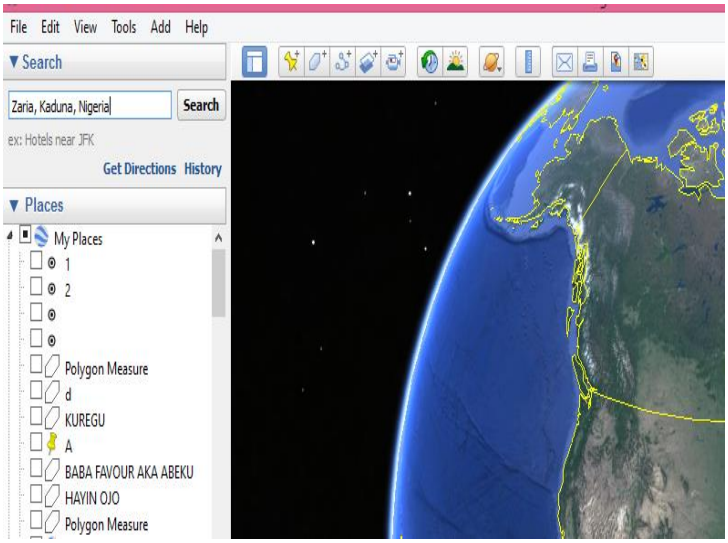

Figure 1: Image download
Source: Google Earth

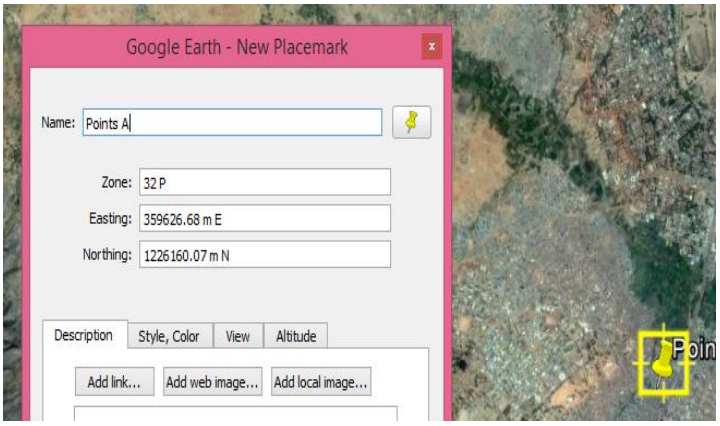

Figure 2: Image registration
Source: Google Earth

Georeferencing the imported google earth image, entails using 4 control points that were created beforehand in Google Earth. In the ArcMap coordinate system was added from the data frame properties by choosing predefined geographic coordinate systems, and then WGS 1984 projection. Then the georeferencing tool was invoked. Then image file was added

from Google Earth software to ArcMap interface. Built pyramids, then zoomed to the top left corner of satellite image from the georeferencing toolbar, click the "add control points" button. Hovered over the exact center of the top left icon created, and left click once then right click once and click on "Input X and Y". Add the correct coordinates for your top-left control point, where X" is LONGITUDE and "Y" is LATITUDE. Repeat the process for the remaining 3 control points (see Figure 3). If the map has disappeared from your view port, just right click on the layer, and select "zoom to layer". To finish your Georeferencing, click on the "Georeferencing" menu item from the toolbar, and select "update Georeferencing" (see Figure 4).

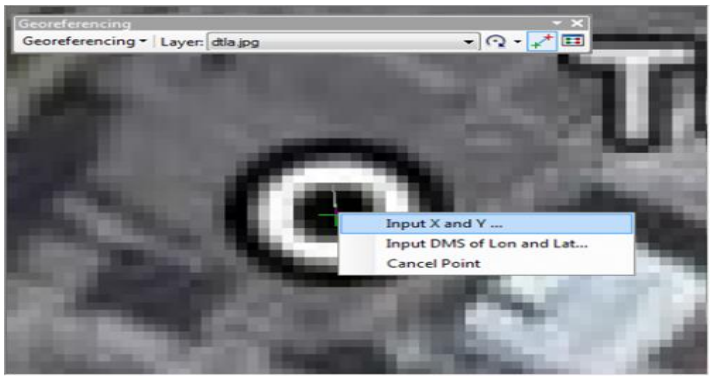

Figure 3: Geo-referencing
Source: ArcGIS 10.5

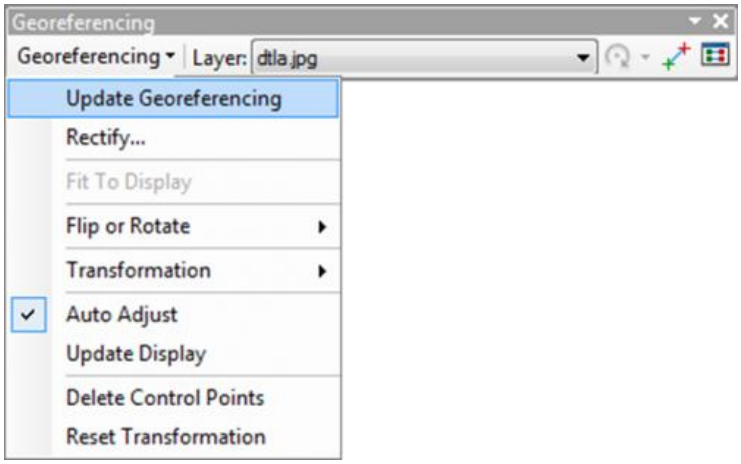

Figure 4: Geo-referencing
Source: ArcGIS 10.5

Digitizing involves using ArcCatalog to create shapefile in a new layer file (points for small isolated features, line for linear features, and polygons for large objects). After selecting polygon for the feature type of the new shape file, then coordinate system was added to the new shapefile. The same coordinate system was selected for the other background layers in ArcMap. If there is no layer added to ArcMap, in ArcMap add at least one GIS layer (assuming the one that you want to have as the background). Add this new blank shapefile to ArcMap. In ArcMap add the editor Toolbar: Clicking the editor/start editing to start digitizing the new shape file. All the landfills are plotted using the GPS coordinates (Table 1).

Table 1: Location/Coordinate of Landfill

S/No	LOCATION	EASTING (m)	NORTHING (m)
1	Pompon gwaiba	359452	1225767
2	Kubanni	360061	1226581
3	Majeh road	360376	1226550
4	Majeh road2	360627	1226164
5	Gyellesu ward	360775	1225976
6	Gyellesu ward	357146	1226663
7	Locost buzai	358173	1220747
8	Kofan gayan (near ganuwa)	358481	1221536
9	Anguwan karfe	358158	1221838
10	Rimin kanbari	357857	1221364

11	Mamuda wafa house	357525	1221873
12	Limacin konan1	357563	1221846
13	Limacin konan2	358710	1222957
14	Kofar fada	359169	1222641
15	Madaka akushi	359281	1222552
16	Anguwan liman beside PHC	358828	1222777
17	Madaka beside gidan tafida	359476	1223202
18	Kofar gidan ciroma (kwarbai)	357913	1222975
19	Anguwan Dan Madaka (kurna)	357775	1222775
20	Iyan juma Tudun masalaci	357244	1222247
21	Galma near secretariat	357089	1225041
22	Garuje (behind Lawal Aliyu)	356611	1225502
23	New market DanMagaji 1	356616	1225522
24	New market DanMagaji 2	359452	1225767
25	Birnin Gwari road	356491	1220871
26	Gonan ganye	353394	1223935
27	Waziri Lawal primary school	363088	1224710

RESULTS AND DISCUSSIONS

GIS analyses were carried out and the outcomes were presented in figures 5, 6, 7, and 8 respectively, and were discussed here under. In an attempt to highlight the study area; as the first objective, the boundary of Zaria LGA. was delineated from the administrative map of Kaduna State. The road network was also digitized, while the settlements, the structures and built-up areas were captured as polygons, and the landfills were presented as points and the result is presented in Figure 5.

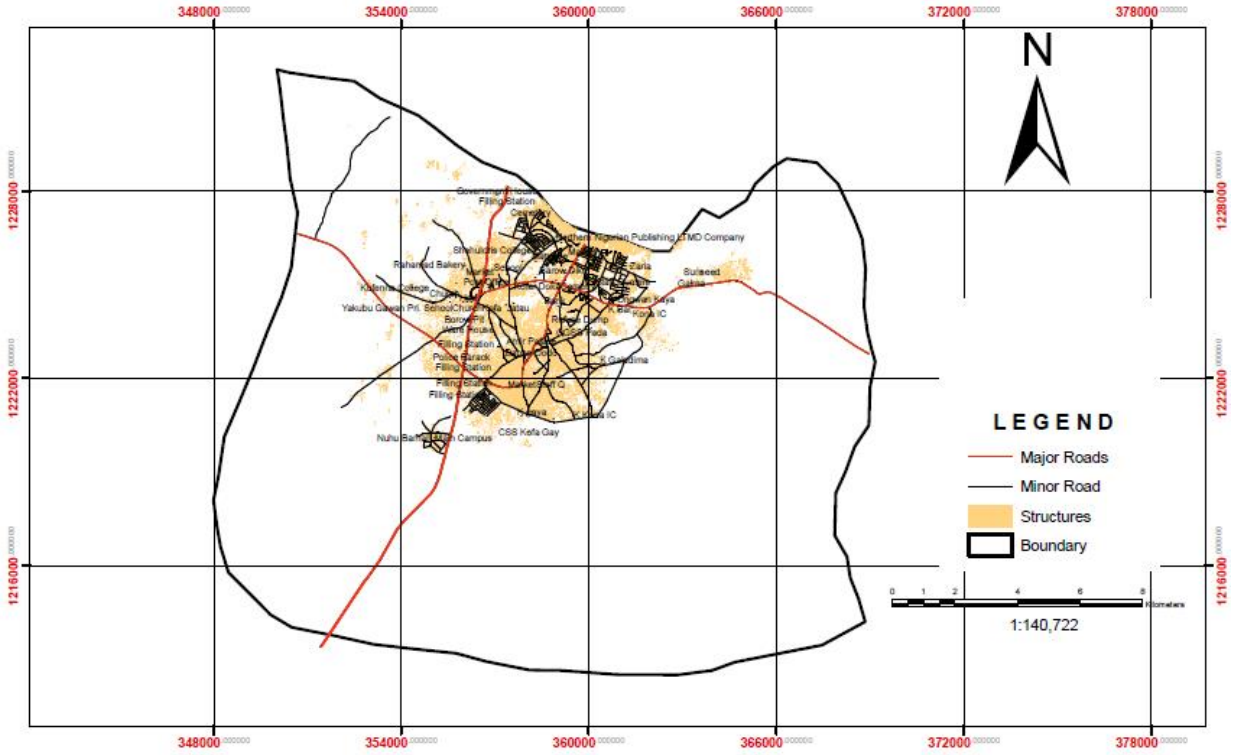

Figure 5: Settlements within the study area
Source: GIS analysis

This section highlighted the spatial distribution of landfill sites in Zaria LGA of Kaduna State, as second objective. The Handheld GPS receiver device was used to obtain the coordinates of each site in the study area. The spatial distribution of the sites was mapped and was presented in Figure 6. A total of 27 landfill sites were located at places within the study area. It can be observed that the landfills are not evenly distributed over the area, but rather tends to be irregular at some flash points such as places with high population density. This could be attributed to the fact the areas are highly populated and people tend to indiscriminately throw away waste, eventually turning the site landfill.

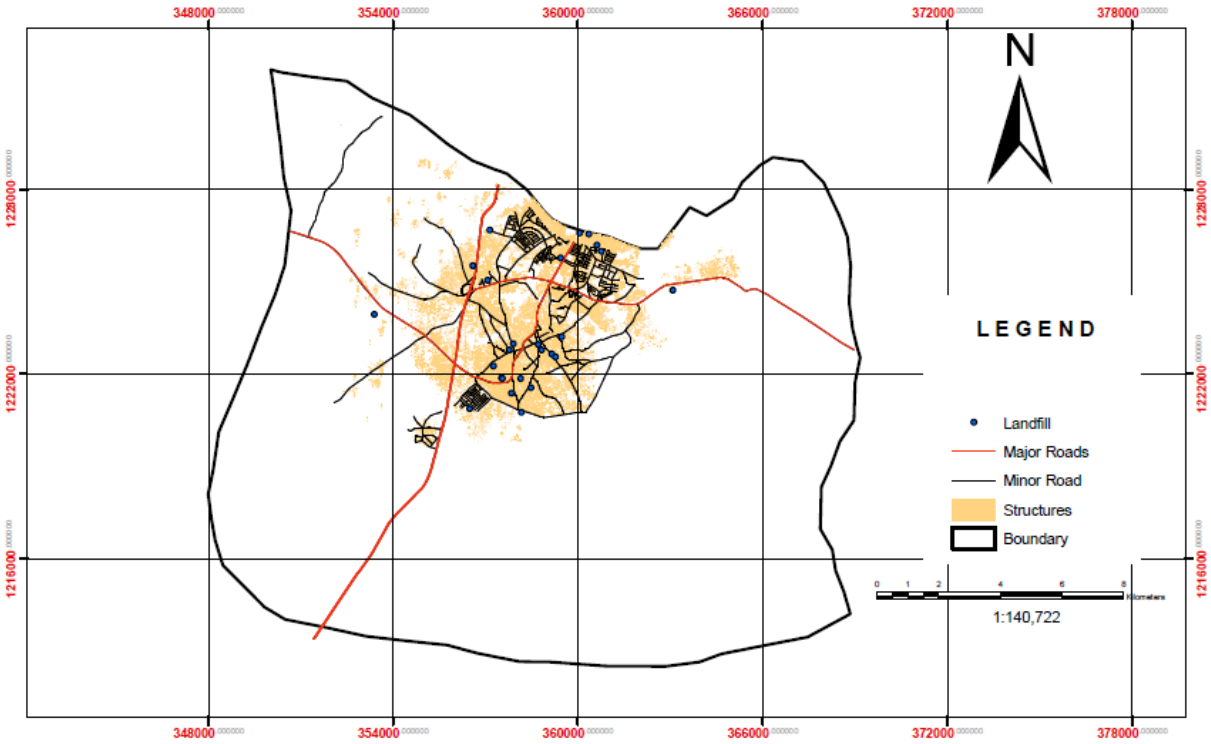

Figure 6: Landfills in the study area
Source: GIS analysis

Figure 7 highlighted the 27 landfill sites within the study area, 5 site were identified as those reserved by government, while 22 were created by users. Observation reveals, the landfill sites reserved by the government could be found somewhat at the outskirts of the study area, while the others were found in close proximity to the residential areas especially where the population is denser. This result indicated that more populated areas generates more waste than lesser population neighbourhoods as residents of such areas tends to dump waste on any convenient vacant land found within that environment.

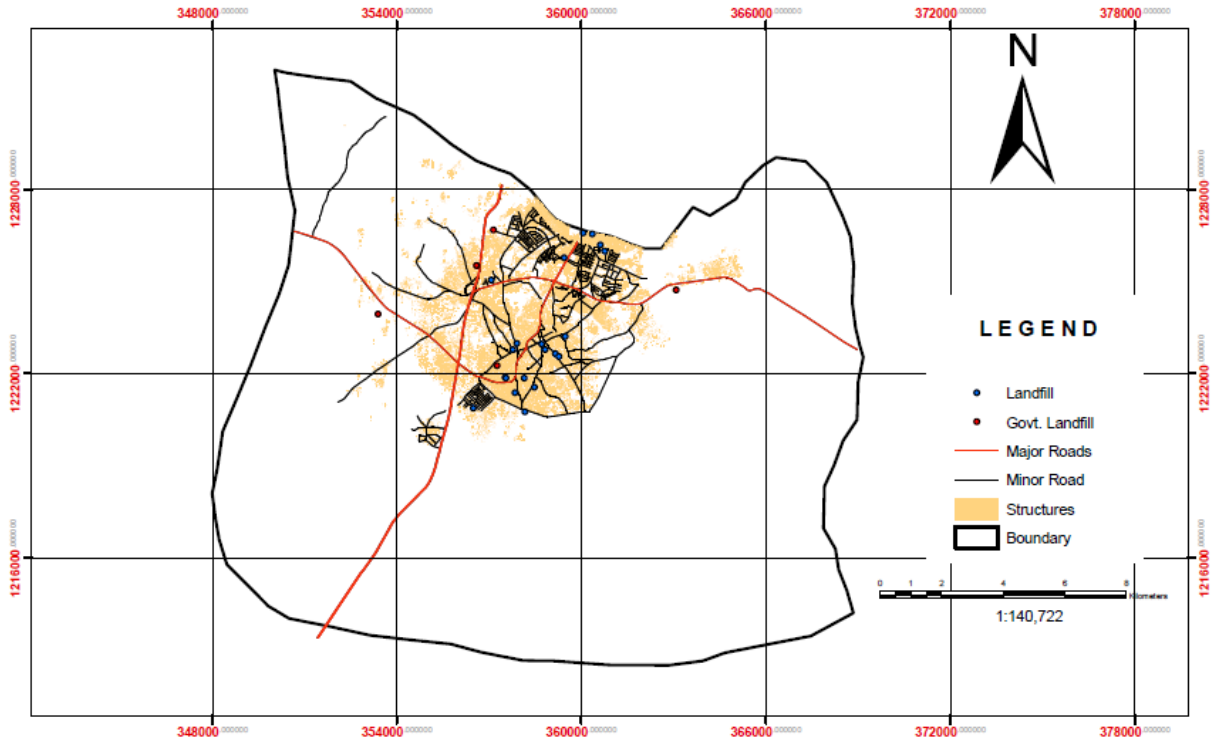

Figure 7: Govt. reserved landfills and others
Source: GIS analysis

Under this section spatial suitability of landfill was assessed by using buffers of 500 meters (KEPA standards) to show proximity or nearness to the people, as the third objective. A Euclidean distance as radius of circle was casted around each landfill to indicate the spatial suitability of the landfills. Figure 8 represented the spatial suitability of the landfills within Zaria LGA, it could be seen that most of the government reserved landfills are located near the outskirt of the study area, which were difficult to be accessed by the people hence the indiscriminate waste dumping. Other accessible ones were not suitable sited as they are too close to the residents and would adversely affect the health and hygiene of the people.

According to Ajibuah (2013), indiscriminate disposal of wastes is the main factor influencing susceptibility of residents along Kaduna River to flooding annually. It was concluded that illegal dumping of refuse may result to fire out break, bad odour, water pollution, proliferation of insect and health hazards among others.

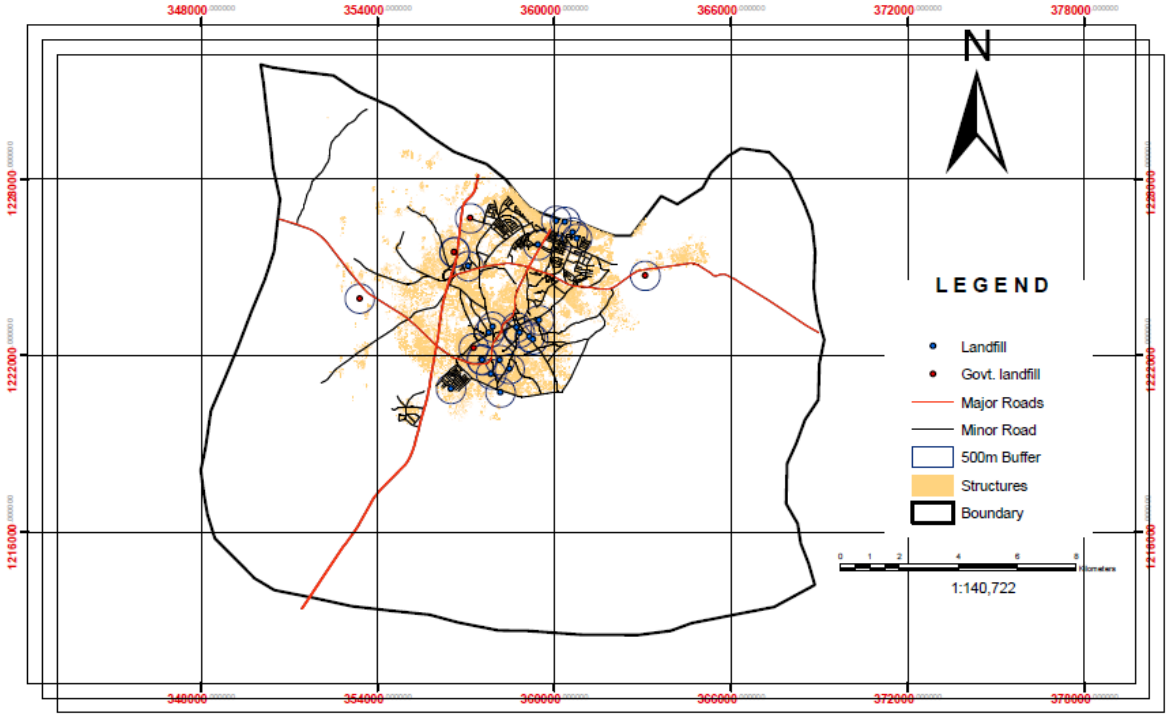

Figure 8: Spatial suitability depicted by circular buffers
Source: GIS analysis

CONCLUSION

This study intended to assess the suitability of landfills in Zaria LGA of Kaduna State by the use of GIS and RS. Hence, all the landfills in the study area were identified (27 landfills) and their locations or spatial data recorded using a GPS. This data as well as an image of the study area from Google were imported into GIS. Hence, the base map of area was digitized and landfills plotted in. Buffers of 500 meters were created around each of the landfills based on KEPA standards of proximity. From GIS analysis, it was found out that only 2 govt. reserved landfills abided by the standards, which depicted that they are appropriately located; while the remaining 25 landfill are not suitable.

Based on the results of this study the following are recommended: all the unsuitable landfills should be abandoned and banned by the govt. New landfills should be designated at outskirts of the town at distances of few kilometers from the people. Pickup points should replace the abandoned landfills, and new ones also designated for efficient waste management. Govt. and stakeholders to ensure frequent evacuation of the pickup points and Landfills.

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