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GIS Based Appraisal of Waste Disposal for Environmental Assessment and Management in Mainland Area of Lagos State, NG

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Abstract

An appraisal of Waste disposal for environmental assessment and management in Lagos Mainland of Lagos state using the GIS has been carried out. GIS has been a veritable tool for analyzing, storing, querying, capturing, displaying and managing of Geographic information or data. This paper addressed the usefulness of Geographic information system applications in Waste disposal distribution and in management. The coordinates of the existing waste dump were collected through field survey and a Garmin 78Sc hand held Global positioning system (GPS) receiver was used in the coordinate acquisition. The result of the field observations and analysis showed that the GIS can be used to efficiently monitor waste disposal location, Scheduling of Waste-Bin and this can invariably be used for proper planning in environmental sanitation, assessment and management holistically. This study shows that the use of Geographic Information system cannot be overemphasized in the spatial mapping of solid waste disposal for environmental management and sanitation assessment.

Keywords: GIS, Spatial Mapping, GPS, Waste Disposal, Lagos Mainland.

Introduction

As poverty, population growth, and high urbanization rates combined with ineffectual and under funded governments to prevent efficient management of wastes (UNDP, 2004); municipal solid waste disposal has been enormous concern in developing countries (Mohammedshum et al., 2014. Geographic Information Systems (GIS) is a relatively young field, with antecedents that is dated back to hundreds of years in the fields of cartography and mapping. Today, GIS provides a digital way for storing, retrieving, manipulating, analysing, and displaying geographically referenced data. Since GIS has the potential of including ecological, biological, demographic, or economic information, it becomes a valuable tool in the environmental and engineering sciences (Goodchild et al, 1999). Over the past five decades or so years, urbanisation - that is the proportional change between the population living in rural areas and that living in urban areas - has become one of the most important trends in human settlements development (Kironde, 2000; Yomralıoğlu, 2000; Direk et al, 2012; Şeker et al., 2013; Goumehei et al., 2016). GIS is among Management Information Systems and part of the Geo information technology adopted in solid waste management in many countries. Experiences may be obtained from developed countries such as the USA, France, Britain, etc. and other developing countries such as Mexico, China, Ghana, South Africa, Kenya, Nigeria; etc. The most common problems associated with improper management of solid waste include diseases transmission, fire hazards, odour nuisance, atmospheric and water pollution, aesthetic nuisance and economic losses (Basağaoğlu, et al., 2007; Gürel et al., 2007). A Disposal site must consider all the socio-economic, environmental and land use factors within the city as well as people safety. Waste disposing is an important part of waste management system, which requires much attention to avoid environmental pollution. The scientific and systemic management of Municipal Solid Waste involves processing of the significant amount of the spatial data, acceptable criteria's and regulations with efficient correlation between them. For proper decision, all inputs have to be considered together at once and correlated. As the complexity of the management increases, there is requirement of computerized software to do the analysis. In recent years, Geographical Information System (GIS) has emerged as a very important tool for decision making in management practices of solid waste. Geographical Information System (GIS), software are capable of handling spatial data along with non-spatial attributes. The effectiveness of solid waste disposal depends upon the selection of proper site and current global trend of waste management problems stems from unsustainable methods of waste disposal, which is ultimately a result of

inadequate planning (Abbas et al., 2011; Baykal, et al., 2003; Menegho, 2019). The prevailing situation of dumping of wastes without proper inspection and separation leads to environmental pollution causing a tremendous growth in health-related problems. "Domestic, industrial and other wastes, either of low or medium level causes environmental pollution perennially for mankind." (Senthil, 2002). Solid Waste disposal and Management is an integral part of the public health and environmental control. Solid waste generated right from the beginning of humanity, earlier societies mostly are natural and food waste. Problems were little earlier, however, with rapid urbanization, growth in urban population, and development of technologies -e.g. packaging-, the problems of solid waste become more complex as more and more solid waste is generated. With the passage of time and continuous urbanization as well as increase in population the situation, get more and more critical. Recently, there has been an increase in research that uses Geographic Information System (GIS) application as a tool for Municipal Solid Waste management estimation and planning. Municipal Solid Waste management practices require collection of decisive information, which is for taking corrective measures as well as for proper planning to ensure sustainability (Ramachandra and Saira, 2003). Waste management in GIS assistance provides a wide range of opportunities at all stages, from the time the waste is reached to the final destination, or at a stage where it does not further threaten the environment. Studies such as Chang et al. (2007), Sharholy et al. (2007), Wilson & Vincent (2008), Sumathi et al. (2008), Rahman & Rahman (2009), Nishanth et al. (2010), Khajuria et al. (2011); Mohammedshum et al. (2014), Rafiu et al., (2018); Allouche et al., (2018) described the role of GIS in solid waste management. Due to the rapid expansion of population and urbanization, it is badly needed to develop controlled solid waste dumping site to prevent contamination problems through illegal dumping of refuse. Therefore, this study aimed at creating a spatially distributed disposal sites, which features waste generation, location of waste bins, type and amount of waste generate in a particular area. The study also proposes the potential waste disposal sites using GIS technique for better Municipal Waste management in the Lagos Mainland area of Lagos State.

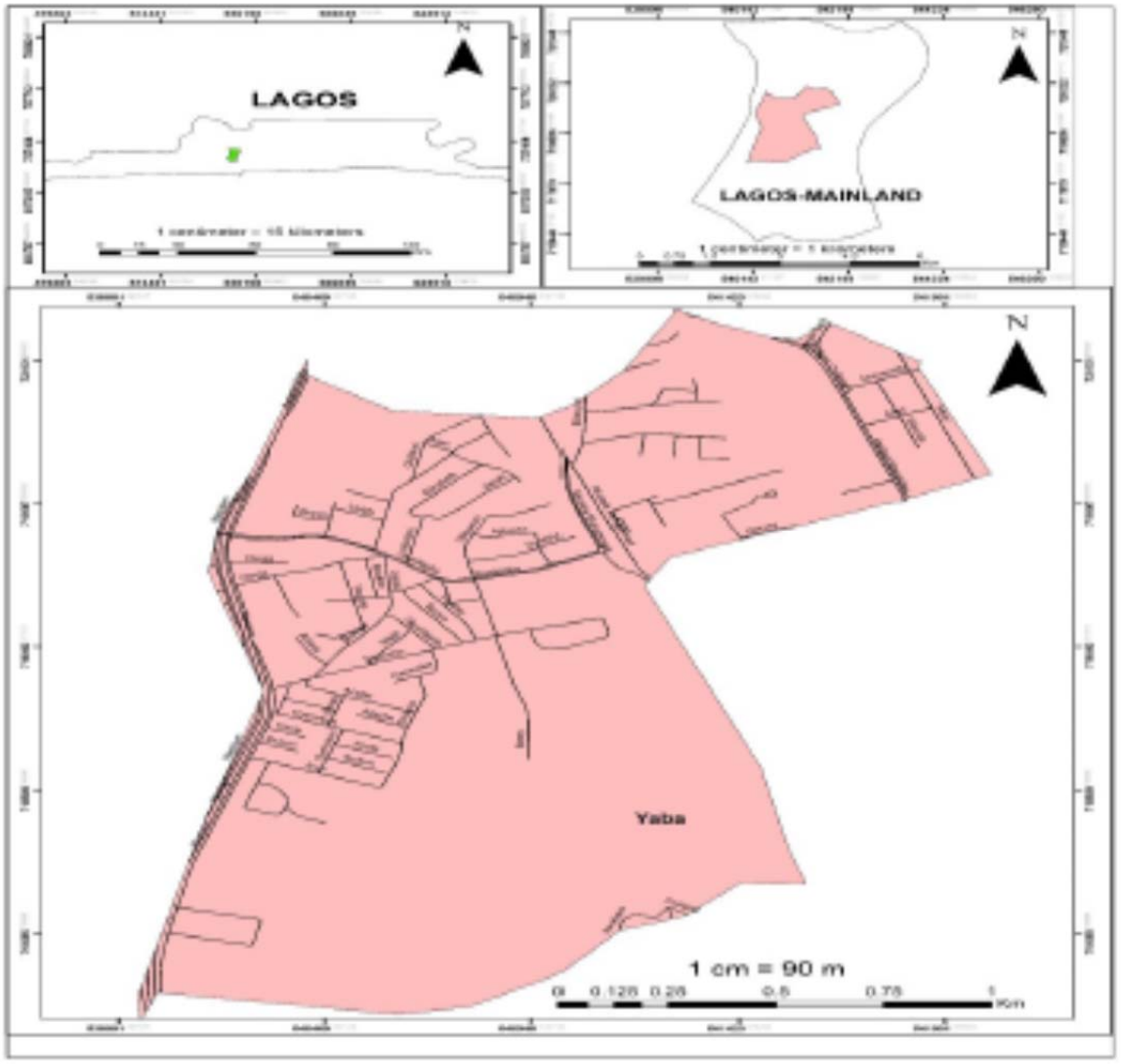

Figure 1: Map showing the study area(Lagos Mainland)

Study Area

The study area is Lagos mainland in the heart of Lagos metropolis, which geographically falls within coordinates of 6050'84''N and 30.38'42'' E as seen in fig 1. There are several Federal Government Institutions in the area, which include Queen's College, the Nigerian Institute of Medical Research, the Yaba College of Technology, Igbobi College, the University of Lagos, the Federal Science and Technical College, and the Federal College of Education. In Yaba community and most local areas in Nigeria, wastes are mostly burnt or dumped in open spaces, usually infringing on the right of ways of infrastructures such as roads, market places, undeveloped plots of land, neighborhood of residential buildings. This can be confirmed from the sight of the spatial pattern of waste dumpsites captured within the study area as shown in the fig 2.

Methodology

The methodology involved acquisition of spatial and attribute data using the coordinates of the existing waste dump acquired by field survey and a Garmin 78Sc hand helded Global positioning system (GPS) receiver, Ikonos satellite imagery 4m resolution of Lagos Mainland area of Lagos State covering the entire Yaba LCDA and a Base Map of Lagos Mainland Local Government showing the road networks. The image was geo-referenced and digitized showing the location of existing waste disposal points. ArcGIS 10.3 software was used to create a database and shape files were also created and on-screen digitization was done. The study adopt field survey and survey research design for the acquisition of spatial and non-spatial data accordingly. Snapshots of some waste locations were taken.

Sources of Data

The sources of data and type of data used for this study involved Ikonos satellite imagery of 4m resolution from RECTAS, Coordinate data from the Garmin 78Sc GPS receiver, which was acquired during the field survey, field survey questionnaire from the field survey carried out.

Table 1: Sources of Data and Data used

Data Acquisition	Data Type	Data	Source
Coordinates of Waste disposal site	Primary	Coordinates generated from the disposal site	Field Survey by GPS
Administered questionnaire	Primary	Respondent data for analysis	Field Survey
IKONOS multispectral	Secondary	Satellite Imagery	RECTAS

Waste Dumpsites Identification

The issue of waste is not only because of increase quantities but also largely because of inadequate management system (E. Tinmaz and I. Demir, 2005) Open dumps cause threat to the public as well as to the environment. Geographic Information Systems (GIS) are increasingly being recognized for their use in storing and analysing the large volumes of data necessary for managing the environment. To attain the study objective, the data needed to perform is the X and Y coordinates of the existing waste dumpsites. The coordinates of the existing waste dump were collected through field measurement/ field survey method. Garmin 78Sc handheld GPS receiver was used to obtain the coordinates. The coordinates of the existing solid waste dumpsites collected during fieldwork were imported into the ArcGIS 10.3 as a text file then converted to shape-file to show the location of the dumpsites. The points were superimposed on the street map.

Management, Assessment and Scheduling of Waste disposal Location

The field observations concern characteristics of dumpsites and general environmental sanitation. The field observations were based on a checklist in relation to such items as spatial extent of dumpsites, location and stage of decomposition of materials. It also consists of interview with some of the dumpsite attendants and close-by residents. From the seventy (70) samples, sixty (60) respondents completed their questionnaire and were subsequently analysed. However, the sixty (60) samples were subsequently used for the study. Seventy Nine (79) Coordinate points were obtained during the site survey, which were the waste disposal points. The results from the questionnaire done for the public shows that virtually about 85.7 % of residents keep their waste in a polythene bags or household waste been and later dump the waste indiscriminately in an open uncovered places near the road, while 14.4 % dump the waste directly in waste bin provided by the local government and most of residents tend to keep their waste for two to three days at their places.

Applications of GIS in waste disposal management

Solid waste management comprises several phases, starting from the stage where the waste is generated until it reaches its final destination or at a stage where it is no more a threat to the environment. It is observed that solid waste management can be bifurcated into mainly two Phases. One is the waste management in the area where it is generated and second is the management of waste at dumping grounds." (Moiz Ahmed Shaikh, 2006). The development of Geographic Information System (GIS) and its use throughout the world has contributed a lot in improving waste management systems. GIS helps to manipulate data in the computer to simulate alternatives

and to take the most effective decisions. GIS can add value to waste management applications by providing outputs for decision support and analysis in a wide spectrum of projects such as route planning for waste collection, site selection exercises for transfer stations, landfills or waste collection points. GIS provides a flexible platform which integrates and analyses maps and waste management databases. GIS has very distinguishing and powerful functions that play an important role in decision- making and planning process. "The most distinguishing parts of a GIS are its functions for spatial analysis, i.e. operations that use spatial data to derive new geo- information. Spatial queries and process models play an important role in satisfying user needs. GIS allows us to create and store as many layers of data or maps as we want and provides various possibilities to integrate tremendous amounts of data and map overlays into a single output to aid in decision-making (Chang et al. 1997).

The changing production and consumption patterns have caused a rise in the volume of solid waste putting considerable pressure on Governments in dealing with the increased waste generation. It implies that local authorities will require huge capital investments and Operational strategies for collection, transportation and disposal of solid waste. Delimiting factors such as limited financial resources have made it imperative to replace existing ad hoc methods employed in solid waste management and planning (Vijay et al. 2008). Sarptas et al. (2005) studied the use GIS in solid waste management in coastal areas as a decision support system with a case study on landfill site selection. The results of the study are that GIS is becoming a powerful tool in Solid Waste Management. However, there are still some drawbacks and deficiencies in applying the method extensively. For example, it is not applied in solid waste generation studies because large fluctuations in solid waste generation by time and space and the dynamic nature of urban areas generate several difficulties in determining the current solid waste generation patterns. In the early period of GIS technology, from the 1980's to the early 1990's, GIS software was capable of executing only basic geographical operations. These Capabilities of GIS software limited the user to only basic tasks such as exclusion and allowed them to determine only alternative landfill sites in landfill siting applications. Advances in information technology and increasing access to computer systems by decision makers have improved the usefulness of computer models and computer aided technologies in decision support system in the last decade.

One of the typical examples is the Solid Waste Management systems. The GIS models do not only support the decision procedure but also facilitate the communication and mutual understanding between decision maker and the people, because the implications of a Solid Waste Management closely affect the society. However, the basic limitations in the use of GIS in Solid Waste Management are the data availability. Because, especially in developing countries the available data are very scarce and access to the data is very poor and tiring. In addition, the existing data are not reliable, not collected, stored and disseminated systematically. More comprehensive researches and more efforts on data gathering to fulfil the needs of GIS models are recommended. Since routing models make extensive use of spatial data, GIS can provide effective handling, displaying and manipulation of such geographical and spatial information. For example, Ghose et al, 2006 proposed a model for the system of Municipal Solid Waste collection that provides planning for distribution of collection bins, load balancing of vehicles and generation of optimal routing based on GIS. Moiz, A. S, 2006, enumerated that GIS support a formal process of optimum location of community waste bins based on buffer electronic maps. The process enables an analyst to consider a variety of geographic factors essential for the planned facility and others merely desirable. However, GIS is an appealing strategy for an agency seeking a rational unbiased location for a local facility such as an incinerator or dumpsite.

Results and Discussion

For an effective environmental management and assessment for decision support system in the Lagos mainland area of Lagos Metropolis, the waste disposal sites has been assessed, evaluated and the spatial distribution of the waste disposal points and coordinates of the sites known as seen in fig 2 respectively. This has proved very useful in the assessment and management of Waste disposal sites. During the field survey, the dumpsites are relatively along the road. These waste dump site are located indiscriminately without considering factors such as centrality, adequacy of space, other neighboring land-uses, etc. with the GPS Location of the waste dump site and the existing road network of the Mainland.

Field Analysis of Wastes Schedule

To determine the quantities of wastes emanating from each waste bin the result of daily solid waste generated per household was considered and average solid waste generated per person per household and the schedule for the days of waste collection. This schedule is very vital as it indicates areas of daily need in deploying personnel and evacuating solid wastes from neighborhoods knowing the locations in the database. The calculations are shown below:

A. The amount of daily waste generated per each household computed were arrived at by applying formula:

DailyW.G / Household=s*ummation of each house hold weighted waste sampled / No.of days weighed*

Summation of daily waste generated by all households sampled= 630.51kg

B. The average daily waste generated per person was computed as below

Summation of daily waste generated by all households sampled= 464.2kg

Summation of the population size of all household sampled=571 persons

AveragedailyW.G/person=*Summation daily waste generated by all households sampled*

Summation of *population size of all household sampled*

Average daily W.G /person =464.2kg / 571= 0.81kg/day/person

C. The day of waste collection from each household was computed, using the different size of waste bin, for some of the households sampled:

Day of waste collection per household=*size of bin average waste generated / house*

For Example, the day of waste collection from house A1 is =100/6.5 = 15

This means that the waste of household A1 is due for collection at the interval of 15 days.

From the figure 3 above, the diagram represents a conceptual model for solid waste collection system and in order to make GIS a veritable tools in solid waste collection system application, a number of tools are needed which are sensitive to management of the process. This includes resources, organisation, information and coordination. Invariably GIS would become essential and powerful veritable tools in solid waste collection if all the aforementioned items are in place.

Figure 2: Spatial distribution of the waste dumpsite in Lagos Mainland

Conclusion

The Application of Geographic Information System (GIS) to appraise waste disposal in Lagos Mainland of Lagos State, Nigeria has been possible for environmental assessment and management. Therefore, in order to showcased an efficient and effective waste management system, GIS has be adopted because of it capability in handling both spatial and non-spatial data necessary for effective waste disposal and collection system. The study presents the type and condition of the waste disposal units in Lagos Mainland Area with at least 79 waste disposal units. Analysis can be made from the results of query/buffering operations conducted, which will enhance decision making by government, and those interested in solid waste management. The database system allows easy access to the condition of waste disposal units, type, and the location of the waste disposal units, storage and updating of the database in the nearest future.

Nowadays, with the rapid population increasing, the urbanization process is accelerating and it is seen that the amount of waste in social consumption is increased as a natural result. In order to solve the environmental problems that arise in this context, regular storage, which is one of solid waste disposal methods, is preferred. However, the most appropriate location for this purpose is a complex and difficult positional problem for decision makers. Waste management in GIS assistance provides a wide range of opportunities at all stages, from the time the waste is reached to the final destination, or at a stage where it does not further threatens the environment.

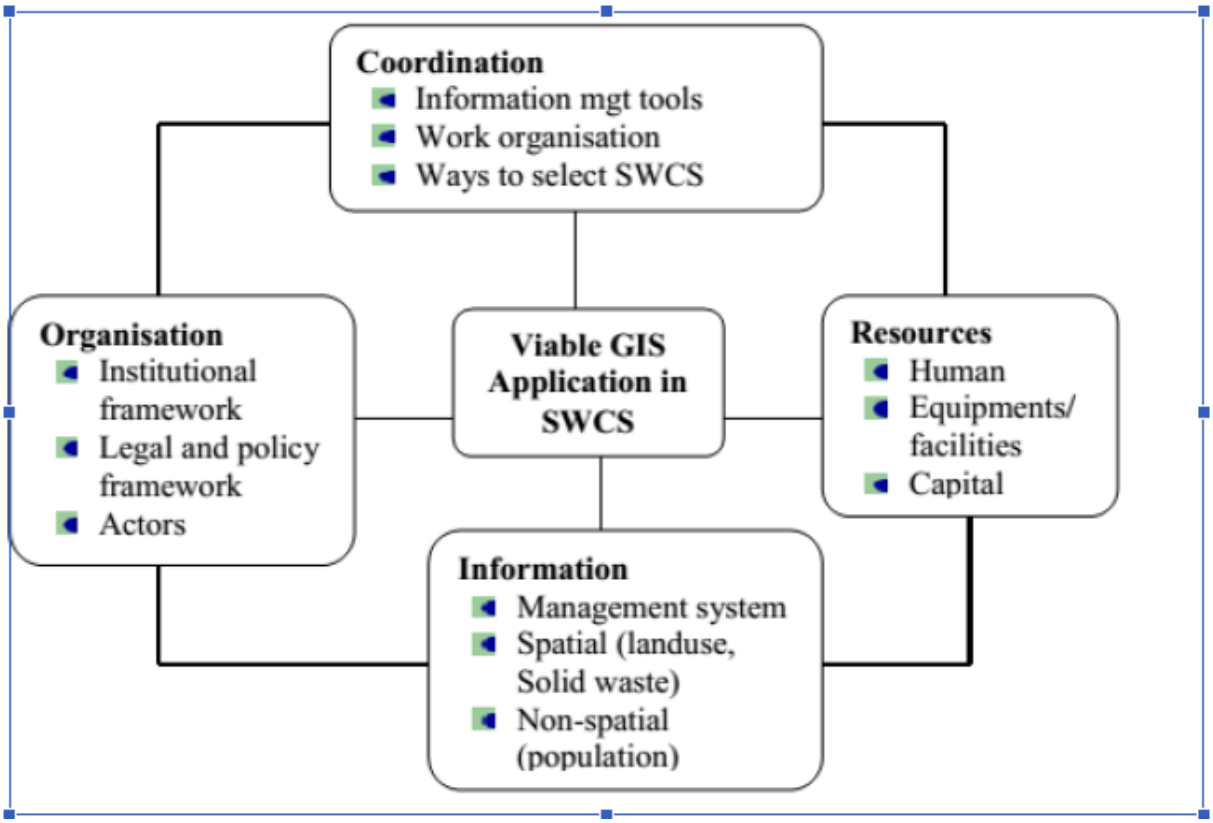

Figure3. Conceptual Model for Solid Waste Collection System (Adopted from Morgan, 2004 and modified by Mwakalinga, 2004)

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