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# SITE SUITABILITY ANALYSIS FOR LANDFILL IN ASHIYIE, GHANA

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## Abstract

*Ashiyie is a town presently experiencing urban growth and one of the challenges in the area is poor waste management system. Proper management of solid waste in the area is necessary to keep the environment clean and tidy, and avoid dump of rubbish at any available open space causing environmental pollution. This study envisage to select an area or site which will be most convenient and more appropriate for landfill site location in Ashiyie community, Ghana, using Geospatial approach. GoeEye satellite imagery and SRTM data of the area were collected, processed and analyzed in ArcGIS software environment. The Boolean overlay operation was employed to select the most suitable sites to solve the environmental problem of landfill in the Study area. Results highlighted a total area of 198 acres for landfill site. Identified suitable locations were superimposed on slope map and sturctural query language (SQL) was applied to select the most suitable, moderate and less suitable. A final suitability map for landfill site was produced. Seven areas were identified to be most suitable, eleven sites were moderately suitable and one site less suitable. It can be concluded from this study that GIS has the capabilities of combining information from various sources into a spatial context, which can be used by policy makers as a well suited decision support making tool. From the study carried out, it is clear that there is need for an effective solid waste disposal management in the study area, therefore, the Chiefs, the Municipal Authorities and the Environmental Protection Agency (EPA) can consider this research and used for proper planning of Ashiyie Community.*

**Keywords**: Ashiyie community, Geospatial, Landfill, Site Suitability

### Résumé

Ashiyie est une ville qui connaît actuellement une croissance urbaine et l'un des défis de la région est le mauvais système de gestion des déchets. Une bonne gestion des déchets solides de la zone est nécessaire pour garder l'environnement propre et éviter le dépôt d'ordures dans tout espace ouvert disponible provoquant une pollution de l'environnement. Cette étude envisage de sélectionner une zone ou un site qui sera le plus pratique et le plus approprié pour l'emplacement de la décharge dans la communauté d'Ashiyie, au Ghana, en utilisant une approche géospatiale. L'imagerie satellitaire GoeEye et les données SRTM de la zone ont été collectées, traitées et analysées dans l'environnement du logiciel ArcGIS. L'opération de superposition booléenne a été utilisée pour sélectionner les sites les plus appropriés pour résoudre le problème environnemental de la décharge dans la zone d'étude. Les résultats ont mis en évidence une superficie totale de 198 acres pour le site de la décharge. Les emplacements appropriés identifiés ont été superposés sur la carte des pentes et le langage de requête structurelle (SQL) a été appliqué pour sélectionner les plus appropriés, modérés et moins appropriés. Une carte finale des zones favorables aux sites de décharge a été produite. Sept zones ont été identifiées comme étant les plus appropriées, onze sites étaient modérément appropriés et un site moins approprié. On peut conclure de cette étude que le SIG a la capacité de combiner des informations provenant de diverses sources dans un contexte spatial, qui peut être utilisé par les décideurs politiques comme un outil d'aide à la décision bien adapté. D'après l'étude réalisée, il est clair qu'une gestion efficace de l'élimination des déchets solides est nécessaire dans la zone d'étude. Par conséquent, les chefs, les autorités municipales et l'Agence de protection de l'environnement (EPA) peuvent envisager cette recherche et l'utiliser pour une planification appropriée de la communauté Ashiyie.

Mots clés : Communauté Ashiyie, Géospatiale, Décharge, Site favorable

## 1. INTRODUCTION

Municipal solid waste management is a global environmental challenge in urban areas, due to the large quantity of municipal solid waste generated as a result of population growth and urbanization, which has made it difficult to locate suitable land areas to be used as landfills (Aboziah., 2016). According Bahrani (2016) landfilling is the most common method used for disposal of solid waste and selection of suitable landfill for municipal solid waste management and plays a vital part in urban planning. Landfill is a disposal site where solid waste, such as paper, glass, and metal, is buried between layers of dirt and other materials in such a way as to reduce contamination of the surrounding land. Modern landfills are often lined with layers of absorbent material and sheets of plastic to keep pollutants from leaking into soil and water also called sanitary landfill (AHSSD, 2014). Modern landfills are well-engineered and managed facilities for the disposal of solid waste. Landfills are located, designed, operated and monitored to ensure compliance with federal regulations. They are also designed to protect the environment from contaminants, which may be present in the waste stream. These monitoring systems check for any sign of groundwater contamination and for landfill gas, as well as provide additional safeguards (US EPA, 2020). Growth in population as well as rise in the quantity of municipal solid waste generated has made it difficult to locate appropriate site for waste disposal in most urban areas. Land filling is now accepted as the most widely used method for addressing this problem in all countries of the world ( Bilintoh *et al*., 2015).

Cities in Ghana as in most developing countries, faces challenges resulting from poor solid waste management due to a number of reasons such as the rise in urban population, the construction era, industrial growth, and unsustainable consumption practices. Site selection for waste disposal and waste management for developing countries always pose major challenges (Nyoni, 2020). Therefore, final disposal of waste has been synonymous with land filling which has been largely described as the simplest and most efficient (World Bank, 1999; EPA, 2002; Parker, 2003; Lim and Missios, 2007). Davies (2003) in particular ascribes the dominance of landfills on the waste disposal terrain to its relative cost-effectiveness, although in reality this advantage is nothing but a compromised situation as many are poorly maintained and operated below acceptable environmental standards. Yet, landfills continue to present

Ghana with a viable option for waste disposal (Oteng-Ababio, 2007). General Waste Management in Ghana is the responsibility of the Ministry of Local Government and Rural Development, which supervises the decentralized Metropolitan, Municipal and District Assemblies (MMDAs). However, regulatory authority is vested in the Environmental Protection Agency (EPA) under the supervision of the Ministry of Environment and Science. The Metropolitan, Municipal and District Assemblies are responsible for the collection and final disposal of solid waste through their Waste Management Departments (WMDs) and their Environmental Health and Sanitation Departments (EPA., 2004).

Currently, Ghana is facing solid waste management issues as landfills are rapidly filling up, the amount of waste generated is increasing, the shortage of disposal land is on the rise, and the resulting environmental and human health impacts are becoming more and more serious. These circumstances are due to the escalating amount and various types of waste generated, caused by the growth in urban populations and industries, as well as the rising standard of living.

To get a good waste disposal site in accordance with technical requirements, economical and environmentally friendly, the right method is needed such as placing the waste disposal with the appropriate geological formations so that pollution can be prevented or reduced. The aim of this project is to identify suitable site for landfill in the Ashiyie community using remote sensing and Geographical Information System techniques. Which will focus on producing land use information and conduct landfill suitability analysis using Boolean overlay techniques.

**Litereture Review**

Landfill site selection in an urban area is a critical issue because of its large impact on the economy and the environmental health of the region and many sitting factors and criteria should be carefully organized and analyzed. Many researchers around the world have studied Landfill site selection problems in waste management using multi criteria decision method (MCDM) alone or in combination with other methods in solving this problem.

Sener et al., (2010) integrated Geographic Information System (GIS) and Multi Criteria Decision Analysis (MCDA) to solve the landfill site selection problem and developed a ranking of the potential landfill areas based on a variety of criteria such as environmental criteria, political criteria, financial and economical criteria, hydrologic and hydrogeologic criteria, topographical criteria, geological criteria, availability of construction material and other criteria. Beynon et al, (2001) introduced a method to solve a MCDM problem called Dempster-Shafer Theory (DST)/Analytical Hierachy Process (AHP) which combines aspects of the DST and AHP (Shafer, 1976). DST/AHP method differs from AHP in that it allows comparisons to be made between groups of alternatives instead of single alternatives, and it uses Dempster's rule of combination for aggregating the criteria instead of simple multiplications and additions. DST provides a unifying framework for representing uncertainty as it can include in the same formulation the cases of risk and ignorance. Chang et al. (2008) combined GIS and fuzzy MCDM for landfill sitting in the suburban area of the City of Harlingen. Fuzzy method of multi-criteria decision making translates verbal expressions into numerical ones, and thereby dealing quantitatively with imprecision in the expression of the importance of each criterion. FMCDM uses variables and 9 fuzzy numbers to aggregate the decision makers' subjective assessment about criteria weightings and appropriateness of alternative candidate sites against selection criteria to obtain the final scores fuzzy appropriateness indices. Al-Jarrah and Abu-Qdais (2006) focused on the problem of sitting a new landfill using an intelligent system based on fuzzy inference. Combination of GIS and multi criteria evaluation (MCE) has been routinely adopted as an approach to assess the suitability of an area to host a landfill (Buenrostro et al., 2008; Malczewski, 2006). According to Gao et al., (2004), any decision making process that focuses on problems that are either dependant or influenced by geographical information is spatial decision making. Spatial Decision Making (SDM) Site selection is a semi-structured process that involves consideration of several factors before an optimal solution is got (Eldrandaly et al., 2003). A Decision Support System (DSS) is a class of computerized information systems that support semi-structured decision-making activities through the support for development and use of mathematical models, and data manipulation (Power, 2004). In problems related to site selection, GIS perform deterministic Overlay and buffer operations while as Multi Criteria Technique evaluate alternatives on the basis of subjective values and priorities of decision maker (Hecson and Macwan, 2017).

**Landfill Site Selection Criteria.**

Some of the factors that several researchers (EPA, 1998; EPA, 2003; Malaysian Government, 1995 as quoted by Gaim, 2004; North Dakota Department of Health, 2002; KCC, 2000; Yaw et al., 2006 among others) have used to determine the appropriateness of a site to be used as a sanitary landfill are as follows.

**i) Site Capacity**: A site should be capable of providing at least 10 years of use in order to; minimize costs for site establishment, operation and closure.

**ii) Land cover**: buffer zones should be provided between the landfill and sensitive areas or other land uses. For example; at least 100m from public A Spatial Decision Support Tool for Landfill Site Selection 173 roads, at least 200m from industrial developments, at least 500m from urban residential or commercial area, at least 1000m from rural residential areas. For the case of Malaysia (Gaim, 2004), land use types such as grassland, forests and cultivated land were considered appropriate for dumping except marshland and swamp type. For this study, grassland and bush land areas were considered appropriate for a landfill site.

**iii) Airports**: The distance between an airport and a landfill should be a minimum of 3km, unless there is a clear demonstration of bird control measures at the landfill.

**iv) Surface Water**: The distance between a landfill and the nearest surface water should be a minimum of 100m, or 200m to minimize the risk of polluting water with leachate. However, North Dakota Department of Health (2002) uses a minimum distance of 60m to the nearest surface water, and Yaw et al., (2006), a distance of 300m from any water body. For this study, at least 200m were considered appropriate for a landfill site.

**v) Groundwater**: An extremely deep water table region is suitable so that underground water is not contaminated by the leachate of the waste. According to North Dakota Department of Health (2002), the bottom of disposal trench should be at least four feet above the water table.

**vi) Local Topography**: landforms located in flat or undulating land, in a disused quarry are suitable for waste disposal. Major landfills must not be sited in hilly areas, those with ground slopes nominally greater than 10%. However, EPA (2003) recommends a slope



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less than 5 %, and North Dakota Department of Health (2002), 15% slope or less. For this study, 20% or less was considered appropriate for a landfill site.

**vii) Soils**: soil should be of sufficiently low permeability to significantly slow the passage of leachate from the site. Thus, sites in clay-rich environments are preferable.

**viii) Climate**: areas with heavy rainfall need extra care to avoid side effects of drainage and erosion, sites with prevailing winds require extra efforts to control litter and dust. Unstable Areas: landfills must not be located within 100m of an unstable area.

**ix) Infrastructure**: Although landfills should have suitable transport access, with power and water available, they should not be located within 100m of any major highways, city streets or other transportation routes. Yaw et al., (2006) recommends 300m. It would be more cost efficient for landfills not to be located so far away in order to avoid high transportation costs. For this study, at least 200m were considered appropriate for a landfill site

***Study Area***

Ashiyie is a suburb of Adenta Municipal Assembly in the Greater Accra Region of Ghana. It is situated along the Adenta-Dodowa Road with a land size of 1396 acres and a total population of about 11,742. It lies on longitudes $0^0$ 7’50” W to $0^0$ 9’36” W and latitudes $5^0$ 43’51” N to $5^0$ 44’50” N of the Greenwich meridian (Figure 1).

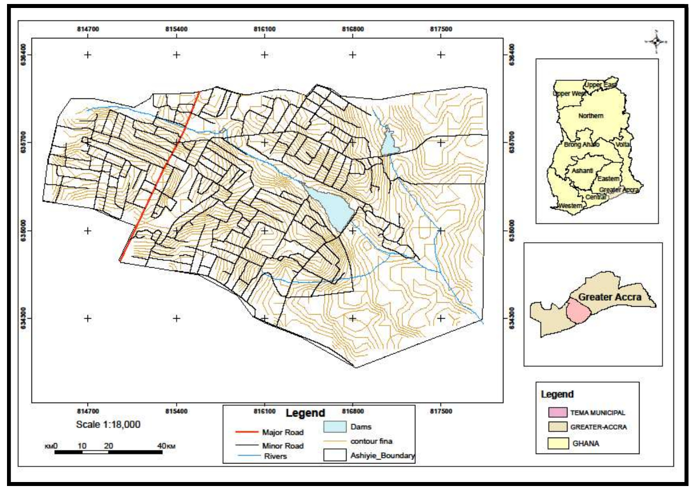


Figure 1: Map of Ashiyie in Adenta Municipal, Ghana

## 2. METHODOLOGY

GoeEye satellite imagery and the Shuttle Radar Topography Mission (SRTM) image from Global Land Cover Facility (GLCF) were used as secondary data. The spatial reference of the image was set using projected coordinate system and the zone used was WGS 1984 UTM Zone 30 N. The image was then georeferenced and the layers Built up areas, Roads, Dam and River were extracted in layers and added to the database see (Figure 2). Geology is also another important factor to be consider when selection a site for landfill. The geology type identify in the study Area was Quartz Schist. This type of geology is heterogeneous assemblage of sericitic, biotitic or chloritic quartz schist. It is fresh rock which has good bearing capacity and slope stability and is resistant to weathering. In weathering zone, rock parts easily along schistosity planes. Soil on top of elevations is often lateritic, while clayey soil develops in flat and depressed areas. This is a suitable geology type for landfill site siting in Ashiyie. But since it is a generalized geology map of some part of Greater Accra Region and with the scale of 1:50000, it was excluded in the final criteria for the suitable site selection.

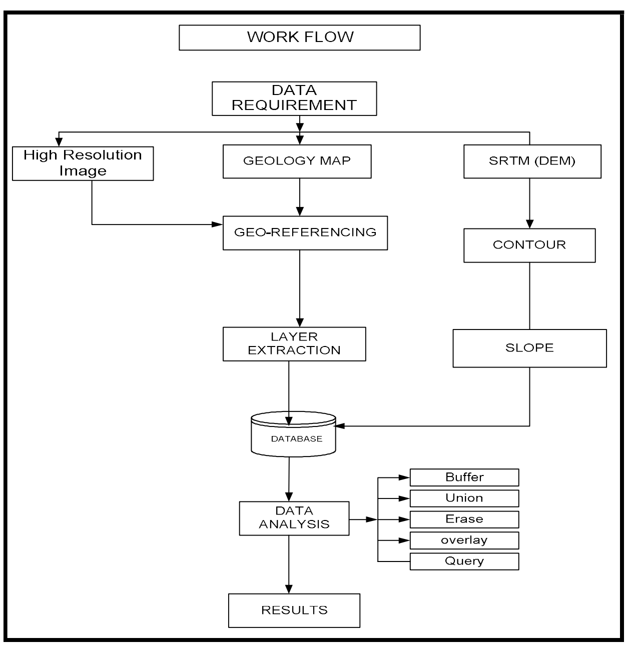


Figure 2: Key Process

## 2.1 GIS Database

### *2.1.1 Conceptual Model*

Abstraction of the characteristics and properties of real world features that are relevant to the purposes of the GIS database was done to determine the spatial relationship among the attributes of each entity. This is show below in the conceptual model diagram (figure 3). In this figure, the entities identified were Roads, Town, Dams, Buildings, Rivers and Geology with their attributes and relationships.

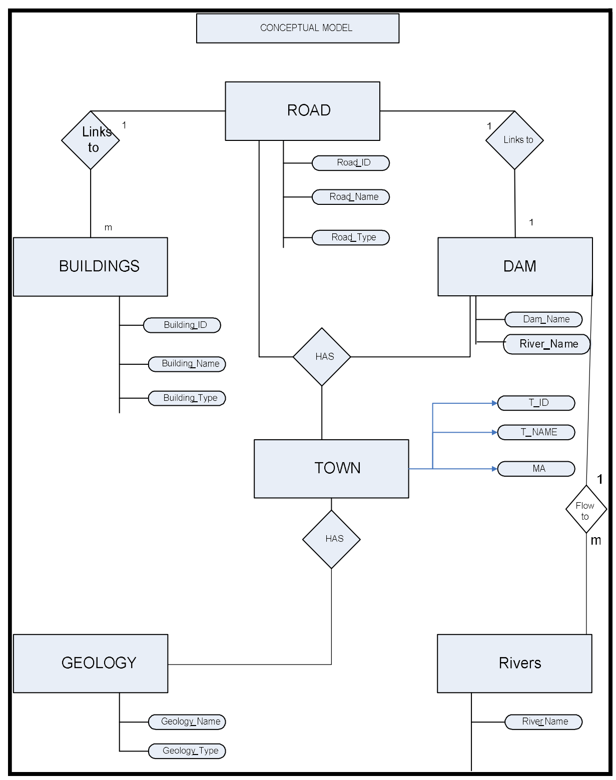


Figure 3: The Conceptual Model



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### 2.1.2 Logical Design

This is the phase of translating the conceptual design into a structure. It's the representation of the data model to reflect the recording of the data in computer system. In logical design, the conceptual model can be translated into families of data or data structure acceptable to the computer system. It is also known as database structure. There are several approaches to the structure: hierarchical structure, network, relational (as used in INFOCAM) and object-oriented approach (as in SMALLWORLD and ONTOS). For this project, the relational database structure was used where data was stored in relations called entities with each entity having items called attributes (Table 1).

Table 1: Logical Design

| | | | | |
|---|---|---|---|---|
| Road | Road_ID | Road_Name | Road_Type | |
| Buildings | Building_ ID | Building_ Name | Building_Type | Road _ID |
| Geology | Geology_ Name | Geology_ Type | | |
| River | River_ Name | Dam_Name | | |
| Dams | Dam_ Name | Road_Name | | |
| Town | Town_ID | Town_Name | Municipal_A | Road _Type |

### 2.1.3 Physical Design

The physical design stage is the implementation stage. It is a representation of data structure in the format applicable to the implementation software. ArcCatalog was used the implementation of the database for this project because it help take care of the geometrical aspect of the database.

## 2.2 Data Analysis

Under data analysis, three different operations were carried out in which the various Data collected were processed and analyzed. These operational analyses to be performed are: contour and slope, buffering and Spatial Overlay Analysis using Boolean Overlay methods.

### 2.2.1 Generation of Contour and Slope

A Contour Map was created from the SRTM image using the 3D analyst tool. Surface analysis was used to create the contour with the contour interval 2 meters. The contour generated was used in the creation of digital terrain model (DTM). A DTM is a topographic model of the bare earth terrain relief that can be manipulated by computer programs. The data files contain the spatial elevation data of the terrain in a digital format which usually presented as a rectangular grid. Features like vegetation, buildings and other man-made (artificial) features are removed digitally - leaving just the underlying terrain. The DTM created was Triangular Irregular Network (TIN) which uses irregular spaced set of points connected as triangles. The contour generated above was used as the input Data for the creation of the TIN in the ArcMap interface using 3D analyst create or modify TIN tools. Slope is generated from DTM in GIS environment. Slope identifies the rate of maximum change in z-value from each cell. It identifies the steepest downhill slope for a location on a surface. This was generated using 3D analyst tool in the ArcMap Software.

### *2.2.2 Buffering Analysis*

It is a spatial analysis known as proximity analysis; it generates zones of a given distance around a feature theme. It forms a polygon around a point, line or polygon theme by locating its boundaries at a specified distance. GIS can be the best tool for creating buffer zones around selected features. Buffering analysis were carried out for the Buildings, Dams, River and Road network of Ashiyie to show the distances at which the landfill site should be located away from the above maintained criteria. Some literature review shows that, a buffer distance from the Road network to the selected landfill site should be at least 30 m away, which was adopted from Allen (2000) and used for this project. According to Cantwell (1999), buffer distance of at least 250 m should be located away from buildings in the study area. This was also adopted in the project. A buffer distance of 100 m and above was used by Sumathi *et al.* (2008) for Dams/Ponds, but in this studies, a buffer of 150 m was used for river while a distance of 200 m was used to buffer around the Dam. The buffer zones were created to eliminate the unsuitable area from the Suitable once to site a landfill. The criteria/factors and their buffer zone are shown in the Table 2

Table 2: Criteria and their buffers

| *NO.* | *CRITERIA* | *BUFFER ZONE (meters)* |
|---|---|---|
| 1. | Major Road | 100 m |
| 2. | Minor Roads | 30 m |
| 3. | Rivers | 150 m |
| 4. | Dams / Pond | 200 m |
| 5. | Building | 250 m |

*(Source: Allen; 2000; Cantwell, 1999; Sumathi et al., 2008)*

### *2.2.3 Overlay Analysis*

An overlay operation is much more than a simple merging of line work. All the attributes of the features taking part in the overlay are carried through by combine the characteristics of several datasets into one. In this study, Boolean Overlay analyses method were carried out and used to determine positive areas or the suitable area and negative areas which is unsuitable areas. Boolean Overlay method uses the logical operators such as intersection (logical AND), Union (logical OR) and Erase operators. The result of the operation will be combined to give result of Unsuitable area and suitable area. According to Luthbom et al 2003, Boolean Overlay method was a rough method used in eliminating areas which are definitely not to be considered as a landfill site.

### *2.2.4 Cartographic model*

The model in Figure 4 shows the step by step approach to how the work was carried out. In the first step, the layers were buffered according the values stated in (Table 2). The minor roads, major roads and the river networks were buffer and union to arrive at the first result which is unsuitable areas. In the second step, the dams were buffer 200 m and the result achieved was union with the unsuitable area 1 in the first step. The results of this union operation produce unsuitable area 2. The buildings in the study area were grouped into built up areas. A buffer distance of 250 m was used to buffer around built up areas and the result obtained show unsuitable area 3. This means that any area in the study area occupied by the buffer is not good for landfill site. Erase operation was carried out on unsuitable areas 3 and the result were suitable areas. Finally, Suitable areas were overlay on the slope map to give the final suitability map.

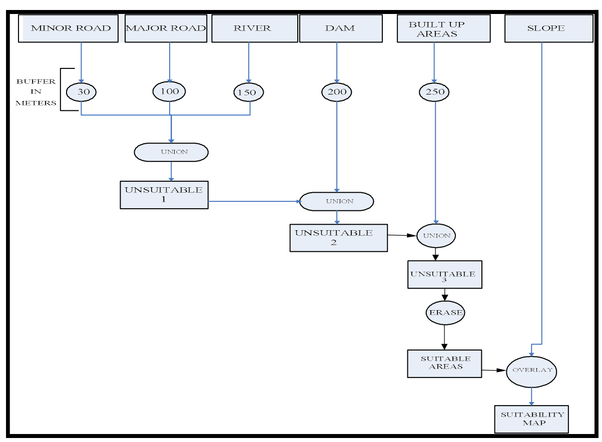


Figure 4 : Cartographic Model

### 2.2.5 Geology

Geology is also another important factor to be consider when selection a site for landfill. The geology type identify in the study Area was Quartz Schist. This type of geology is heterogeneous assemblage of sericitic, biotitic or chloritic quartz schist. It is fresh rock which has good bearing capacity and slope stability and is resistant to weathering. In weathering zone, rock parts easily along schistosity planes. Soil on top of elevations is often lateritic, while clayey soil develops in flat and depressed areas. This is a suitable geology type for landfill site siting in Ashiyie. But since it is a generalized geology map of some part of Greater Accra Region and with the scale of 1:50000, it was excluded in the final criteria for the suitable site selection

## 3. RESULTS AND DISCUSSION

### *3.1 Extraction of Built up areas and Roads from High Resolution Image*

Analysis of builtup and roads from GoeEye satellite imagery revealed that the study area covers 739.933 acres of builtup land and 167 number of roads which only one of them is a major road and others are minor roads (Figure 5 and 6). The built up area and the road networks were considered because the waste generated from built up areas are transported through the road to the final disposals site. The road network map of the study area was categorized into two different types which are major road and minor roads. This show the distribution of access in the study area.

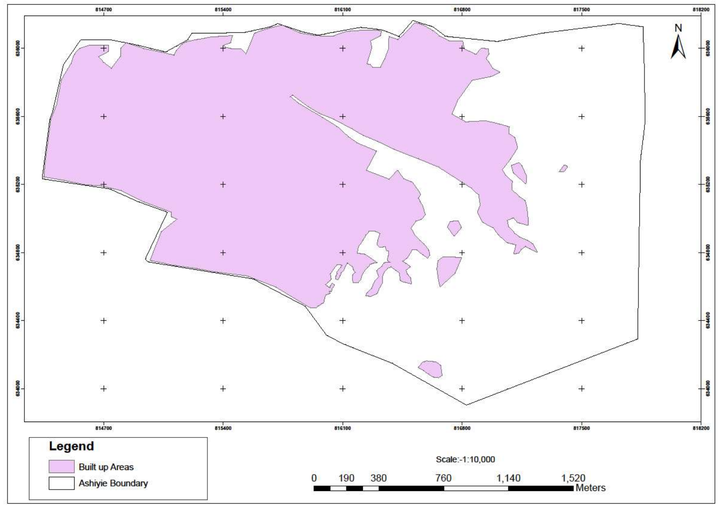


Figure 5: Built up areas

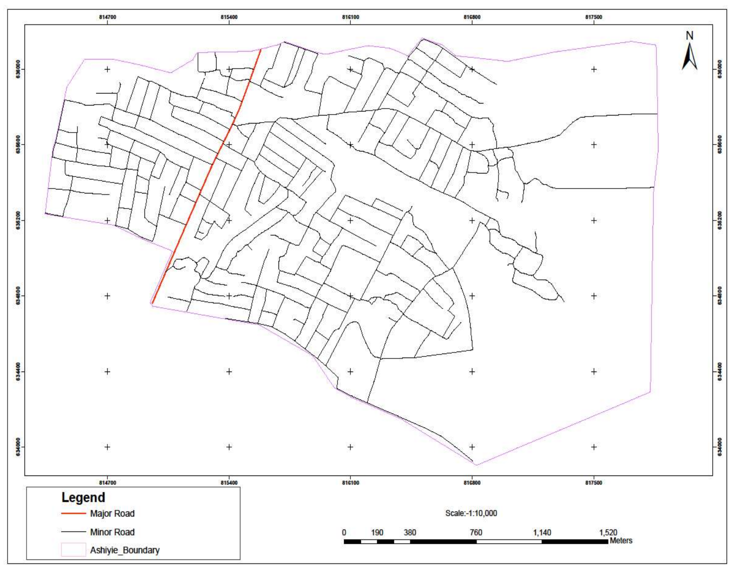


Figure 6: Road network in the study area.

### *3.2 River Networks and Dams information generation*

The study reveals that three different river sources exist in the area and the rivers were damed at three different places which save



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the community for domestic and agricultural purposes. Generally, waste disposal site must not be sited near rivers, lakes, ponds or dams.

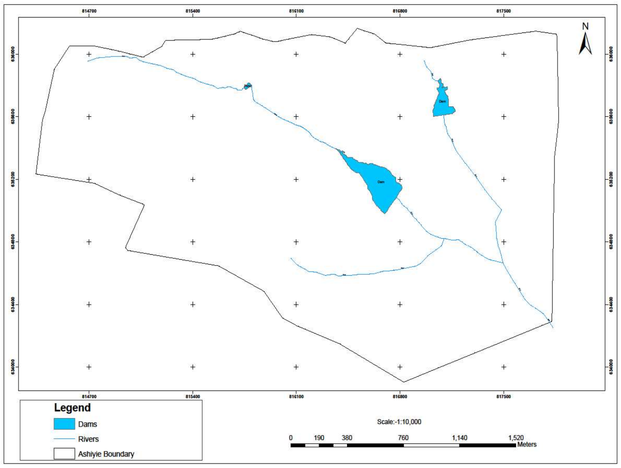


Fig. 7: Rivers and Dams in the study areas**.**

### *3.3 Distances from Road Network, Rivers and Dams*

The major road was buffered 100 meter which means that all areas less than 100 meters within are not suitable for landfill site location but the areas greater than 100 m (area > 100m) are the most suitable areas that landfill site can be located. With minor roads, a buffer of 30 meters was assigned to them. The unsuitable areas here are the areas less than 30 meters which are shown in the light blue colour on the map. All other areas showed white within the limit of the study are the most suitable areas. Within those areas where minor roads are greater than 30 m, landfill site can be sited for easy transportation of waste to the deposal site. On the other hand, the landfill site should not be placed too far away from existing road networks to avoid the expensive cost of constructing connecting roads (Lin, 1999). See result in Figure 7. With distances from Rivers and Dams, generally landfill site should not be sited close to existing rivers, pond or dams because of the contamination of the underground water. Therefore, a buffer of 150 meters and 200 meters were assigned to the rivers and Dams / pond respectively. The buffer areas on the map show the unsuitable areas where the site cannot be located while the other areas in white within the Ashiyie Boundary show the suitable areas for landfill siting (Figure 8).

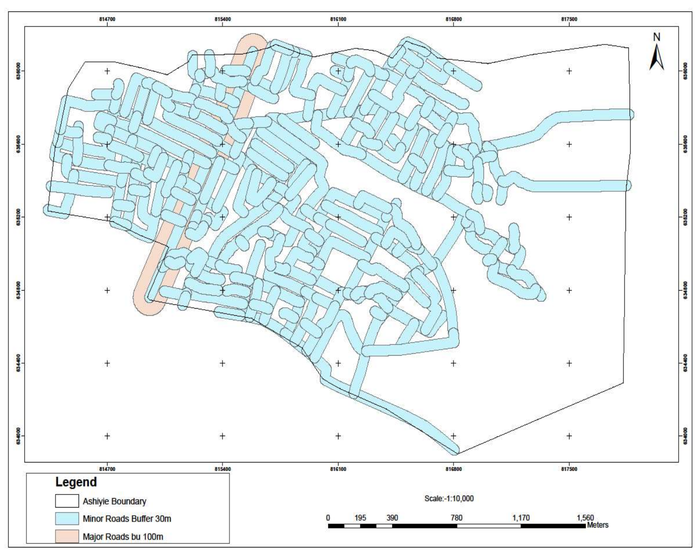


Figure 8: The Roads Buffer Zone

### *3.4 slope*

Slope refers to the measures of the rate of change of elevation at a surface location and normally expressed in percent or degree slope. In this project, the slope was generated from SRTM DEM. This was expressed in degrees and categorized or classified into three (3) classes. The first class of $0^{o} - 2^{o}$ show in Green is the most suitable Area where landfill site can be best sited. Followed by the second class of $3^{o} {}^{-} 10^{o}$ shown yellow which is moderately suitable for landfill site selection and finally the red colour ranging from $20^{o} - 40^{o}$ is less suitable area for siting landfill site see Figure 9.

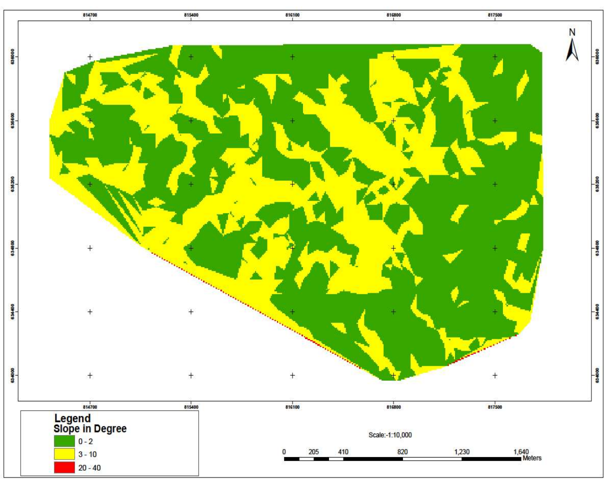


Figure 9: Slope map of the study area in degrees

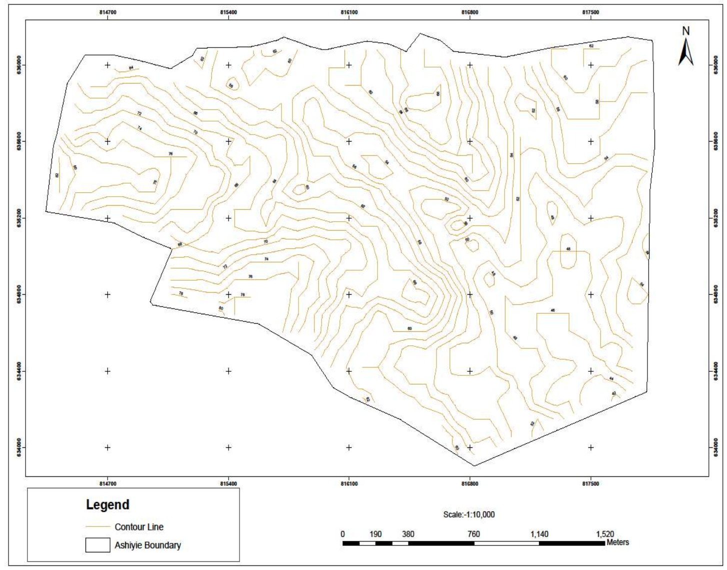


Figure 10: Contour map

### *3.5 Land use Map*

The total acreage of land at Ashiyie was 1396 acres. This was put into different land used type in the community. The result of the digitizing show that the built up area covers about 739.933 acres, vegetation covers 516.298 acres in the study area while the Dams covers 19.213 acres. This is the outcome of the first objective of the studies.



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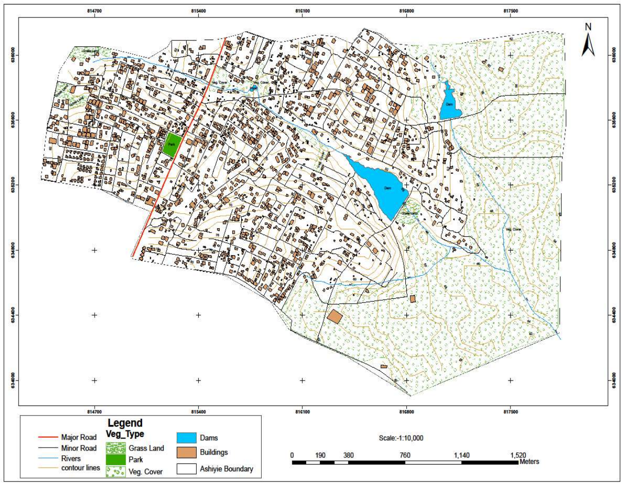


Figure 11: Land use map of the study area

### *3.6 Unsuitable areas analysis*

#### *3.6.1 Unsuitable Area 1*

Boolean overlay method for site selection was used where all linear features such as Road network and Rivers buffered in the study area are union to show the areas in the study area which are not suitable for landfill site. The union operation method helps to combined various layers as one layer (Figure 12).

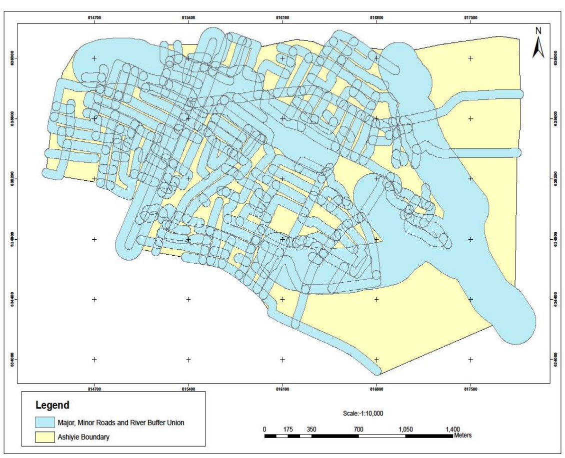


Figure 12: Unsuitable map 1

#### *3.6.2 Unsuitable area 2*

A union operation was carried out for the unsuitable map 1 (Figure 12) and the dams in the study area to show areas which are not suitable for the landfill site location. Therefore the analysis was carried out to eliminate the criteria which are not favorable for landfill siting. The result of this operation reveals that areas on the map (Figure 13) showing Atlantic blue and Moss Green colour are the areas that are not suitable for landfill site, while the areas shown yellow are the suitable site.

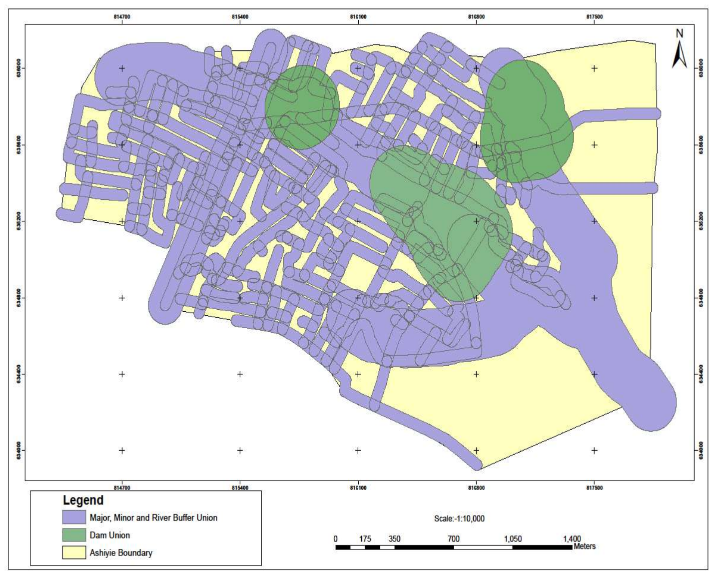


Figure 13: Unsuitable area 2 map (Union of Dams and all linear features)



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#### 3.6.3 Unsuitable area 3

In Figure 14, the overlay operation was carried out to overlay the unsuitable area 2 on the built up areas buffered to display those areas that are not suitable for landfill site location using union operation analysis. The result from this operation reveals that areas shown lilac Dust colour are not suitable for landfill site selection since they did not meet the criteria for landfill site selection.

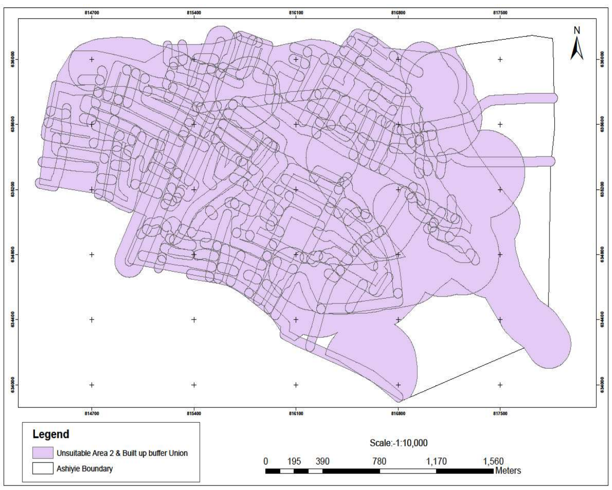


Figure 14: Unsuitable map 3 (Built up areas buffer and unsuitable map 2 union)

### 3.7 Suitable area analysis

Erase operation was conducted using the Boolean overlay analysis. The unsuitable area 3 which comprises of built up area buffer, Rivers buffer, Dams buffer and the Road network buffer were all erased from the study areas. The result shows that, the remaining areas left in the study areas are the possible suitable areas where landfill site can be sited. The total area highlighted for landfill site location is 198 acres (Figure 15). Since slope is an important criterion to consider when selecting site for landfill, there is a need to overlay the suitable areas identified in the study area on the slope to select areas which are most suitable, moderately suitable and less suitable. Since landfill site can be sited at a higher ground, the areas with higher values in degree were assigned less suitable which is shown in red colour in the legend ranging from 20 – 40 degrees (Figure 16). The yellow colour shows areas which are moderately suitable have a range 3 – 10 while the green portion shows the most suitable areas with a range of 0 - 2.

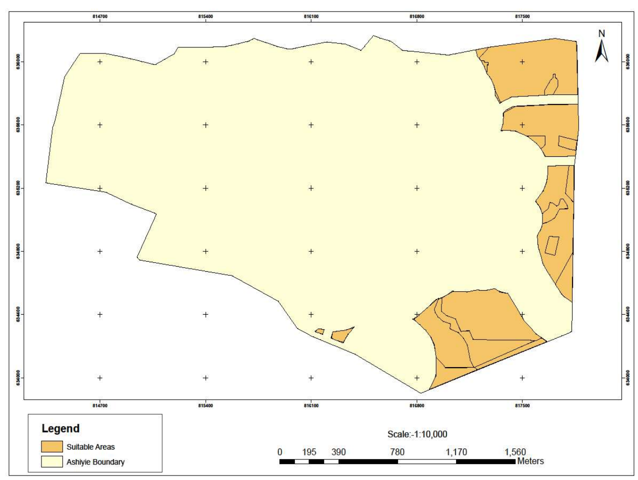


Figure 15: Suitable areas for the landfill site

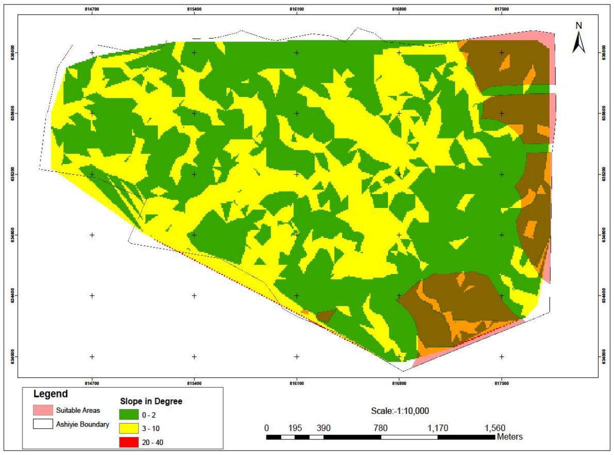


Figure 16: Suitable areas overlaid on the slope map

### *3.8 Final suitability map*

Special queries language (SQL) was used in querying the system to select the most suitable area as 3, moderately suitable as 2 and less suitable as 1. This can be performed by selection; select by attributes then select from the layer suitability areas. The method create a new selection; id = 3 for most suitable areas. A final suitability map was produced (Figure 17). All areas with dark umber colour show the most suitable areas where landfill site can be sited. These results were achieved taken into consideration all the criteria stated for this study. The electron gold colour on the map shows the moderately suitable areas for landfill siting and lastly the light apple colour shows the less suitable area for landfill siting. The other layers of the study area were also added to make the final suitability map complete. In this result, six (6) areas were identified as the most suitable sites, ten (10) for moderately suitable and only one area was identified to be less suitable site (Figure 17).

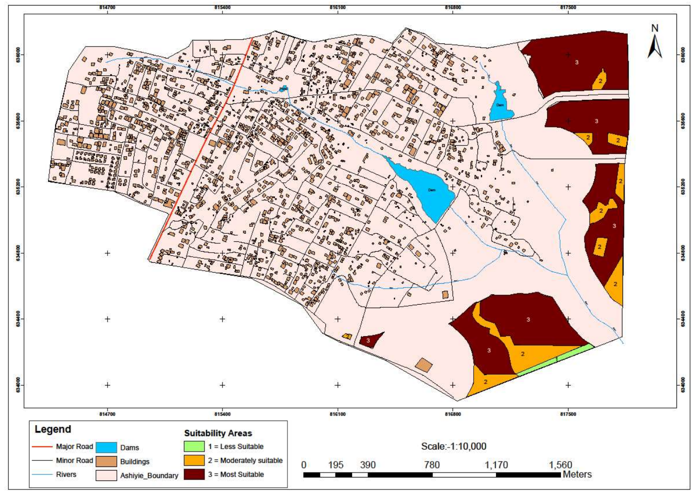


Figure 17: Final suitability map

## 4. CONCLUSION

In this research, the best landfill site for Ashiyie community in the Adenta Municipal Assembly of Ghana was located. The methodology described above is an efficient approach for a landfill siting process adopted from Boolean Overlay Method in GIS environment. The built up areas, Rivers, Roads, Pond and Dams layer in the study area were vectorized and used in carrying out the analysis. Buffering, union, intersection, erase, overlay and query analyses were perform to arrived at the final suitability Map for landfill site. It can be concluded from this study that six (6) areas were identified as the most suitable sites, ten (10) moderately suitable and only one area was identified to be less suitable site. From the study carried out, it is clear that there is need for an effective solid waste disposal management in the study area, therefore, the Chiefs, the Municipal Authorities and the Environmental Protection Agency (EPA) can consider this research and used for proper planning of Ashiyie Community.

## REFERENCES

Aboziah, R. A. (2016). Landfill Site Selection for Solid Waste Disposal Using Geographical Information System (GIS) and Multi-Criteria Approach in the Tarkwa Nsuaem Municipality, Ghana. BSc. Geomatic Engineering, KNUST, Department of Environmental Science, College of Science.

AHSSD (2014). Second Edition of the American Heritage Student Science Dictionary (AHSSD) by Hologhton Mifflin Harcourt publishing Company.

Akbari, V. (2008). Landfill Site Selection by Combining GIS and Fuzzy Multi Criteria Decision Analysis, Case Study: Bandar Abbas, Iran. *Journal of Department of Surveying and Geomatics Engineering, University of Tehran, Iran. World Applied Sciences, 3 (1), 39-47.*

Allen, A. R. (2002). Attenuation: A cost effective landfill strategy for developing Countries, Proceedings of 9th Congress of the international Association for Engineering Geology and the Environment, Durban, South Africa, 16-20 September 2002.

Al-Jarrah, A., and Abu-Qdnis, H.,(2005). "Municipal solid waste landfill using Intelligent system". Waste Management, Vol. 26. Issue 3.

Bahrani, S., Ebadi, T, Ehsani, H., *et al*. (2016). Modeling landfill site selection by multi-criteria decision making and fuzzy functions in GIS, Case study: Shabester, Iran. *Environmental Earth Science* 75, 337 (2016). *https:/doi.org/10.1007/s12665-015-5144-4*

Beynon, M., Cosker, D., Marshal, D., (2001). An expert system for multi-criteria decision making using Dumpster Shafer theory. Cardiff Business School, Cardiff University, Wales, UK.

Buenrostro Delgado, O., Mendoza, M., Lopez Granados, E., Geneletti, D., (2008). Analysis of land suitability for the sitting of inter-municipal landfills in the Cuitzeo Lake Basin, Mexico. Waste Management 28, 1137–1146

Cantwell, R., (1999). Putting Data to Work – GIS and Site Selection Studies for Waste Management Facilities. Eurogise 1999. Conference Proceedings.

Chang, N., Parvathinathan, G., Breeden, J.B., (2008). Combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast growing urban region. J. Env. Man. 87, 139–153

Davies, A. (2003): Waste wars: public attitudes and the politics of place waste management strategies. *Irish Geography,* 36(1), 77-92.

DWAF, (1998). Department of Water Affairs and Forestry Report. Second Edition.

EPA Anniversary Lecture, August (2004). Urban Land Use Planning Considerations in Environmental Management in Ghana. Pp 9 – 11.

Eldrandaly, E., Neil, E., and Dan, S. (2003). A COM-based Spatial Decision Support System for Industrial Site Selection. *Journal of Geographic Information and Decision Analysis,* 7(2), 72 92.

EPA (1998). Guidelines for Major Solid Waste Landfill Depots in South Australia. http:// www.epa.sa.gov.au/pdfs/swlandfill.pdf.

EPA (2003). Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites in the Northern Territory. http://www.nt.gov.au/nreta/environment/waste/codes/pdf.

Gao, S., Sundaram, D., and Paynter, J., (2004). Flexible Support for Spatial Decision-Making. Proceedings of the 37th Hawaii International Conference on System Sciences, 03(3): 30064a.

Gaim, J.K. (2004). GIS as Decision Support Tool for Landfills Siting. Proceedings of Map Asia 2004, Beijing, China. August 26-29.

Hecson, H., Macwan, J.E.M., (2017). Landfill site selection through GIS approach for fast growing urban area. Int. J. Civ. Eng. Tech. 8, 10–23.

KCC (2000). Environment Impact Statement for the Proposed Extension to Mpererwe Sanitary Landfill. KCC Library.

Kontos, T. D., Komilis, D. P. and Halvadakis, C. P., (2005). Siting MSW landfills with a spatialmultiple criteria analysis methodology. *Waste Management* 25(8), 818–832.

Luthbom K., and Lagerkvist, A. (2003). Tools For Landfill Siting: Division of Waste Science and Technology, Luleå University of Technology,Sweden. *In Proceeding Ninth International Waste Management and Landfill Symposium, 1-8.*

Lin, H., and Kao, J. J. (1999). Enhanced spatial model for landfill siting analysis. *Journal of Environmental Engineering,* 125 (9), 845-851.

Lim, J. S. and Missios, P., (2007): Does size really matter? Landfill scale impacts on property values. *Applied Economics Letter,* (14) 719 – 723.

Malczewski, J., (2006). GIS-based multi criteria decision analysis: a survey of the literature. International *Journal of Geographical Information Science,* 20 (7), 703–726.

North Dakota Department of Health - Division of Waste Management, (2002). Guideline 14 Emergency Waste Disposal Variance Notification: Dead Or Diseased Livestock. http:// www.health.state.nd.us.

Nyoni, T**.** (2020). Application Of Gis In Landfill Site Selection For Solid Waste Management In An Urban Environment, *6 (6),* 2395-4396.

Power, D. J. (2004). Free Decision Support Systems Glossary.http://DSSResources. COM/glossary, Accessed September 2005.

Oteng-Ababio, M. (2007): Private-Public partnership in solid waste management in the Greater Accra Metropolitan Area in Ghana. Unpublished PhD. dissertation, University of Ghana, Legon.

Sener,S., Sener, E., Nas, B., & Karaguzel, R. (2010). Combining AHP with GIS for landfill site selection: A case Study in the Lake Beysehir catchment area (Konya, Turkey)

United States Stemn, E., and Bilintoh T. M., (2015). Municipal solid waste landfill site selection in the Sekondi-Takoradi metropolis of Ghana using fuzzy logic in a GIS environment: Case study. *Journal of Envinronment and Waste Management*. 2 (2), 071-078 .

Sumathi, V. R., Natesan, U., and Sarkar, C. (2008). GIS-based approach for optimized siting of municipal solid waste landfill. *Waste Management*, (28), 2146-2160.

Environmental Protection Agency, last update (2020). Basic Information about Landfills.

Yaw, A.T. et al., (2006). Use of Geo-Spatial Data for Sustainable Management of Solid Waste in Niamey, Niger. Journal of Sustainable Development in Africa, 08(1), 203-210.