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# GIS IN FACILITY MANAGEMENT OF MULTI-CAMPUS UNIVERSITIES IN NIGERIA: A CASE FOR SOLID WASTE MANAGEMENT IN UNIVERSITY OF NIGERIA, ENUGU CAMPUS.

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## ABSTRACT

Solid waste management has posed serious environmental threat and challenges over the years especially in developing countries. There seems to be poor solid waste management system in Nigeria universities with University of Nigeria not being an exception. This study examined the effectiveness of the waste management system through automation of the system using Geographical Information System. Data was collected through direct field observation using Geographical Positioning System and IKONOS for image data of University of Nigeria, Enugu Campus. A geodata base was created and several spatial analysis was performed using ArcGIS 10.5.

**Keyword:** Facility Management, Geographical Information System, Geographical Positioning System, Solid Waste Management, University of Nigeria Nsukka

## 1.0 INTRODUCTION

Solid waste is an inevitable by-product of man's activities. As the population increases so will the rate of waste generation increase. Hence, solid waste management becomes paramount. The dynamics in demographics certainly demand more proactive approaches in solid waste management. No doubt, challenges in management of solid waste is a global phenomenon, however, Global South has more issues with solid waste management. Nigeria, a well-known developing country in West Africa is no exception to this. The challenges in solid waste management in most developing countries has increased in recent times due to increases in population, industrialization, urbanization and globalization (Butu et al, 2013). Municipal solid wastes are generated from various sources and are stored in bins and dumpsters that are placed at various designated areas for collection by the management agency.

Solid waste is solid or semi-solid materials resulting from human and animal activities that are useless, unwanted or hazardous (Huang, 2008). Solid wastes are refuse which are useless, unwanted or ill-discarded materials that arises from man's daily activities. It should be properly disposed of. Waste can be classified on the basis of source of generation and type (Muniu et al, 2017). The classifications based on source include: residential, commercial, institutional, municipal, industrial and agricultural. On the other hand, the classifications based on type include: garbage, ashes and residues, combustible and non-combustible, bulky wastes, street wastes, biogradable and non-biodegradable, dead animals, abandoned vehicles, construction and demolition waste, farm waste, hazardous wastes and sewage waste.

Tertiary Institutions have enormous challenges dealing with solid waste. This is more so due to population surge in the admissions year by year. The case of University of Nigeria is further visible with the multi-campus operated by the Institution. The University has the following Campuses:

i. Nsukka Campus
ii. Enugu Campus
iii. Ituku Ozalla Campus
iv. Aba Campus

The locations of the dumpsters/ waste bins, prompt evacuation of the bins and distances of the bins from buildings are basic environmental challenges.

Recourse to the provisions by the Nigerian Universities Commission (NUC) and Nigerian Environmental Standards and Regulations Enforcement Agency (NESREA) revealed that emphasis was on adequate provisions of the waste bins/ dumpsters. No guidelines or stipulations on distances from buildings for instances. Furthermore, the need for route optimization in placement or location of the dumpsters necessitated an automated approach to the solid waste management in our tertiary institutions. The use of sensors will also ensure timely evacuation of the waste once an alert is received.

A lot can be achieved through automation of the solid waste management in our tertiary institutions. University of Nigeria, a foremost Federal-owned tertiary institution in Nigeria has no official geodata base for its solid waste management. This paper thus makes a case for improved solid waste management in University of Nigeria, Enugu Campus by automation of the system through creating a geodata base for solid waste management and spatial analysis thereafter. The aim of this paper is to examine the application of GIS in determining the spatial location and distribution of the solid waste dumpsters in University of Nigeria, Enugu Campus with a view to achieving a more efficient and effective solid waste management system.

The specific objectives are:

i. To find out the various locations of the dumpsters/waste bins in UNEC
ii. To carry out spatial analysis for route optimization, suitability of the dumpsters location among others
iii. To develop geodata base for the waste dumpsters in UNEC

# 2.0 LITERATURE REVIEW

## 2.1 Conceptual Review

### 2.1.1 Concept of Geographical Information System

Geographic Information Systems (GIS) are a powerful set of computer-based tools used to collect, store, manipulate, analyze and display spatially referenced information (Burrough & McDonnell 1998; Rusko et al, 2010; Yogesh, 2018). GIS is a computerized system that combines spatial and descriptive data for mapping and analysis (Brooker, 2002). GIS are a set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes (Burrough, 1986). Geographical Information System is any system that captures, stores, analyzes, manages, and presents data that is linked to location (Akankpo, & Igboekwe, 2012). GIS is an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (Environmental Systems Research Institute, 1990). Technically, GIS is a system that includes mapping software and its application to remote sensing, land surveying, aerial photography, mathematics, photogrammetry, and geography. (Akankpo, & Igboekwe, 2012).

One of the main strengths of a GIS is its ability to integrate different types of spatial data. GIS provides facilities for data capture, data management, data manipulation, analysis, and the presentation of geographical data (Arnoff, 1989; Rusko et al, 2010). GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps (Environmental Systems Research Institute, 1990). From the foregoing, we define GIS as a computerized tool that is used to collect, store, manage, manipulate, transform, analyse, update, display and retrieve geographical data in a quick and efficient manner in other to aid analysis and decision making.

### 2.1.2 Solid Waste Management (SWM)

Waste management involves the collection, transportation, processing, disposal, management and monitoring of waste materials (Coker et al, 2015). SWM is the control of generation, storage, collection, transfer, transportation, processing and disposal of solid wastes in a manner that is in accord with the best

principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations (Yadav, 2015). SWM basically includes the storage, collection, transfer, transportation, disposal, and treatment of solid waste which includes recycling of organic waste, thermal treatment techniques, recovery of recyclable products and landfilling (Sharholy et al, 2008). In its scope, SWM includes all administrative, financial, legal, planning and engineering functions involved in the whole spectrum of solutions to problems of solid wastes thrust upon the community by its inhabitants (Tchobanaglous et al., 1997). SWM is made up of many drivers that can be used to reduce the volumes of solid waste and this are reusing and recycling materials, composting, and source reduction (Jibril et al, 2012). The main objectives of SWM are the maintenance of clean and hygienic conditions and reduction in the quantity of solid waste (SW), which is disposed of in the sanitary landfill facility (SLF) of the area after recovery of material and energy from it (Ammar et al, 2019).

## 2.2 Empirical Review

### 2.2.1 Review of Studies on the Application of GIS in Educational Institutions

Makinde et al. (2020) examined the use of GIS geo-database for waste management in University of Lagos, Nigeria. Data was retrieved via field observations using GPS, questionnaires and interviews, and Google Earth satellite image data of the University of Lagos. A geo-database was created, and several spatial analyses were performed using ArcGIS 10.6 and MySQL software. The study revealed that the model created could serve as a useful alternative method in managing waste in the University. Arrasyid et al. (2019) developed a space-based geography learning media for high schools in Indonesia. This study used a quasi-experimental design to examine the influence of GIS in geography learning. The study population were social class eleventh graders at SMAN 15 Kota Bandung, Indonesia which is the experimental site as well. The analytical technique used was Kolalogov-Smirnov. The study created and developed a user-friendly GIS system which was able to display data in a variety of formats. The user interface was designed to be simple with such basic facilities as thematic maps, data searching, and data display in various formats. The GIS-based learning media developed showed significant influence on learning achievement of learners.

Lin & Li (2018) developed a campus navigation system in China using GIS. The system included four function modules for map query, campus navigation, campus environment preview and campus profile. The campus navigation function modules accurately provided the school road conditions and building facilities to visitors, helping them to familiarize themselves with the location and information of various types of building facilities on campus and selecting the optimal route. The campus profile function was used to identify and connect properties. Campus environment preview function was used to show the real shot maps of the various facilities on campus. The campus navigation system describes the distribution of

campus teaching facilities, living facilities, other buildings, and relative location relationships. Inyang (2018) examined the use of GIS in University of Calabar library. The study traced in-use statistics in the different divisions of the library for a 3-years period which gave the data for study of all the functional areas. Analysis was presented using different types of GIS charts: Lines with markers charts, Radar charts, and a 3-D 100% stacked column chart. The findings revealed that the library use data can be represented using a GIS. When data is accurate, whatever GIS design used for presentation and visualization will be accurate, most times self-explanatory and easy to understand.

Ngunyi & Makokha (2017) examined the application of web GIS in accreditation and monitoring of professional training institutions in Kenya for quality assurance. A survey of user requirements was undertaken. Spatial locations of training institutions were digitized using Google Earth geobrowser. An accreditation geodatabase was designed in ArcGIS, and used to store both spatial and attribute data. The data was then exported to ArcGIS Online where the use of web GIS technology ensured the creation of an Accreditation Web App. The app simplified the accreditation process and offers accreditation officers, students and other stakeholders a web-based GIS enabled solution. It also provides management with the ability to perform market research, and integrate the app with other existing systems in order to enhance efficient use of resources. Al-Rawabdeh et al (2014) built a 3D GIS map and all utility information for Al al-Bayt University campus to improve its data management and to develop methods using 3D spatial analysis for specific applications at the university. The study showed that 3D GIS model expresses terrain features in an intuitive way which enhances the management and analysis of a proposed project through 3D visualization. The 3D GIS model provides access to mapping data to support planning, design and data management. Integration of GIS spatial data with campus organization helps to improve quality, productivity and asset management.

Haghparast et al. (2013) examined the use of GIS in carbon sequestration in Pune University. GIS Arc view 9.2 was used along with field measurements to obtain accurate calculation and interpretation of different layers of ground biomass, soil organic carbon, leaf litter, herb biomass distribution and it was used as a technique for indicating dominant species in the study area and marking hot spots of the project. The study revealed that the Dalbergiamelanoxylon and Gliricidia sepium are the most dominant species in terms of carbon sequestration, whereas species such as Ficusbengalensis and Samaniasaman, Cocosnucifera and Delonixregia were categorized next to this two species. GIS based map showed the location and value of above-ground carbon sequestration for each plot in the study area.

Akankpo & Igboekwe (2012) examined the application of GIS in mapping of groundwater quality for Michael Okpara University of Agriculture Umudike, Nigeria. GIS software ILWIS 2.1 was used to

analyze and create groundwater pollution sensitive zone map. Spatial variability maps of different groundwater quality parameters were generated using interpolation operation in the software and were incorporated as data layers in the software for further generation of groundwater pollution sensitive zone map. The effect of various data layers (elevation map, contour lines, and land use activities) on the distribution of groundwater pollution was also studied. The study revealed that GIS software is very useful in the analysis of topographic slope, groundwater table variation and land use activities in the distribution of groundwater pollution.

Ibraheem & Falih (2012) built a GIS based system for Nahrain University that provides information for use on which all aspects of the Pavement Maintenance and Management System (PMMS) process can be built. Twenty three sections was selected along the roadways of Nahrain University and all these sections were found to be in bad conditions. The present serviceability binder (PSI) of these sections ranged between 1 to 4, and most of these sections in the low ranged between 1 to 2. The study revealed that the spatial nature of transportation data makes GIS a logical choice on which to base systems such as pavement maintenance system (PMS). GIS has proved to be an effective tool for integrating, managing, storing, displaying, mapping, querying, and spatially analyzing transportation data.

Donnelly (2010) gave an overview of free and open source (FOSS) GIS software and posed the question of whether libraries and academic departments should consider adopting FOSS GIS. The process of creating a basic thematic map was used to test six FOSS GIS software packages. Each of the individual FOSS GIS packages had their own particular strengths and weakness, and some performed well for thematic mapping. The FOSS packages generally were weaker compared to ArcGIS in terms of support for various projection and coordinate systems, joining attribute data to GIS files, and automatic labelling, but their advantage was that they were free in terms of cost and licensing restrictions. When coupled with plug-ins and helper applications the viability of the FOSS GIS packages increased.

Fisher & Toepfer (1998) surveyed fisheries programmes at 24 US universities about their training in GIS and uses of GIS in fisheries research. The study revealed that on average, 21% to 40% of fisheries faculty and students indicated they occasionally used GIS in their research. The most common fisheries-related uses of GIS were mapping and modelling fish distributions and aquatic habitats, and evaluating the effects of watershed land use on fish populations, communities and habitats.

### 2.2.2 Review of Studies on Solid Waste Management (SWM) in Tertiary Institutions

Ugwu et al. (2020) examined the waste generated in the University of Nigeria, Nsukka campus using ASTM D5231-92 method. The study revealed that 96.58% of the total waste is recyclable, and has about 51.85% biomass potential. Parvez et al (2019) evaluated SWM at Indian Institute of Technology Roorkee (IITR). Data was retrieved through observations, interviews with staff and students, and documents from the campus authorities. The SWM at IITR was disorganized and incompetent. Lack of awareness and improper collection, imprecise segregation, exposed transportation, inefficient processing and disorganized disposal of solid waste are the major reasons for it. Moqbel (2018) evaluated the SW characterization of the University of Jordan. The study estimated the generation rate of SW generated on campus. The study revealed that 87% of the waste generated on campus may be recycled.

Coker et al (2015) examined SWM in Covenant University. Data was gotten using key-informant interview and personal field observations. Results showed that SW were collected using appropriate waste collection bags and mobile bin positioned at strategic corners of the university premises. The waste materials after collection were segregated into plastics, bottles, nylon and organic materials by scavengers. Ekong & Enefiok (2013) examined waste disposal habits of the students of the University of Uyo. Questionnaire, interview and observation was used to retrieve primary data. The study revealed that the environments where students are accommodated was poor as a result of the indiscriminate waste disposal habits of the university students. Jibril et al. (2012) analysed the Reduce, Reuse and Recycle strategic approach for the awareness amongst the waste generators within Higher Educational Institutions. The study used exploratory research approach relying on secondary data. The study revealed that most of the Institutions and communities do not use 3R s system in managing their waste generated, which threatens the health of human and other living organisms.

Gakungu et al. (2012) examined SWM in 29 public technical training institutions. Students, principals, and officers in-charge of waste management in the institutions were administered with questionnaire and interviewed. Direct observations was also used in the study. The study revealed that the cost of SWM in the institutions was dependent on both the waste generated and the institutional population. Taghizadeh et al (2012) analysed the wastes generated in University of Tabriz. Sampling of waste and determination of waste composition methods was according to standard for determining unprocessed municipal SW composition (ASTM D5231- 92), and waste handling trucks were weighed. The results showed that more than 80% of waste generated could be diverted through waste reduction, recycling and composting activities. Olusegun & Udonwan (2012) analysed the SW materials generated in selected sites in Covenant University, Nigeria. During the 10 weeks study period, solid waste were weighed before their

delivery to landfills. The study showed that SW could be managed using landfill system, bio-gasification scheme, recycling, co-incineration, pyrolysis, and gasification system.

Smyth et al (2010) evaluated the waste generated by Prince George Campus of the University of Northern British Columbia (UNBC). Waste haulage and disposal records were obtained through the UNBC facilities department and key informant interviews. The location of interior and exterior waste, recycling and compost receptacles were mapped. The Wilcoxon signed-rank test was used for analysis. The study revealed that more than 70% of waste could be diverted through waste reduction, recycling and composting activities. Malakahmad et al (2010) analysed the SW generated at University Technology Petronas (UTP). Questionnaire was administered to students and staff in the campus. The study revealed that 80% of students and staff were interested to take part in recycling activities only 53% of them have practiced in it and the main reasons were that 75 and 83% of them could not find suitable and enough number of recycle bin, respectively. Up to 80% of produced materials at academic building are recyclable.

Farzadkia et al (2009) investigated SWM in eight teaching hospitals of Iran University of Medical Sciences. Data was retrieved through a questionnaire and direct observation. The results showed that the challenges of SWM in the study area were lack of separation between hazardous and non-hazardous waste; absence of the necessary rules and regulations applying to the collection of waste from hospital wards and on-site transport to a temporary storage location; lack of proper waste treatment; and disposal of hospital waste along with municipal garbage. Vega et al. (2008) evaluated the recycling potential of SW for the Campus Mexicali I of the Autonomous University of Baja California (UABC). The research methodology involved estimate of the daily SW generation; SW sampling and characterization of samples; and data capture and analysis of the amounts and types of wastes generated. It was found that more than 65% of SW are recyclable or potentially recyclable. Dehghani et al (2008) evaluated SW generated in 12 educational hospitals of Tehran University of Medical Sciences. Descriptive, cross-sectional and interviews with the authorities of the healthcare facilities and personnel involved in the management of the wastes was conducted. The results showed that 92% of medical wastes of hospitals were collected by covered-trucks. In 46% of hospitals, transferring of medical wastes to temporary stations was done manually.

### 2.2.3 Application of GIS in Facility Management (FM)

Mirarchi et al (2018) examined FM processes through end-users' integration and coordinated BIM-GIS technologies. A workflow was defined and designed, in which a FM supporting platform was proposed and characterized, featuring indoor positioning systems to allow end users to send geo-referenced reports to central virtual models. Result showed that the integration of end users in the maintenance processes

through smart and easy tools can overcome the existing limits of barcode systems and building management systems for failure localization. The proposed framework allows the identification of every element of an asset including wide physical building elements without requiring a prior mapping; and the entire cycle of maintenance activities is managed through a unique integrated system.

Makinde et al. (2017) created a 2D and 3D visual facility map of University of Lagos. The spatial attributes of the facilities were collected with the aid of total stations. Google earth software was used as source of data to produce 2-dimensional facilities through digitization process. SRTM Digital elevation model image was downloaded from United State Geological Survey website to give the elevation data required for the 3-dimensional representation. All these data were processed with ArcGIS 10.2.1. The 2D and 3D model carried out in this project identified numerous cultural and natural ground features, such as roads, buildings, power transmission lines, lakes, streams, swamps, slopes, trees cleared land, highway names etc. Kang et al. (2016) created a software architecture for the effective integration of BIM into a GIS-based FM system at the Korea Institute of Construction Technology (KICT). The databases which were integrated with the current system for information interoperability, were Excelbased structures constructed for the BIM-based FM of the main building at KICT, and the BIM objects were modeled using the Revit software. For a GIS based FM, the property information was extracted from BIM models and transformed using the ETL (extract, transform, and load) concept. The results show that BG-DI and BIM/GIS integration has benefits such as reusability and extensibility.

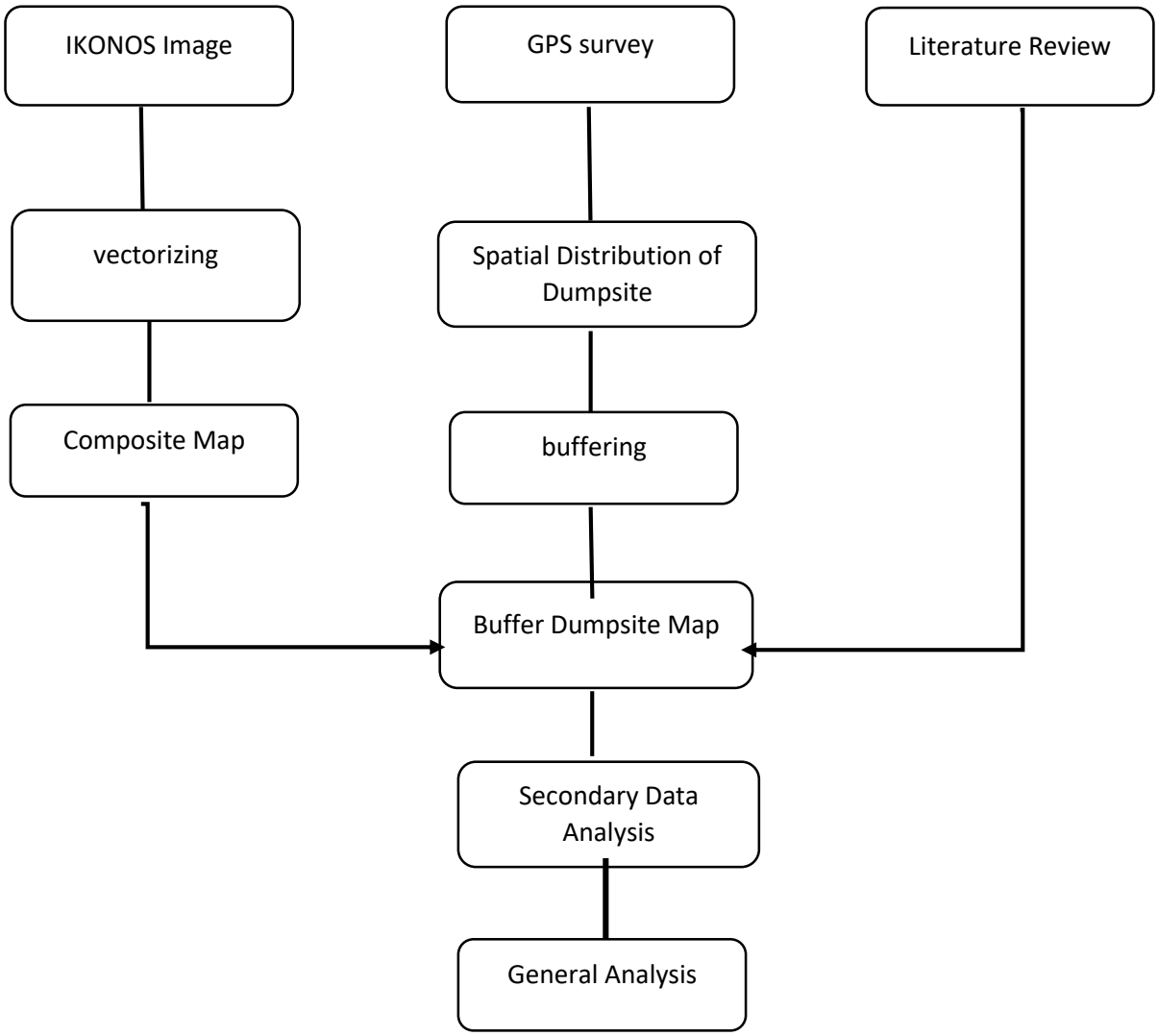
Mwaniki & Odera (2014) examined the application of GIS in space management in International Livestock Research Institute (ILRI). A GIS database which integrated spatial and non-spatial data of facilities in ILRI was built. Data obtained from AutoCAD, ArchiCAD and PDF files was geo-referenced, and used to create spatial entities. Non-spatial data was obtained from Excel and PDF files. GIS analyses were then carried out on the data stored in the geo-database. These analyses included determination of the main types of facilities that occupy the organizations' space and their areas; and potential locations for fire assembly points. Finally a web map of the underground and surface facilities was built using features stored in the geo-database. Motuka (2008) developed an integrated GIS of the U-block of the Kenya Polytechnic University College. ArcView GIS and/or ArcGIS, Microsoft Access, and Microsoft Excel, was used to provide operations of data input and conversion**.** The floor plans (after digitization) and the room-specific data were analyzed using GIS software. From the U-Block database, the study was able to extract information on the amount space available, the department to which some space is assigned, and the maximum number of students a room can accommodate (stations).

An important fact that has emerged from the review of extant related literature is that most previous studies on the GIS application was centered on issues such as space management, facility mapping,

carbon sequestration, mapping of ground water quality, management of transportation data, use of library resources, and campus navigation. Only the study of Makinde et al. (2020) examined the use of GIS in waste management; however, the study was domiciled in the University of Lagos. Therefore from literatures available to the researcher no study has examined the application of GIS in solid waste management in the University of Nigeria, Enugu Campus; hence the need for this study to also fill this extant literature lacuna.

## 3.0 METHODOLOGY

The primary data include the geographical coordinates of all the dumpsites in the UNEC using hand held GPS while the secondary data used include; administrative boundary maps (Ancillary data). The methods adopted for data collection were: Field survey was conducted using handheld GPS, GARMIN 78sC to obtain Geographic Coordinate of dumpsites located within UNEC. Secondly, high resolution Image (IKONOS) covering UNEC was used to extract and produce the Composite Map. Data was analyzed in ArcGIS 10.5 in Windows OS environment.




**Flow chart of methodology**

**Figure 1: Flow Chart of Methodology**

## 4.0 RESULTS AND DISCUSSION

Geospatial analysis of the waste management facilities, reveals a total of 41 dumpsters and 2 major waste collection points (Located behind Lady Ibiam Hostel and Ojukwu Hostel) were identified in the University of Nigeria, Enugu Campus and mapped. The resulting feature layer was used to develop a waste collection system. It was observed that there were more dumpsters located in the Northern part of the university when compared to the other parts. This could be because of the high population of people occupying that axis of the university. The administrative offices of the university and guest house are in this section of the university, while the Southern side are where the staff quarter is located

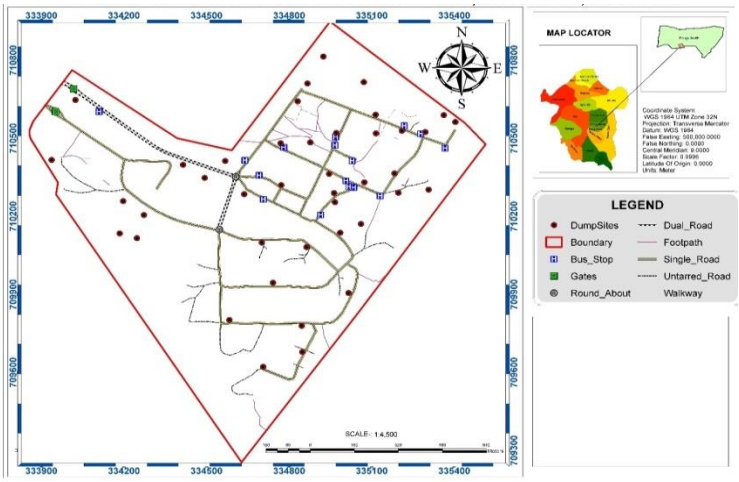



**Figure 2: Map Showing the Location of Dumpsters in the Study Area**

**Source: Department of Land Surveying and Geoinformatics Geographic Information System (GIS), University of Nigeria Nsukka.**

The proximity of the dumpster was assessed. It was observed that within 50m radius, certain areas on campus had their dumpster filled up and litters around the dumpster. A proximity analysis was performed of dumpsters to buildings on campus. It was observed that most of the buildings do not have any dumpster located within 4m. Places such as Lady Ibiam and some Bus stop had its closest dumpster within about 10m and it was filled up. Others were CEMAC, Faculty of law areas of the campus.

Thus, it is suggested that dumpster should be placed at least 4m of every building on campus for proper waste management

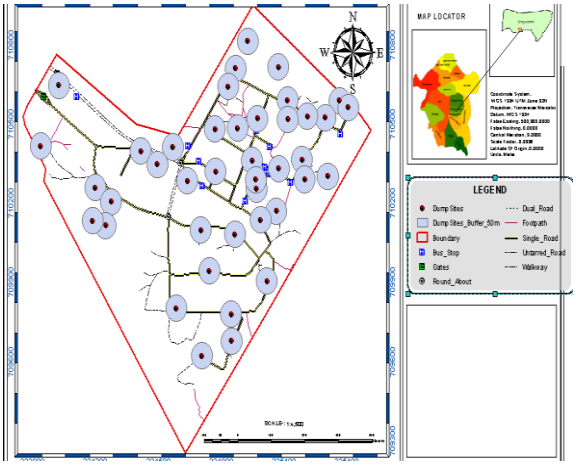



**Figure 3: Map Showing the Proximity of Dumpsters**
**Source: Department of Land Surveying and Geoinformatics Geographic Information System (GIS), University of Nigeria Nsukka.**

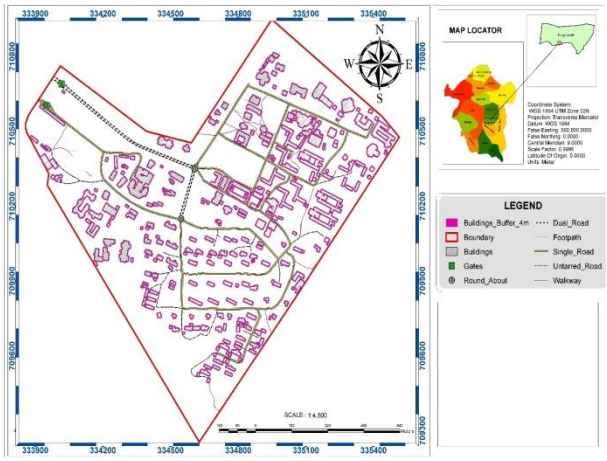



**Figure 4: Map Showing a Buffer of Placing Dumpsters Within 4m Radius**
**Source: Department of Land Surveying and Geoinformatics Geographic Information System (GIS), University of Nigeria Nsukka.**

An analysis was performed to identify the location of dumpsters along the roads, to assess the ease of pedestrians disposing their waste on campus. We observed that the most of the major roads in UNEC did not have sufficient roadside dumpsters.

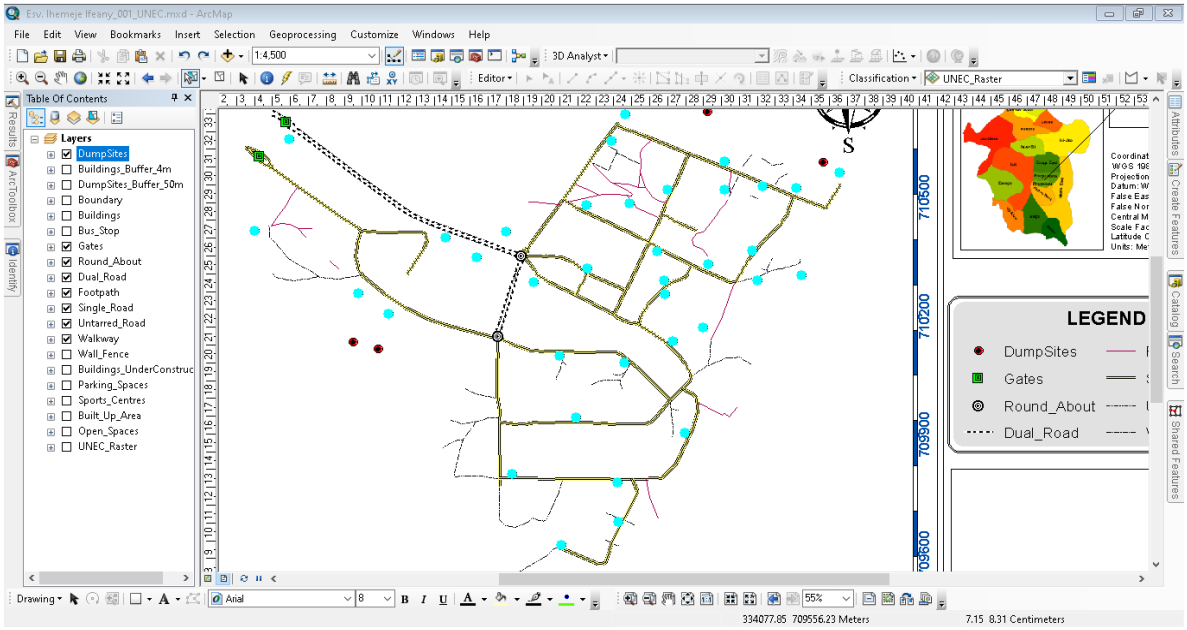



**Figure 5: Proximity of Dumpsters to Road Side**
**Source: Department of Land Surveying and Geoinformatics Geographic Information System (GIS), University of Nigeria Nsukka.**

We observed that there are currently two major dumpsites on campus: the first one (which is the main one) is located behind Lady Ibiam while the second is located behind Ojukwu and Manuwa Hall or residence. Waste is moved from first dumpsite to the second for sorting and some form of recycling. Suitability analysis was applied to assess the location of one of these two dumpsites (Lady Ibiam), and it was observed that the dumpsite behind the Lady Ibiam fell within the 500m buffer even the one behind Ojukwu and Manuwa Intercepted with the Lady Ibiam at Buffer of 500m. It is recommended that this dumpsite should be relocated based on health reasons or the university should provide a way of daily disposing of waste generated.

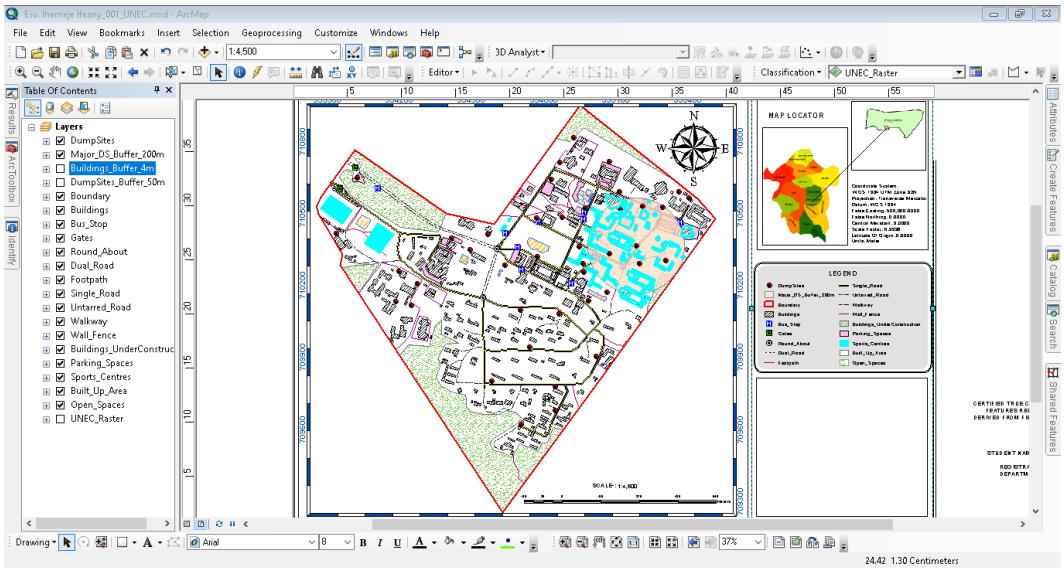



**Figure 6: Map Showing the Suitability Analysis for Siting a Dumpsite**
**Source: Department of Land Surveying and Geoinformatics Geographic Information System (GIS), University of Nigeria Nsukka.**

## 5.0 CONCLUSION

This study created a GIS database model for waste management in the University of Nigeria, Enugu Campus. It incorporated the use of GIS and GPS methods of survey to solving the management of waste. Spatial analysis was performed, and maps created. The maps created can be used as a decision support tool to enhance the current management system. Furthermore, this research can serve as a primary beacon with which another research can be founded upon. The research ends up providing us spatial location of waste bin located in university of Nigeria Enugu Campus and its proximity to each other, buildings (offices, library, classroom, hostels and Guest houses) roads and so on. Their spatial locations will help in further research, decision making and was well as having analysis on its effects to proximity to either Buildings or road.

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