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**APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM (GIS) TO URBAN WASTE MANAGEMENT IN ONITSHA, ANAMBRA STATE**

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**Abstract**

Geographic information system (GIS) are computer based system for collection, storage, editing, retrieval analysis manipulation, display and presentation of spatial data in a problem solving environment for decision-making. GIS focuses on spatial data and their characteristics. It has a spatial and an attribute database in which the characteristics of location are stored, spatial problem of which waste is part of are often difficult to resolve. This difficulty lies in the inter-relationship between spatial features that have to be taken into consideration in the search for a solution. GIS provides set of tools and technologies for tackling these inter-relationship in order to resolve the problem under consideration (Rasheed, 2003). Waste management has become a very serious and highly unmanageable problem in major urban cities in Nigeria today. This is so because the public has come to the conclusion that it is the responsibility of the government to manage waste. In nearly all the state of the federation, the state government that possess the wherewithal to tackle this problem has passed on the responsibility to the local government.

**Keywords: Geographic Information System, spatial data, Urban, environment and Waste Management**

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**Introduction**

Geographic information system (GIS) are computer based system for collection, storage, editing, retrieval analysis manipulation, display and presentation of spatial data in a problem solving environment for decision-making. GIS focuses on spatial data and their characteristics. It has a spatial and an attribute database in which the characteristics of location are stored, spatial problem of which waste is part of are often difficult to resolve. This difficulty lies in the inter-relationship between spatial features that have to be taken into consideration in the search for a solution. GIS provides set of tools and technologies for tackling these inter-relationship in order to resolve the problem under consideration (Rasheed, 2003). Waste management has become a very serious and highly unmanageable problem in major urban cities in Nigeria today. This is so because the public has come to the conclusion that it is the responsibility of the government to manage waste. In nearly all the state of the federation, the state government that possess the where that to tackle this problem has passed on the responsibility to the local government. Meanwhile, the local government are themselves over burdened with various statutory duties they find almost impossible to handle, hence, they have little or no funds for waste management. Most local government have had to admit their inability to cope with this problem, hence in Anambra the state government has taken up the responsibility of waste management, but with little success still. An expression of this problem is the common sight of refuse heaps that threaten to make roads impassable, refuse dumps that dot the city land scape, oozing noxious odours and fumes, blocked drains and severs filled with garbage, pure water sachets littering the entire city and roads sides. The aesthetic look of cities is greatly affected apart from the likely health hazard. Posed by this unchecked pollution of the environment. Waste management problems often result from the inability of the local government to match the collection and disposal of wastes with their generation. Similarly, the problem could be raced to lack of suitable dumping site for waste disposal and treatment. To formulate effective strategy for urban waste management, some fundamental issues have to be examined:

1. What kind of waste is being generated, solid liquid, gaseous, industrial, domestic other?
2. What are the points or sources of generation of these wastes?
3. How do we move these waste to the disposal sites and facilities?
4. Where do we locate these disposal/management facilities?

All the information relating to the above can be spatially referenced and an appropriately chosen GIS can now be used and analyse. In addition to information management and analysis there are frequent requirements for assistance in decision making. This requires making effective choice between alternative possible future courses of action (Peckham, 1997). Spatial analysis provides a way of enriching the information available to the decision makers by generating new parameters from the spatially referenced data. In environmental management such parameters are typically indicators of environmental impacts of the proposed development or the number of people or other living species exposed to risk, noise pollution. Most of the information needed to run a municipal government is geo-referenced. That is to say, it is referenced to a specific geographic location (Aronoff 1995). In the context of urban and regional planning, the different sources of information typically includes cadastral maps,population census, data, utilities, network maps and plans, area photographers and satellites, imagries, well task and legal information these data, all spatially referenced will often be differently structured. Only a data base such as the GIS has the ability to structure these data in an integrated system with possibilities for analysis and combination. GIS can this be used to provide support to management in decision making.

**GIS as a Tool for Decision Support.**

GIS provides a visual representation of data related to waste generation, disposal sites and collection routes, facilitating informed decision-making for authorities. Application of GIS for the selection of suitable site for waste collection point is based on the over laying of datasets and places that satisfy certain suitable criteria (Ahmad, 2018). It therefore, combined the spatial analysis tools provided bi GIS to integrate and evaluate criteria in order to determine potential waste sites. The principal sub-criteria that were used for spatial analysis include slope, built-up areas, road networks, drainage etc. the information gathered showed that in selecting sites for solid waste disposal, there are some issues to be considered such as population, lifestyle which includes the type of food they consume and socio-economic background and so on. It was also learnt that waste are sorted into various waste particles like: combustible waste, non-combustible waste, degradable waste, non-degradable waste and garbage waste. The process of sorting is squid to be classification of solid waste according to their characteristics, nature and structure (Onuigbo and Bello, 2014).

**Waste Disposal System in Anambra State**

These are related to the waste disposal system in Anambra State:  
a. Anambra State Waste Management Agency (ASWMA): ASWMA has commenced door-to-door waste collection in Awka and Onitsha (ASWMA, [2020](tel:2020))  
b. Private sector participation: Intercity Waste Management Services has partnered with ASWMA to provide waste collection services in Anambra State (Vanguard Newspaper, [2019](tel:2019)).  
c. Community-based initiatives: The Onitsha Community Waste Management Group has

established a recycling program to reduce waste in the area (The Guardian Nigeria, [2020](tel:2020)).  
d. Government policies: The Anambra State Environmental Law ([2019](tel:2019)) aims to regulate waste management and enforce proper disposal practices (Anambra State Government, [2019](tel:2019)).  
e. Challenges: Inadequate waste disposal is a major challenge in Anambra State, with only 30% of waste collected (Nigerian Tribune, [2018](tel:2018)).  
f. Initiatives: ASWMA has launched a community recycling program to promote waste reduction and recycling (Daily Sun, [2020](tel:2020)).  
g. Partnerships: ANSEPA has partnered with the private sector to establish waste-to-energy projects in Anambra State. (This Day Live, [2019](tel:2019)).

Geographic Information System (GIS) technology is a powerful tool for identifying and evaluating potential waste disposal sites.

Here are some ways GIS can be applied to waste disposal site selection:  
a. Site suitability analysis: GIS helps identify areas that meet specific criteria, such as distance from water sources, population density, and geological stability.  
b. Environmental impact assessment: GIS analyzes the potential impact on sensitive ecosystems, habitats, and natural resources.  
c. Proximity analysis: GIS determines the proximity of potential sites to existing infrastructure, such as roads, landfills, and waste management facilities.  
d. Geological and hydrological analysis: GIS assesses the geological and hydrological characteristics of potential sites, ensuring they can contain waste safely.  
e. Multi-criteria evaluation: GIS weighs various factors, such as cost, accessibility, and community acceptance, to identify the most suitable site.  
f. Visualization and mapping: GIS creates maps and visualizations to communicate site selection results to stakeholders and the public.  
g. Monitoring and management: GIS tracks waste disposal activities, monitors environmental impacts, and supports long-term site management.  
By applying GIS to waste disposal site selection, decision-makers can make informed, data-driven choices that balance human needs with environmental protection.

A Geographic Information System (GIS) is a computer-based tool used for capturing, storing, analyzing, and displaying geographically referenced data. It allows users to:  
i. Create and edit maps: Build and modify maps with various layers of information.  
ii. Analyze spatial data: Examine relationships, patterns, and trends between geographic features.  
iii. Query and select data: Retrieve specific data based on location, attributes, or spatial relationships.  
iv. Visualize and present results: Communicate findings through maps, reports, and other visualizations.

**General Application of GIS**  
GIS applications are diverse and widespread, including:  
a. Urban planning: Land use planning, transportation, and infrastructure management.  
b.Environmental management: Natural resource conservation, climate change analysis, and disaster response.  
c. Emergency services: Emergency response, ambulance routing, and fire station location planning.  
d. Transportation: Route planning, traffic management, and logistics optimization.  
e. Epidemiology: Disease tracking, outbreak analysis, and healthcare resource allocation.  
f. Business and marketing: Market research, customer segmentation, and location-based services.  
**Components of a GIS**

The key components of a GIS include:  
i. Hardware: Computers, servers, and mobile devices.  
ii Software: GIS applications and tools, such as ArcGIS, QGIS, or GRASS.  
iii Data: Geographic data, including vectors (points, lines, polygons), rasters (images), and attributes (tables).  
iv. People: Users, analysts, and decision-makers who work with the GIS.  
By integrating these components, GIS provides a powerful platform for spatial analysis, decision-making, and problem-solving.

Therefore, Geographic Information System (GIS) applications are:   
i. Emergency Response: The American Red Cross uses GIS to track disasters, respond to emergencies, and allocate resources effectively. (American Red Cross, [2020](tel:2020))  
ii. Urban Planning: The City of New York uses GIS to manage its urban planning efforts, including zoning, land use, and infrastructure development. (NYC Department of City Planning, [2022](tel:2022))  
iii. Environmental Conservation\*: The World Wildlife Fund (WWF) employs GIS to monitor deforestation, track wildlife habitats, and identify conservation areas. (WWF, [2019](tel:2019))  
iv. Epidemiology\*: The Centers for Disease Control and Prevention (CDC) uses GIS to track disease outbreaks, analyze health trends, and inform public health policy. (CDC, [2020](tel:2020))  
v. Transportation\*: The Federal Highway Administration (FHWA) uses GIS to plan and manage transportation infrastructure, including roads, highways, and public transportation systems. (FHWA, [2022](tel:2022))  
vi. Business Intelligence\*: Walmart uses GIS to analyze customer behavior, optimize store locations, and manage supply chains. (Walmart, [2020](tel:2020))

vii. Climate Change: The National Oceanic and Atmospheric Administration (NOAA,2020) uses GIS to study climate change impacts, sea-level rise, and coastal vulnerability.   
viii. Natural Resource Management: The US Forest Service uses GIS to manage forests, track wildfires, and plan conservation efforts. (US Forest Service, [2022](tel:2022))

**Strategies for treatment and disposal of urban waste.**

We will consider the decision support strategies for urban waste management. GIS would support information on the quantities of the different classes of waste being produced and on the location, types and capacities of facilities for waste treatment and disposal. Spatially referenced information on population, land use, geology, rivers and water bodies and the location of natural parks and sites of special interest for nature conservation, are required in order to assess the impacts of different strategies on these features. We could also include a description of the transportation network in order to estimate costs, risks, and environmental impacts associated with the transportation off the wastes from the sites of production to the disposal sites. Once this information is set up in the GIS, the spatial analysis facilities can be applied in the following ways:

1. In the assessment of the environmental impact of waste disposal facilities on the different classes of land use, for example, by calculating the percentage area of the different classes of land use in the sub-region of the local government area containing the facilities or within a given radius of the facilities.
2. In the assessment of impact of waste disposal facilities on natural parks or biotopes, for example by finding the distance from each facility to the nearest biotope. Using the distance as a criterion, strategies can be devised giving preference to use of sites located further from the biotopes.
3. In the assessment of risks to the population by calculating population densities in the areas surrounding facilities.
4. In the assessment of transportation risk by calculating population densities near transportation routes; if a path generator is included , alternative transportation routes and their corresponding risk criteria can be analyzed automatically.
5. In the assessment of impacts on underground water, by relating location of facilities to maps of geology and depth of the water table.

**Application of GIS to Waste Disposal Site Selection**

Rushbrook and Pugh (1994) are quite explicit on how to develop and implement its waste management plan. According to them:

The selection of a site for developing a land fill is one of the most important decisions to be made by the municipality in developing and implementing its waste management plan. A poorly chosen site is likely to require unnecessarily high expenditure on waste transport site development site operations or environmental protection. To ensure that an appropriate site is identified a systematic process of selection needs to be followed. The selection criteria are themselves subject to prioritization. Many factors are critical in the selection of a site for waste management/disposal. Among these are types of soil suitable for waste disposal, geological formation of the site transport accessibility to the site, proximity to stream and rivers, proximity to residential neighborhood, hospitals, school, markets and recreational zones.

These factors are combined in this example to select the most suitable site that meets stipulated conditions. Onitsha is a metropolitan town in Anambra state. Onitsha particularly is made it to Onitsha north and Onitsha south local government’s area. Onitsha metropolitan city extends beyond Onitsha north and Onitsha south it extends to Oyi, Idemili north and south and Ogbaru local government areas. The population of Onitsha metropolitan city is estimated to be this occupies the areas of about and possesses all typical. Features of an urban areas in developing world: over population leading to congestion and overcrowding, traffic build-up inadequate infrastructure and lack of adequate finances to run the urban administration. Waste management is a serious problem with this metropolitan city of Onitsha, Anambra state.

**Analysis Procedures**

Our GIS will contain coverage (data layers) of these stipulated conditions (criteria) as well as the base map of the constituent local government areas in Anambra state (fig 1). We have three layers which show the distribution of soils within the areas under consideration. The soils would have been classified as highly suitable, suitable and unsuitable. We have two layers showing geological formation over the area. The same classification in the soil types is used:

Layer 5 shows streams and rivers

Layer 6 shows the road, networks

Layer 7 shows the spatial distribution of residential areas.

Layer 8 shows location of hospitals

Layer 9 shows the location of schools.

The result of our soil over lay and classification operation is several in anew coverage (layer 10) showing highly suitable soils. Likewise, the result of the classification of the geology is saved in a new coverage (layer 11) showing highly suitable geology. Over lay layers 10 and 11 to look for the best combinations of soil type and geological formation most suitable for waste disposal. Our overlay result create a new layer of information which we label as layer 12 best termain (fig 2). Supposing that we specify condition that the waste site should be at least 200m of a major road. To include this criterion we buffer the road by 200m. the results of our buffering operation is saved in layer 13. Layer 12 and 13 are overlayed to find suitable locations for waste disposal that would be within 200m of a major road. Our overlay result is now stored in layer 14 (figure 3). Another criterion could be that the waste disposal site should be at least a minimum of 500m away from stream in order to prevent possible pollution of the stream by underground see page. To incorporate this, we specify a buffer of 500 meters around each stream and we save it as layer 15. Layer 16 highly suitable location sites (fig 4). We further specify a criterion, for instance, that the site should be at a minimum distance of one kilometer to residential area, we specify a buffer of 1km around them and store in layer 17. The residential areas has been digitalized as point data instead of area (polygon data) due to constants of urban land space layer 17 is then overlayed with our result saved in layer 16. This result show all the areas falling within the specified area in layer 16 and also falling outside the residential areas buffer (layer 17). The result is presented as the most suitable location sites (fig 5). These are the very best sites that specify all the above stated criteria. A chat indicating the steps in resolving these they decision is presented in figure 6.

**Conclusion**

An attempt has been made to explain the usefulness of GIS as a tool for decision-making in waste management. It has been demonstrated how criteria could be combined in order to arrive at the best sites(s). That meets all the set conditions. The employment of this technology will be of immense benefit to decision makers in both the public and private sectors concerned with the choice of location for an activity. Particularly, question such as where is the best site for locating retail outlet? Where is the most suitable site to practice intensive Agriculture? Which site would yield the maximum benefit for a production function? And host of other questions could be answered.

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