

## Site Selection For New Landfill Using GIS &RS Techniques (Case Study Omdurman Town)

Siddig Nourin Ali Abdelrahman<sup>1</sup>, Mohammed Hamed Hassan Abubkr<sup>2</sup>, Noof Ali Yousef AL keyal<sup>3</sup>

### Abstract:

*The study examined and analyzed the selection of the most appropriate sites for waste dumps in Omdurman. The study used many methods, tools and mechanisms to determine the best location according to the international standards for determining sites that contribute to waste collection and reduce their risks and environmental and social impacts on communities. For the dumpsites in the city of Omdurman and it is as follows the first site is characterized by unique characteristics in terms of area with a total area of 170.249691 km, and away from all the residential and agricultural areas and various water sources in the region fit to be N Industrial zone for recycling and recycling of waste site. The second is identical to all the criteria used in selecting the site in terms of location and area, with an area of 72.670089 km and far from the agricultural and residential areas, but located in the region of Odaya, the third location of this site meets all the criteria and its advantage is a road transport road with an area of 16.80428 km.*

*The site has a total area of 15.904759 km, but it is located in the middle of the agricultural land. The fifth site is identical to all the criteria in the selection of sites, but it is located in the agricultural and residential lands with an area of 2.82416 km. After careful analysis and verification of spatial characteristics under a model, A priority of each site separately and the importance of the decision makers. The study recommended the use of geographic information systems in the selection of the best sites of landfills, as this technology has a great role in facilitating the selection of sites, the need to search for an alternative site for the current site of the sites reached by the study to establish a factory for recycling and recycling of waste and benefit*

### الملخص:

*اختيار موقع جديد لمكب النفايات باستخدام تقنيات نظم المعلومات الجغرافية والاستشعار عن بعد "دراسة حالة لمدينة أمدرمان"*

*الكلمات المفتاحية: الموقع- المكب- نظم المعلومات الجغرافية- الاستشعار عن بعد- الزراعة والبيئة.*

<sup>1</sup>Department of Geography& GIS, Faculty of Arts, Imam Abdelurahman Bin Faisal University. KSA. Orcid ID 0000-0002-5608-7868

<sup>2</sup>Department of Geographical and cartography, Faculty of Geographical and Environmental University of Khartoum.

<sup>3</sup>Department of Geography& GIS, Faculty of Arts, Imam Abdelurahman Bin Faisal University. KSA.

قام البحث بدراسة وتحليل اختيار الموقع الأكثر ملاءمة لمداخن النفايات في أمدرمان. استخدمت الدراسة العديد من الأساليب والآليات لتحديد الموقع الأفضل وفق المعايير العالمية لتحديد الموقع التي تساهم في جمع النفايات وتقليل مخاطرها وتأثيراتها البيئية والاجتماعية على المجتمعات بالنسبة للمكبات بمدينة أمدرمان وهي على النحو التالي إذ يتميز الموقع الأول بخصائص فريدة من حيث المساحة تبلغ مساحتها الإجمالية 170 كم<sup>2</sup>، ويبعد عن كافة المناطق السكنية والزراعية ومصادر المياه المختلفة بالمدينة، فالمنطقة تصلح أن تكون منطقة صناعية لإعادة التدوير وخاصة النفايات، بينما الثاني مطابق لجميع المعايير المستخدمة في اختيار الموقع من حيث الموقع والمساحة وتبلغ مساحتها نحو 72670089 كم<sup>2</sup>، ويبعد عن المناطق الزراعية والسكنية. الموقع الثالث يقع منطقة قضايا له مطابق لجميع المعايير وميزته، طريق النقل البري بمساحة 16 كم<sup>2</sup> والرابع تبلغ المساحة الإجمالية 15.904759 كم<sup>2</sup>، إلا أنه يقع في وسط الأراضي الزراعية. الموقع الخامس مطابق لجميع المعايير في اختيار المواقع ولكنها أيضا تقع في المناطق الزراعية والسكنية بمساحة 282416 كم<sup>2</sup>. وبعد التحليل الدقيق والتحقق من الخصائص المكانية في ظل نموذج يتم تحديد أولوية كل موقع على حده وأهميته لدى متخذي القرار. أوصت الدراسة بأن استخدام نظام المعلومات الجغرافية ينبع في اختيار أفضل مواقع مدافن للنفايات حيث أن لهذه التقنية دور كبير في تسهيل اختيار الموقع كضرورة للبحث عن موقع بديل عن الموقع الحالي ضمن المواقع التي توصلت إليها الدراسة لإنشاء مصنع لتدوير النفايات والاستفادة منها.

**Keywords:** landfill n, GIS, s, Remote sensing, Agricultural. Environmenta.l

## Introduction

Waste management issues are coming to the forefront of the global environmental agenda at an increasing frequency, as population and consumption growth result in increasing quantities of waste. In the context of the above-mentioned challenge a New Paradigm for waste management has emerged, shifting attention to resources efficiency and minimization of environmental impacts throughout the life cycle of waste management, from waste prevention to safe disposal.

Technically, GIS is a set of software tools that is used to input, store, manipulate, analyze and display geographical information. Strategically, GIS may be a philosophy, a way of making decisions within an organization where all information is held centrally and is related by its location. Technological development in computer science has introduced geographic information system (GIS) as an innovative tool in landfill process. GIS combines spatial data (maps, aerial photographs, satellite images) with the other quantitative, qualitative and descriptive information databases.

Remote sensing is one of the excellent tools for inventory and analysis of environment and its resources, owing to its unique ability of providing the synoptic view of a large area of the earth's surfaces and its capacity of repetitive coverage. Its multispectral capability provides appropriate contrast between various natural features where as its repetitive coverage provides information on the dynamic changes taking place over the earth surface and the natural environment. When remotely sensed data are combined with other landscape variables organized with in a GIS environment provide an excellent frame work for data capture, storage, synthesis, measurement and analysis. For assessing a site as a possible location for solid waste disposal, several environmental and political factors and legislations should be considered.

## Problem Identification

Due to the population increasing in Omdurman and changes in living and consumption patterns, the quantities of waste resulting from human activity have increased significantly.

- The existing landfills have proved problematic due to:
- Closeness to the urban built-up area (Less than 1 km) resulting in high probability of disease spreading
- Social protest
- Possibilities of violence
- Poor management of waste

### **Objectives of the study**

- The objective of this study is to choose the best site landfill for Omdurman
- To contribute in the field of the suitable site selection for landfill at Omdurman and provide support for planner's decision makers.
- Contribute to sustainable urban land management

### **Research Questions:**

- Does the current landfill site match with international standards?
  - What are their environmental and social impacts of the current waste dump?
  - What are the trends of population growth in Omdurman

What is the most suitable location for the landfill sites that serve the objective of sustainable urban management?

### **Justifications choosing topic of study**

- The existing landfill in Omdurman poses serious concerns with the issues of health, population stability and future sustainable management of the urban environment. The slow disposal of waste due to lack of sufficient mechanisms
- Issue of environmental sustainability has recently become an important and legitimate area of scientific research
- The research is intended to provide practical scientific solution to one of the major environmental problems facing the capacity city of Khartoum, of which Omdurman is the largest concentration.
- The study will provide valuable information to urban planners and decision makers.

### **Literature review**

- Salem. M. Issa (September 2012), (a GIS-based multi-criteria evaluation system for selection of landfill sites), a case study from Abu Dhabi, United Arab Emirates, Landfill sites receive 92% of total annual solid waste produced by municipalities in the emirate of Abu Dhabi. In this study, candidate sites for an appropriate landfill location for the Abu Dhabi municipal area are determined by integrating geographic information systems (GIS) and multi-criteria evaluation (MCE) analysis. Methodologies used are normally based on a composite suitability analysis using map overlays and their extension to include statistical analysis. There are a number of integration models in GIS. Probably the simplest and best-known type of GIS model is based on Boolean operation. It involves the logical combination of binary maps resulting from the application of conditional operators. Results revealed that 30% of the study area was identified as highly suitable, 25% as suitable, and 45% as unsuitable. The selection of the final landfill site, however, requires further field research.
- Elsevier Ltd. (2011), (Multi-criteria GIS-based siting of an incineration plant for municipal solid waste), Siting a municipal solid waste (MSW) incineration plant requires a comprehensive evaluation to identify the best available location(s) that can simultaneously meet the requirements of regulations and minimize economic, environmental, health, and social costs. A spatial multi-criteria evaluation methodology is presented to assess land suitability for a plant siting and applied in this study, it combines the analytical hierarchy process (AHP) to estimate the selected evaluation criteria weights with GIS for spatial data analysis.

- R. S. Aziz<sup>1</sup> & L. Khodakarami<sup>2</sup>, (2013), (Application of GIS models in site selection of waste disposal in an urban area), in this study using the Boolean process to finding a proper site as the best location.
- Ali Jalil Chabuk<sup>1</sup> & Nadhir Al-Ansari<sup>1</sup>, (21 February 2017), (GIS-based assessment of combined AHP and SAW methods for selecting suitable sites for landfill in Al-Musayib Qadhaa, Babylon, Iraq), two methods were adopted to derive weights for criteria. They were used in the application of spatial extension tool “Map Algebra” in GIS to produce the final output map for suitability index for landfill site after implementing the comparison between these two methods. This was achieved as follows: (1) Simple additive weighting (SAW), also defined as weighted linear combination or scoring method, is considered as a simple method that uses multi-attribute decision technique. (2) The analytical hierarchy process (AHP) is one of the most common methods in multi-criteria decision-making.

## Material and methods

### Study Area

The study area of this research (Omdurman town) is town in Khartoum state between longitude (31° 50' 00" \_ 32° 50' 00") E latitude (14° 40' 00" \_ 15° 10' 00") N central Sudan with area approximately 7599.083355 km<sup>2</sup>

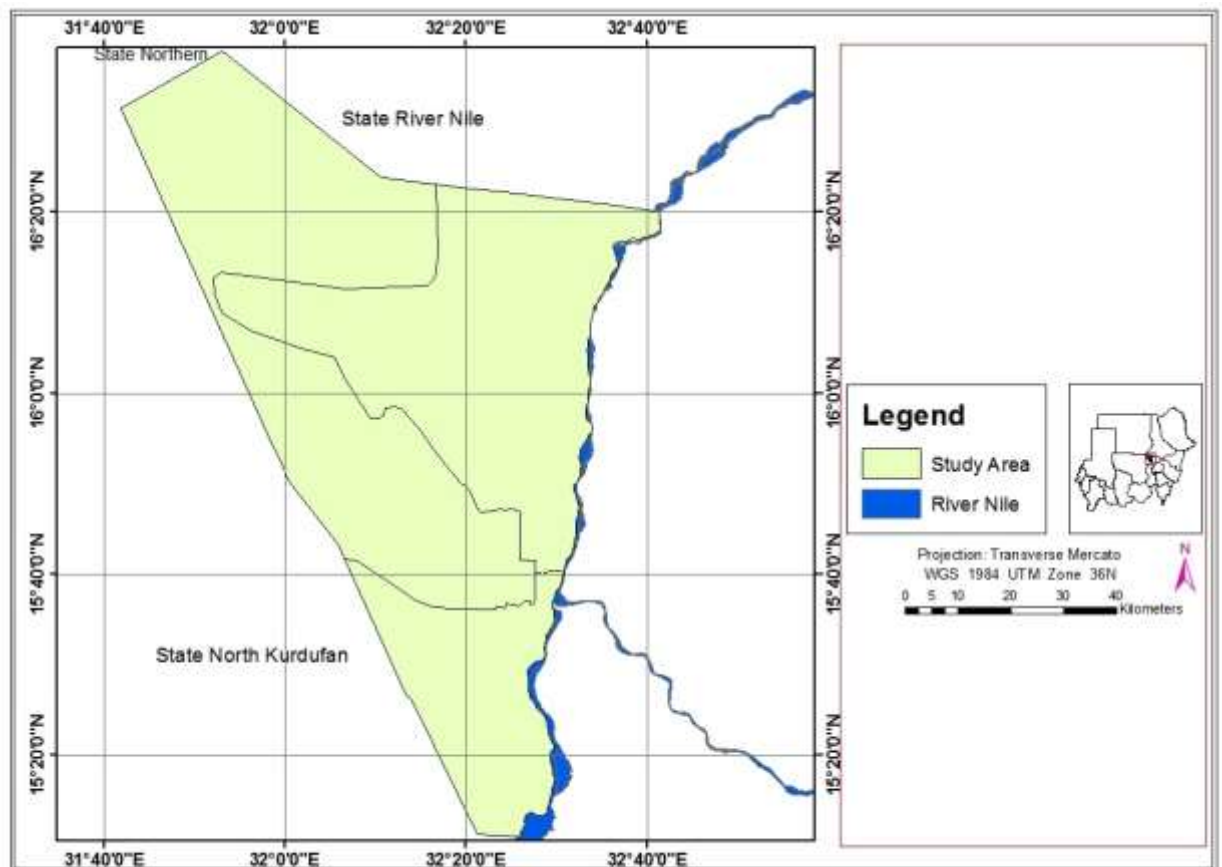


Figure 1. Location of the study area

### Climate.

Omdurman features a hot desert climate, with only the months of July and August seeing significant precipitation. Khartoum averages a little over 155 millimeters (6.1 in) of precipitation per year. Based on annual mean temperatures, Omdurman is one of the hottest major cities in the world. Temperatures may exceed 53 °C (127 °F) in mid-summer. It has dry winters

### Temperatures

Its average annual high temperature is 37.1 °C (99 °F), with six months of the year seeing an average monthly high temperature of at least 38 °C (100 °F). Furthermore, throughout the year, none of its monthly average high temperatures falls below 30 °C (86 °F). This is something not seen in other major cities with hot desert climates such as Riyadh or Baghdad or Phoenix. Although it's diurnal temperature variation is fair enough temperatures cool off during the night , with Khartoum's lowest average low temperature of the year just above 15 °C (59 °F). The city literally does not experience seasons, just like most parts of the Arabian Peninsula and north-eastern Africa where it's either hot or very hot all year long.

### Data preparation and data requirement

Data for the research has been collected from different sources

NO	Data Layers	Sources and References
1	DEM	United States Geological Survey <a href="http://glovis.usgs.gov/">http://glovis.usgs.gov/</a>
2	Riva Nile	DIU (Dams Implementation Unit)
3	Daring system	DIU (Dams Implementation Unit)
	Roads	Sudanese Survey Authority
4	Land use land cover	FOA Agriculture Organization
5	Urban	Ministry of Infrastructure
6	soil	Geological Research Authority
7	geology	Geological Research Authority
8	Wind direction	<a href="https://ar.wikipedia.org/wiki/">https://ar.wikipedia.org/wiki/</a>

### Data Validation

Data was validated for the data processing method.

### Data used in the study.

#### 3.14.1 Digital elevation model

DEM is primary layer uses to extract slope

#### Urban

The data was Obtained from the Ministry of Infrastructure to represent residential area The dump site must be away from the residential areas, a map of the villages in the area was obtained and the dump must be as far as possible.

#### Daring system

It's derived from DEM 90 products that to show flow through study area.,

#### Land cover and land use:

There are a lot of criteria for the use of land which is built on the basis of the use of local land to suit the desired purpose of the study.

There are four land uses found in Omdurman town two of them are accepted and the others are rejected to serve the purpose of the study which is shown in the following:

**shows the land use systems used in the study**

O	Category	Name	The acceptability
1	UR	Urban areas	Rejected
2	BS	Bare soil	Accepted
3	AS	Artificial surfaces	Rejected
4	AG	Agriculture	Accepted

**Soil**

Soil types have been classified into four hydrological groups as follows:

The first group (A):The Soil of this group has a low level of discharge when they are completely wet, it performs water freely within the soil.

The second group (B):Soil in this group have a low average discharge when they are completely wet, and the water is able to penetrate the soil.

The third group (C): These soils have a high average discharge when they are completely wet, and water Penetration into the soil is limited.

The forth Group (D): This soil High discharged when they are completely wet, and the water movement of within the soil particles is very limited.

Group D and C is accepted and group A and C was rejected in this study because of its low discharge.

**Wind direction.**

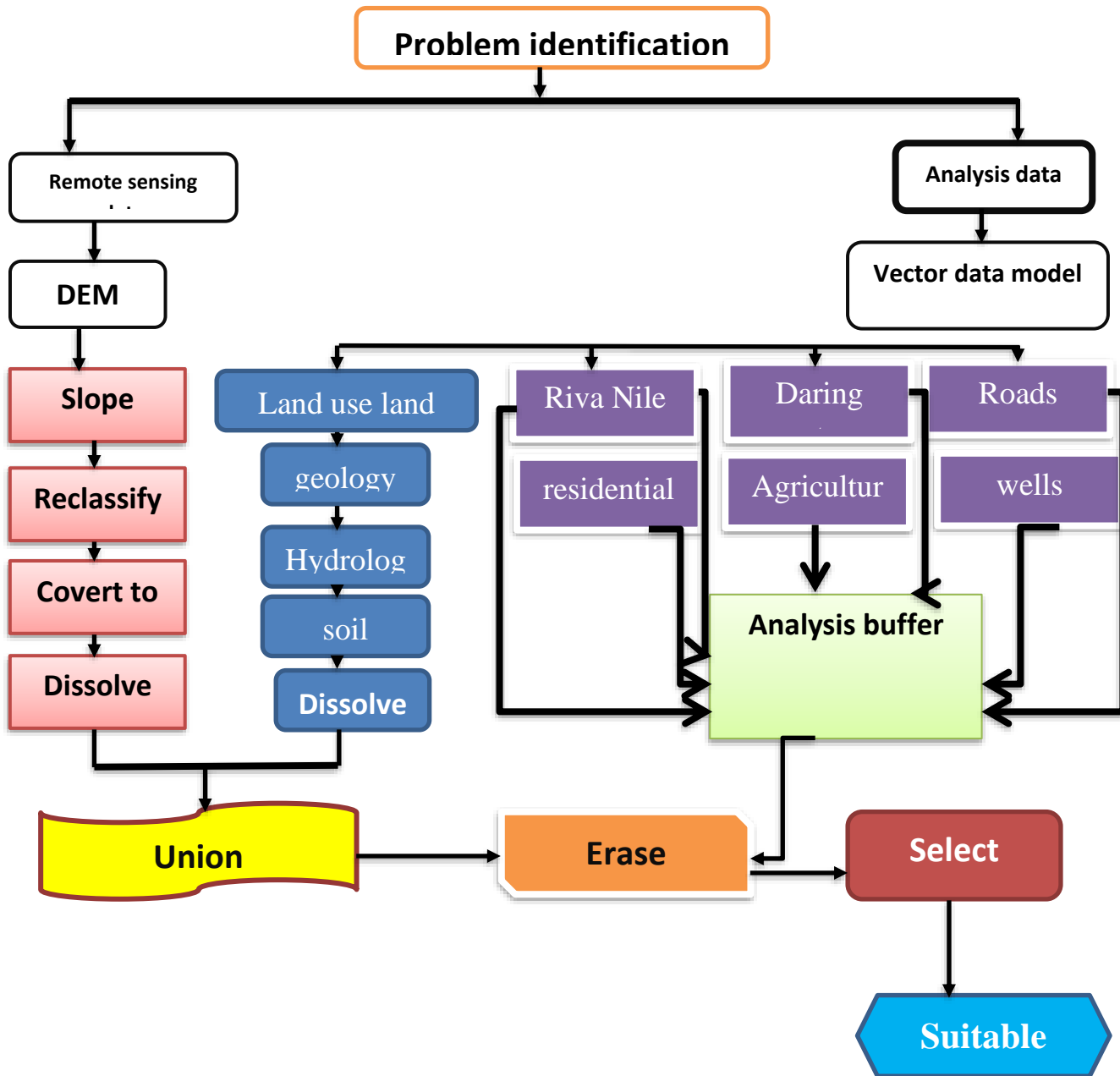
ind direction its very importune uses in selection site .

**Geology.**

Geology its very importune uses to select the basement rack in site selection

**Flow chart :**

diagram illustrated the procedures and sequencing steps that shows proplem identification, pre-processing for analysis vector data model, remote sensing data, and processing operation to obtain final results of research as



**Data inputs and criteria**

. Summary of Site Selection Criteria

Criteria	Data set
Accepted Area with Buffer distance > 2000 m	River Nile
Accepted Area with Buffer distance > 1500 m	Daring system
Accepted Area with Buffer distance > 2000 m	wells
Accepted clay loam	soil
Accepted basement	geology
Accepted Bare soil	Land use land cover
Accepted Area with Buffer distance > 9 km	residential

Accepted Area with Buffer distance > 1000 m	Roads
Accepted Area with slop suitable	slop
Accepted Area with Buffer distance > 1000 m	Agricultural

### Data Processing.

The Model-builder is primary tool to build the model and analysis to obtain the final result.

#### Pre-processing (Tools)

**Buffer** which creates buffers at specified distances around the input features. These buffers can optionally be merged and dissolved using the buffer distance values to create non-overlapping buffers

Using **Erase tool** to prepare study area with buffer layers.

Using **Merge tool** to integrate two layers which infer of buffer tool and infer of eraser tool for some layers.

Using **Convert Polygon To Raster** to be the polygon as raster grid

**Reclassify** each criterion layer to either a suitability of acceptance layer

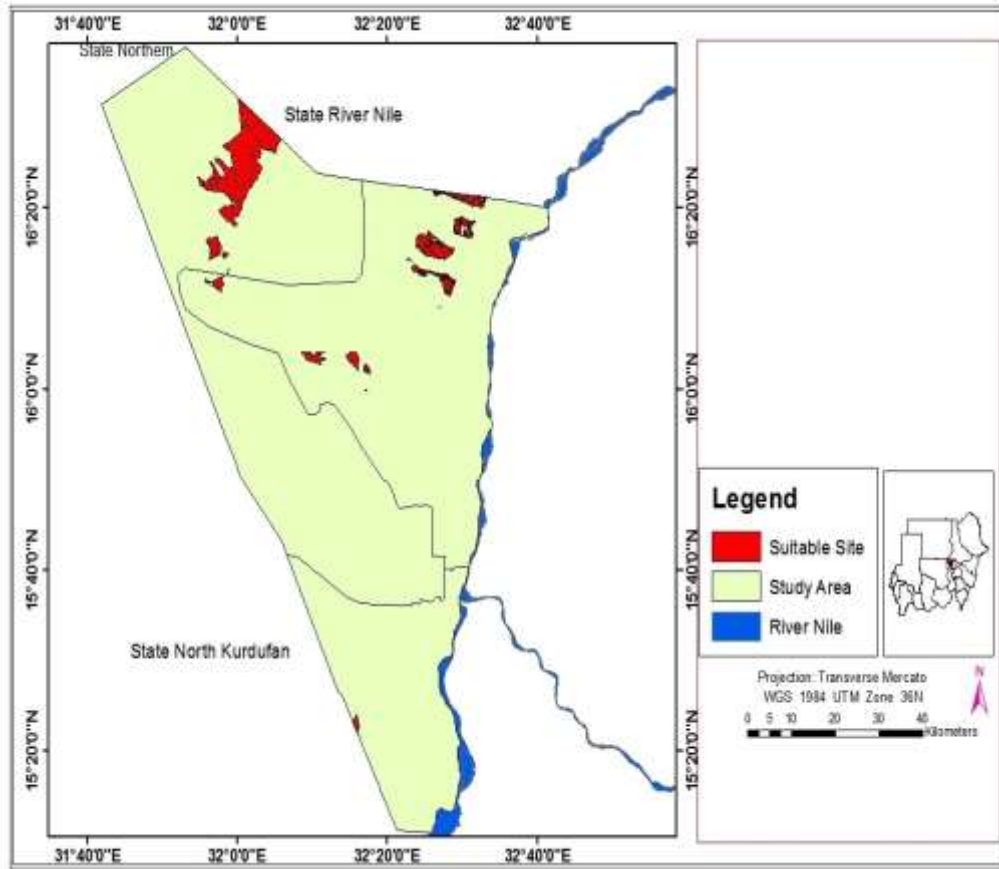
#### Software Used

ArcGIS (Geographic Information Systems) is a powerful tool used for computerized mapping and spatial analysis. ArcGIS provides functionality to capture, store, query, analyze, display and output geographic information. As of January 2000, Arc View 3.2 was superseded by ArcGIS 8. The term ArcView was applied to the lowest level tier of ArcGIS 8. Progressively higher tiers, all with a common interface, were termed Arc Editor and Arc Info. ArcGIS 10.4.1 (The latest release) focuses primarily on geodatabase editing and topology. it includes all of the tools needed to build, manage, and maintain any geographic information in geodatabases In this research we use Arc map to work within the program is the main mapping application which allows to create maps, query attributes, analyze spatial relationships, and layout final maps

#### - Results and Discussion

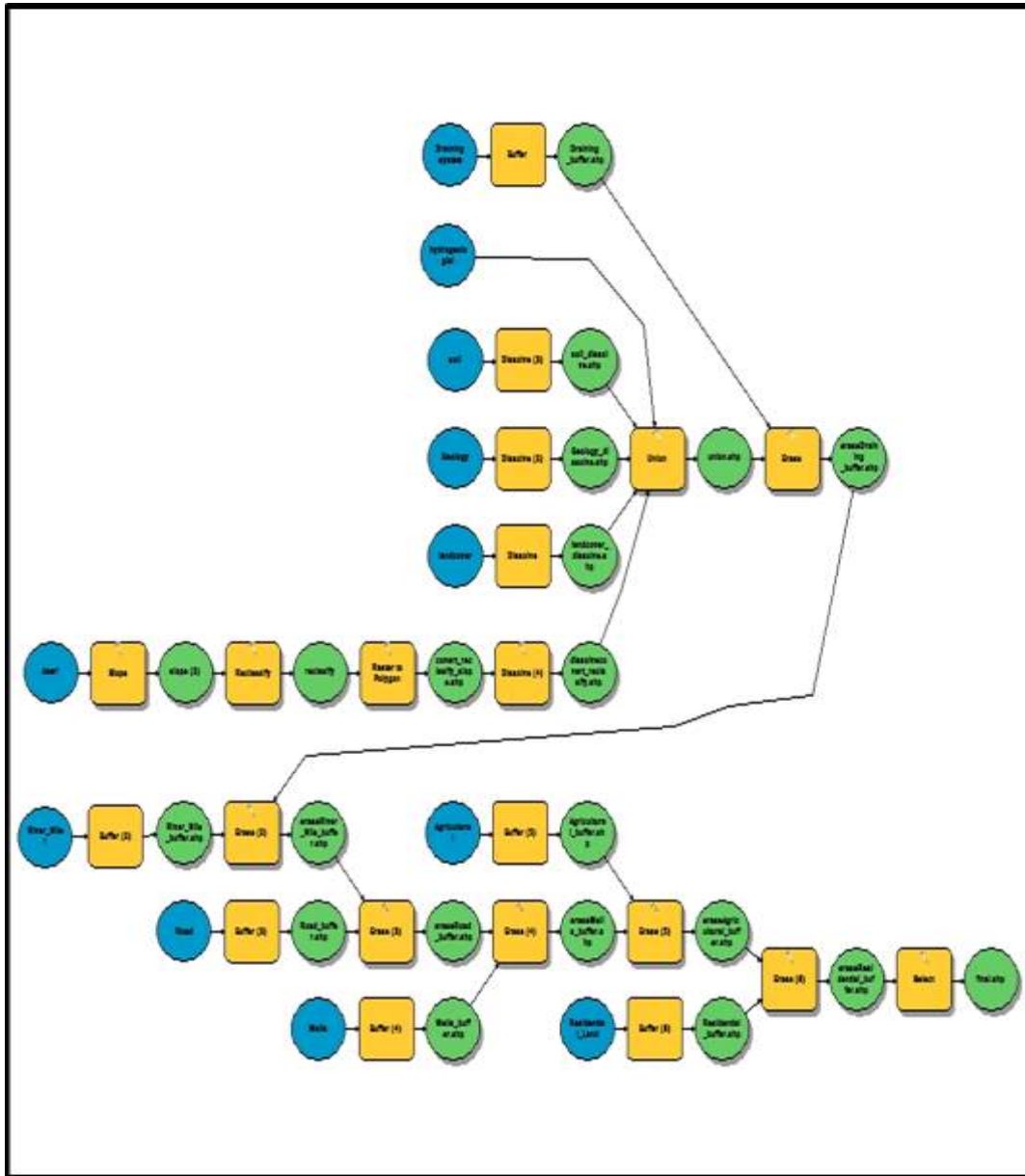
The objective of this study is to choose the best landfill site for Omdurman state using GIS techniques through effective layers in landfill Constructions which are DEM, Riva Nile, daring system, Roads, Land use land cover, Urban, soil, geology, agriculture and hydrological, wells. Suitability Modeling was used to overlay those layers using vector analysis techniques

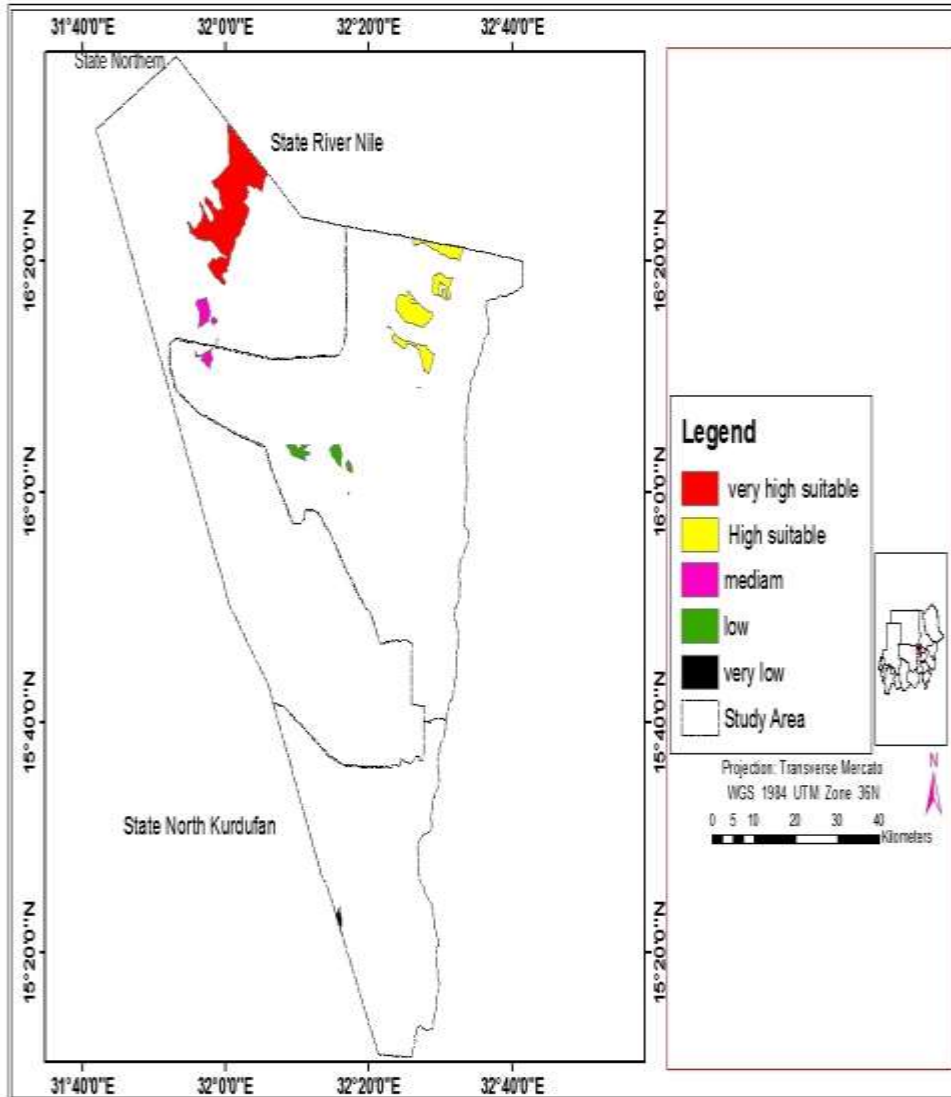




Final map

Final Model





Classification Result as five categories. map

**Data Analysis and Results Discus**

After the analysis of the data has been given above the study reached to the following results, which is the five suitable sites selection for landfill in Omdurman town. Moreover, the researcher has divided the location for five sites suitable areas:

**Site one: very high suitable:**

In this site the researcher depended on the criteria that have been used on the regional level. Which is far from agricultural lands, residential areas and drainage system? Also this site have large area is approximately 170.249691 km<sup>2</sup> in addition to the wends direction were blowing from north east to the south word that location is far from residential area.

Table 3. Very high suitable

ON	Data Layers	Site No (1) very high suitable
1	DEM	very high suitable
2	Riva Nile	
3	Daring system	
4	Roads	
5	Land use land cover	
6	residential	
7	soil	
8	geology	
9	Agriculture	
10	Hydrological	
11	wells	

### High suitable:

This site is high suitable for landfill because it is located far from agricultural area and residential area and also have a large area is about 72.670089km , asough of this site is suitable but the location stretched over the drainage system this can be a real problem in spite of its possibility to be a high suitable site selection for landfill, moreover the wends directions in Sudan generally was Blowing from north eastern word direction which can effects the residential area.

### High suitable

NO	Data Layers	Site No (2) High suitable
1	DEM	High suitable
2	Riva Nile	
3	Daring system	
4	Roads	
5	Land use land cover	
6	residential	
7	soil	
8	geology	
9	Agriculture	
10	Hydrological	
11	wells	

### Medium site suitable:

In this site the agricultural lands is very closed to this site, therefor the researcher selected it as the third type of classification that can be possible for landfill area in Omdurman town, the

characteristics of this site are mostly far from residential areas and river Nile, in addition to that the roads are near to this site but also the landfill can effects on cultivation which is closed to the location the area abut 16.80428km.

**medium site suitable**

Table 4 NO	Data Layers	Site No (3) Medium site suitable
1	DEM	<b>Medium site suitable</b>
2	River Nile	
3	Daring system	
4	Roads	
5	Land use land cover	
6	residential	
7	soil	
8	geology	
9	Agriculture	
10	Hydrological	
11	wells	

**Low suitable site landfill:**

Due to this site characteristic were all suitable but the agricultural area is around the site, in spite of the agricultural lads is closed but it can help and easier the recycling process of harvest out can be treated and manage in this site area abut15.904759km.

**Low suitable site landfill:**

NO	Data Layers	Site No (4) Low suitable site landfill
1	DEM	<b>Low suitable site landfill</b>
2	Riva Nile	
3	Daring system	
4	Roads	
5	Land use land cover	
6	residential	
7	soil	

8	geology	
9	Agriculture	
10	Hydrological	
11	wells	

**very Low site suitable landfill**

This site can be a landfill but the suitability depends on the regional criteria which that mean all of Human activities and the ecological location cannot be used for the activities the area abuts 2.824162km.

**Table 6 . very Low site suitable landfill**

NO	Data Layers	Site No (5) very Low site landfill
1	DEM	<b>very Low site suitable landfill</b>
2	Riva Nile	
3	Daring system	
4	Roads	
5	Land use land cover	
6	residential	
7	soil	
8	geology	
9	Agriculture	
10	Hydrological	
11	wells	

**Conclusion**

The study dealt with the explanation and analysis of the selection of the best site for landfill in the city of Omdurman.

The study used a number of methods including GIS, remote sensing, tools and mechanisms to determine the best sites according to the international standards for determining sites that contribute to the collection of waste and reduce its risks and environmental and social impacts on the communities.

The study mechanism was developed according to the methods used by the researcher. The study summarized the best location of the waste dump in Medina, which is as follows. (A)**very high suitable. In** this site the researcher depended on the criteria that have been used on the regional level. Which is far from agricultural lands, residential areas and drainage system? Also, this site have large area is approximately 170.249691 km<sup>2</sup> in addition to the wends direction were blowing from north east to the south word that location (B)**High suitable:** This site is high suitable for landfill because it is located far from agricultural area and residential area and also have a large area is about 72.670089km<sup>2</sup>, as Hough of this site is suitable but the location stretched over the drainage system this can be a real problem in spite of its possibility

to be a high suitable site selection for landfill, moreover the winds directions in Sudan generally was Blowing from north eastern word direction which can effects the residential area.(C) **Medium site suitable:** In this site the agricultural lands is very closed to this site, therefor the researcher selected it as the third type of classification that can be possible for landfill area in Omdurman town, the characteristics of this site are mostly far from residential areas and river Nile, in addition to that the roads are near to this site but also the landfill can effects on cultivation which is closed to the location the area abut 16.80428km. (D)**Low suitable site landfill**

Due to this site characteristic were all suitable but the agricultural area is around the site, in spite of the agricultural lads is closed but it can help and easier the recycling process of harvest out can be treated and manage in this site area abut15.904759km (E)**very Low site suitable landfill** This site can be a landfill but the suitability depends on the regional criteria which that mean all of Human activities and the ecological location cannot be used for the activities the area abuts 2.824162km. After careful analysis and verification through the development of all the spatial characteristics under the global model used in this area and showed us the advantage of each site on a fictional basis as a dumping site for waste decision-makers

### Recommendations

- The need to use geographic information systems in the selection of the best sites for the dumps of the dumps because this technology has a great role in facilitating the process of selecting the best sites.
- The study suggests that the current landfill does not comply with the requirements of the landfill selection process and that the Umrah has expired
- The need to search for alternative sites within the sites that have reached the study
- Urging officials, especially the Ministry of Environment, to follow the health rules and standards in selecting waste dump sites and to take into account the health conditions and criteria for choosing the best sites
- The need for coordination between the relevant institutions and ministries of the need for attention and follow-up to the current waste site
- Establishment of factories for recycling, recycling and utilization of waste

### Refers

- Bilgehan Nas · Tayfun Cay · Fatih Iscan · Ali Berkay. Selection of MSW landfill site for Konya, Turkey using GIS and multi-criteria evaluation Received: 29 September 2008 / Accepted: 23 December 2008 / Published online: 24 January 2009 © Springer Science + Business Media B.V. 2009
- Vasilios Despotakis. Alexander P. Economopoulos (2007) A GIS model for landfill sitting
- Hinde. Ibrahim Mohammad Nimer. " Cost Analysis of Solid Waste Management for the city of Qalqilia" driss" . An- Najah National University. 2010.
- El-hawi, M, Et Al. " Intergrated Sustainable Approach to Disposal Site Selection using GIS: the Gaza Strip case.
- Fides K. Kirimi 1, Edward H. Waithaka2 (2012) Determination of Suitable Landfill Site Using Geospatial Techniques and Multi-Criteria Decision Analysis: A Case Study of Nakuru Town, Kenya