ENVIRONMENTAL SUITABILITY OF LANDFILL SITE IN IFO AREA OF OGUN STATE

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Abstract

One of the simple and affordable management techniques for getting rid of solid waste is landfill. It is employed in many places of the world. However, poor management and inefficient placement will cause environmental pollution and public health risks. Because of its improper location, the Ifo local government has long used an open dumping system that is neither ecologically friendly nor socially acceptable. This study's primary goal was to find a suitable location for the disposal of solid waste utilizing cutting-edge technology to ensure environmental sustainability and public health protection. The research area's landfill was chosen based on factors such land use and land cover, slope, water body drainage patterns, roads, etc. The geospatial decision-making process was carried out using a GIS-based Multi-Criteria Evaluation approach. To determine the external and internal weight values for each class inside each criterion and for all criteria, a pair-wise comparison module of Analytical Hierarchy process (AHP) was used. An overall land fill suitability map was created by combining the criterion maps using weighted linear combination. As a result, of the entire research area, it was determined that, in that order, 48.1km2 (10.2%), 58.1 km (12.07%), 25.5 km (5.3%), and 369.7 km (76.8%) were very, moderately, marginally, and un-suitable for disposal.

Keywords: *AHP, Disease, GIS, Landfill Suitability, Management, Pollution*

Introduction

Both industrialized and developing nations have severe environmental concerns about the issue of waste generation and management. Even though industrialized nations have been able to handle this issue, the majority of developing nations have failed to give a long-term solution to the effects of waste disposal in sanitary landfills. Due to the growing influx of people, the majority of metropolitan centers in emerging nations are connected with big settlements and residential issues. Because of this, the majority of trash is carelessly discarded in and around residential areas, in the open air, and in any adjacent pits without any regard for environmental preservation. The individuals who live near these improper waste disposal facilities may face health risks due to the unclean conditions they frequently produce.

The degradation of solid waste may cause the release of carbon dioxide (CO2), methane (CH4), and other trace gases, which may lower the quality of drinking water and result in diseases like jaundice, nausea, and asthma (Amar, Chandrasekhar, Pratapsingh, & Dhanraj, 2008) and (MeBean, Rovers, & Teddy, 1995). Industrial effluents and solid wastes have also significantly harmed surface and groundwater resources in growing urban cities and towns as a result of poor waste management, which frequently leads to a serious environmental issue that might put people's lives in risk.

According to Kao and Lin (1996), the most frequent issues related to trash may include disease transmission, fire risks, olfactory annoyance, air and water pollution, visual nuisance, and economic losses. Lack of planning, a lack of technical expertise, inadequate administration, and lax enforcement of current laws might all contribute to the ineffective management of wastes (UNEP, 2005). Most developing countries utilize landfills as part of their efforts to lessen the danger of careless disposal of solid waste. This is so that garbage may be disposed of in the easiest, most affordable, and most efficient way possible (Barrett & Lawlor, 1995). The process of choosing a landfill site (LSS) is challenging and complicated, requiring consideration of a wide range of considerations, including social, environmental, and economic ones. Choosing a location for a sanitary landfill necessitates a thorough assessment of the best available location.

This location must reduce economic, environmental, and social expenses while also adhering to legislative rules. The first step in a thorough review process is the identification of critical elements, which is followed by the organization and analysis of several siting considerations using Geographic Information system (GIS) technology. The use of GIS in trash management has gained acceptance on a global scale. According to Saravanan, Prasad, Sudha, and Ilangovan (2011), GIS technologies have been shown to be helpful in locating acceptable sites for proper waste disposal as well as in identifying solid wastes and changes in land use. In addition, it has multi- and hyperspectral capabilities that enable it to discern between different kinds of natural phenomena and offer precise information on dynamic changes occurring on the earth's surface.

GIS is an art, science, and technology (or computer-based technique) that deals with the collection, storage, analysis, and management of spatial data and information, as well as its classification, integration, processing, presentation (cartography), and dissemination. It also includes applications for planning and decision support with a variety of special tools that are very useful in the processes of mapping pollution and choosing landfills. It is a robust tool for identifying locations that would reveal good landfill sites because of its multi-disciplinary capability and capacity to merge several spatial data layers, including maps, satellite pictures, aerial photography, and geophysics, with other quantitative and qualitative data.

Site selection or suitability analysis is a type of study used to identify the best location or site for particular environmental phenomenon. A new hospital, company, or school, dump site placement etc are just one such site that may be taken into account in an appropriateness study. The tracking and labeling of possible dangers, such as earthquakes, contaminants, or even criminality, may be done through suitability analysis. It may also be used to find prime sites for business hubs (Briney, 2014).

GIS-AHP Application

Due to the complexity of decision-making, numerous forms of multi-criteria decision making (MCDM) have been developed, including the Analytic Hierarchy Process (AHP), which was created by Saaty in the 1970s (Saaty, 2008). By employing this technique, (Erkut & Moran, 1991) showed how a big problem may be broken down into a number of minor problems in the form of a decision hierarchy. As a result, Khan and Faisal (2008), Charusiri and Ladachart (2008), and Demesouka, Vavatsikos, and Anagnostopoulos (2013) frequently combine these two strategies to effectively handle the landfill site selection problem.

Aim of the Study

This study aimed to determine a suitable landfill site in Ifo LGA Area through a number of objectives, namely;

- Data collection and storage
- Data input
- Establish the criteria for the factors such as distances from rivers, residential areas, roads etc.
- Carry out Analytical hierarchical analysis on the factors
- Identify existing landfill sites
- Deriving a final suitable area based on criteria, each with individual weights.

Area of Study

Ifo Local Government Area in Ogun State is bounded by the coordinates 6°49′00″N 3°12′00″E coverage area of approximately 521 km^2 with a population of 698,837 at the 2006 census. Ifo LGA is characterized by incessant indiscriminate waste disposal. This has been a major threat to the health of the people in area for years. The existing land use in the study area are mainly built up area, shrubs, crops, water bodies and slope. The total built up and agricultural farm land area is 369km^2.

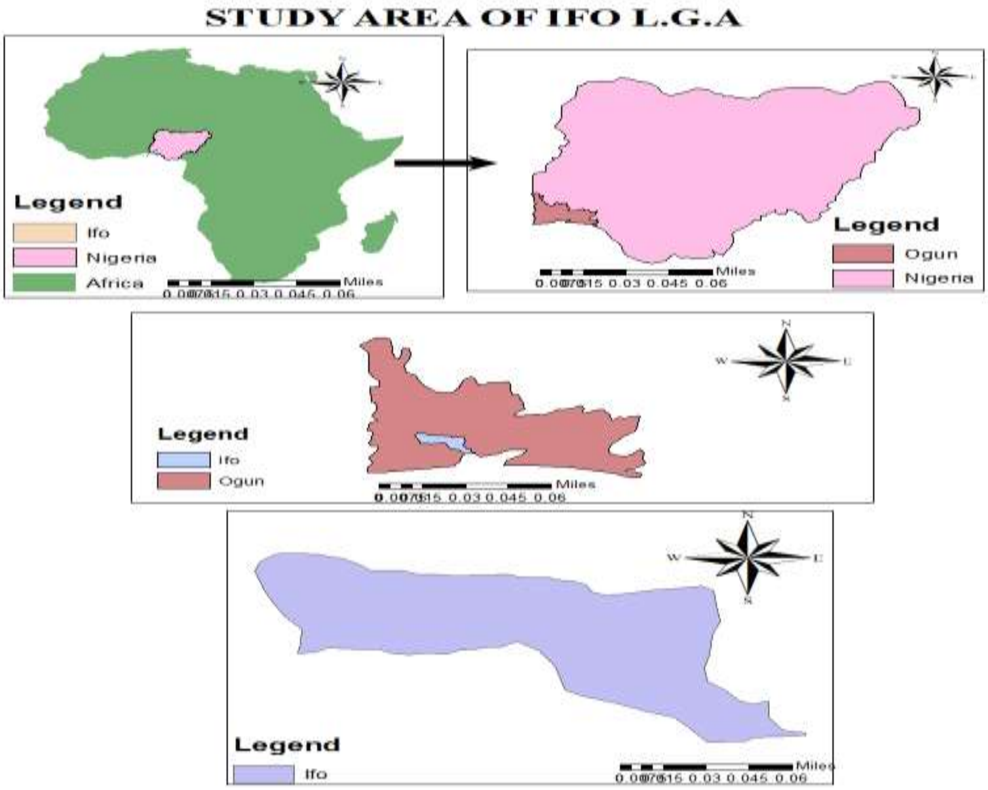

Figure 1: Description of the study area

Methodology

ArcMap 10.6.1 and AHP were used to choose the landfill's location. AHP breaks down the decision issues into manageable components, which are then individually examined and logically combined (Saaty, 1980). Data acquired for this work are; Land use/land cover map from Sentinel 2 Land use Land cover downloader, explaining Administrative maps of the area showing (roads, built up areas, water bodies etc) from archive of the department of Surveying & Geoinformatics, Federal Polytechnic, Ilaro. The distance and width of the road networks was calculated including the coverage area of the builtup areas, shrubs, crops, waterbodies etc, and Digital Elevation Model (DEM) downloaded using path and row method from the USGS portal. DEMs are raster files with elevation data for each raster cell.

A structural hierarchy was created with the following tiers to help with decision-making: (i) landfill site selection; (ii) environmental, sociocultural, and technical-economic variables; and (iii) criterion and sub-criteria. Each criterion was assessed using a point allocation methodology. It is one of the most straightforward grading systems and is based on assigning points between 0 and 9, with 9 denoting the best case scenario for that criterion.

In this work, multi-criteria decision-making is combined with spatial data analysis in a GIS setting. The area's satellite image was first georeferenced, and then it was vectorised to display the elements that were taken into consideration while choosing the location of the landfill for municipal solid waste. For the purpose of excluding locations where a municipal solid waste dump cannot be established, buffer analysis was done on the vectorised features. Then, maps with criterion feature and buffer analysis were created. The research area's prospective landfill sites were identified using an analysis of the buffered maps. The number of candidate landfill sites was decreased based on geographic location and distinguishing characteristics, and the AHP model was used as part of an MCDA decision-making process to choose the optimum landfill site in the research region.

Figure 2: Built-up area buffer of Ifo L.G.A

Figure 31: Shrubs buffer of Ifo L.G.A

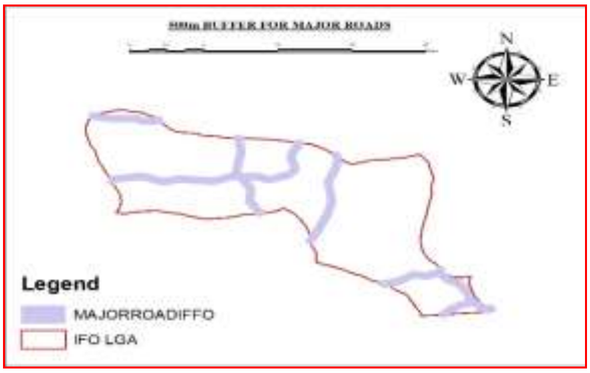

Figure 42: Major roads buffer of Ifo L.G.A

Figure 5 Minor roads buffer of Ifo L.G.A

Figure 63: Rivers buffer of Ifo L.G.A

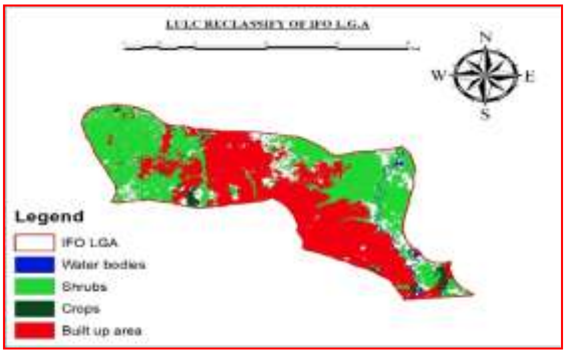

Figure7: Reclassified LULC of Ifo L.G.A

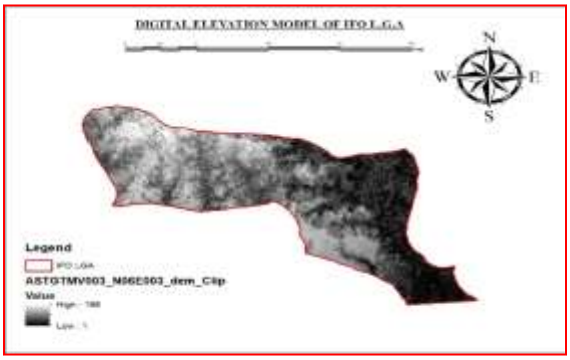

Figure 8: DEM image of Ifo L.G.A

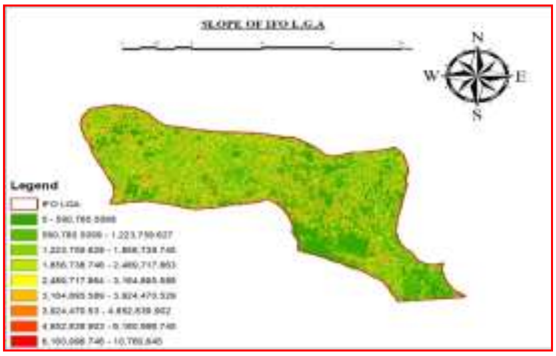

Figure 9: Slope raster of Ifo L.G.A

Selection Criteria

Criterion were selected based on existing literatures on landfill suitability analysis (Table 4), using GIS. The factor maps were weighted in the analysis and then combined (overlaid) with constraint maps. AHP was adopted for valuation of the criteria features obtained from the GIS analysis.

Table 1: Showing the criteria way for sitting landfill

Criterion	Buffer zone(m)	Adopted Buffer Distance(m)
Built up Area	500 - 1000	1000
Water bodies	100 - 1000	500
Crops	100 - 500	300
Major Road	100 -700	500
Minor Road	100 - 1000	250
Slope	2%–10%	Relatively Flat
Railroads	200 -700	350
Shrubs	300 - 500	300

The selection process, which takes into account the distinctive features of candidate locations acquired from the GIS analysis, takes into account water bodies, built-up areas, crops, major and minor highways, railways, hills, institutions, bushes, and marketplaces. As a result, it is easier to prioritize alternatives (possible landfill sites) when comparing them using pair-wise (Table 6). By allowing for an independent assessment of each factor's influence, this pair-wise comparison makes the decision-making process simpler. The pair-wise comparisons of various criteria were usually arranged into a square matrix with one as the diagonal element. The consistency of the comparison was checked thus, allowing for improvement in making decision.

Table 2: Ranking or Criteria comparison matrix

	Ranking or Criteria Comparison Matrix (C)									
CRITERIA	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Average**	*Weight*
Built up area	**1.00**	7.00	5.00	4.00	3.00	2.00	2.00	1.00	0.29	28.52
Water bodies	0.14	**1.00**	2.00	2.00	2.00	2.00	4.00	5.00	0.15	14.71
Crops	0.20	0.50	**1.00**	3.00	2.00	3.00	4.00	3.00	0.14	14.05
Major roads	0.25	0.50	0.33	**1.00**	3.00	3.00	5.00	2.00	0.12	12.09
Minor roads	0.33	0.50	0.50	0.33	**1.00**	2.00	3.00	3.00	0.09	9.08
Railroads	0.50	0.50	0.33	0.33	0.50	**1.00**	3.00	2.00	0.08	7.74
Slope	0.50	0.25	0.25	0.20	0.33	0.33	**1.00**	5.00	0.07	7.14
Shrubs	1.00	0.20	0.33	0.50	0.33	0.50	0.20	**1.00**	0.07	6.67
SUM	**4.29**	**11.28**	**10.58**	**12.37**	**13.17**	**14.83**	**23.20**	**23.00**	1.00	100.00

DISCUSSION OF RESULTS

Three processes; preliminary study, multi-criteria evaluation, and suitability analysis, were adopted in the site selection methods. Preliminary study which is the input of the rasterized data layers required the development of a map of the study area. Multi-criteria evaluation using many criteria includes final constraint maps, final factor maps, and Suitability Analysis emphasizes finding the most suitable site. Many potential sites were established as clearly represented in Overlay analysis by superimposing all buffered layers of the parameters under study. The four constraint maps (layers) namely, built up area, agricultural area, roads, and water bodies were combined using overlay function (using direct multiplication of the binary integer values) to create the final constraint map. The overlay map showed a number of potentially suitable sites for situating the landfill. All areas that are of dark green colour code are potential sites for landfill location (figure 10).

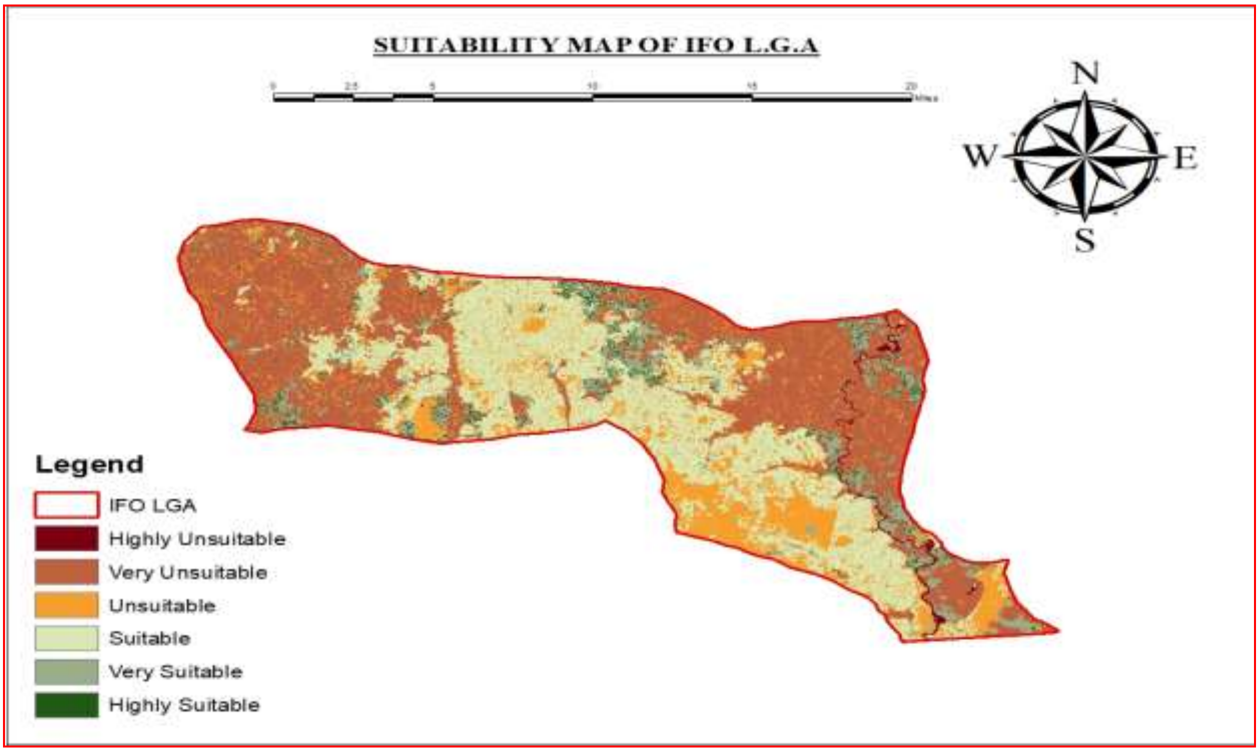

Figure 10: Landfill Suitability map of Ifo LGA

Conclusion

This work portrays the complexities in the factors and processes involved in determining the best location for siting a landfill in Ifo Local Government Area. The application of GIS in selection of suitable and appropriate location of landfill site in Ifo L.G.A amidst the complexities has brought a number of lessons; the capability of GIS has displayed results showing all the trends in the Geodatabase; the advantage of the capability of handling bulky spatial and non-spatial data in a repository.

Recommendations

While the results of this study can be used to indicate how landfill sitting can be carried out in other circumstances. The need to give insight on how future studies on the subject should be conducted to produce the greatest results cannot be ruled out. The facility siting process has benefited substantially from the use of GIS technology, which has shown to be efficient in managing vast volumes of data. Its simplicity of use and thorough presentation enable user-friendly operational chores.

This study will help build Ifo LGA geographical database of environmental and social data, which will aid in the development of the alternatives that are accessible. In the end, this research may be utilized by facility site planners as a resource for location of landfill locations in other Local Government Areas in Ogun State and Nigeria.

Since the government cannot resolve the current challenges alone, it is also important to provide NGOs priority participation in investments through state cooperating entities to tackle waste management concerns. Everyone operates in a collective manner to ensure cleanliness.

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