Selection of Landfill Site in Khartoum State Using (GIS) Techniques and Multicriteria Decision Analysis (MCDA)

Dr. Yosif Ali Yosif[1]
Dr. Abdul Alraheem Alhag Abdul Azzez[2]
FADWA A. HUSSIENPH.D (student)[3]

Abstract

In this study, candidate sites for an appropriate landfill area of Khartoum are determined by using the integration of Geographic Information Systems (GIS) and multicriteria decision analysis (MCDA).Using these approaches leading to integrated environmental management are necessary to allow consideration of all components and processes in environmentGIS and environmental models function with a broad spectrum of geospatial data that are used for diverse applications and spatial analyses at different scales.Data are collected through observation, measurement, and inference.The examination and organization of data into a useful form produced information, whichthen enables appropriate analysis and modeling. for this purpose, input digital map layers including settlement (urban center, villages, and industrial areas), main roads , airports, wetlands, digital elevation model , land use (camps, palace, water and waste water treatment plants, agricultural zone, gardens and buildings) and surface water (streams and main irrigation channels) are prepared and Weighted Overlaymethod are implemented to a geographical information system. It has focused on the formulation ofstandardsLandfill planning, and give it arranged for each standard and weighted , and then build a model and extract map representing more convenient for the establishment of landfill waste sitesto stay healthy waste dumps in the state of Khartoum

الملخص

في هذه الدراسة، ويتم تحديد المواقع المرشحة لمساحة المكب المناسبة في ولاية الخرطوم باستخدام التكامل بين نظم المعلومات الجغرافية (GIS) وتحليل القرار (MCDA) . وباستخدام هذه الطرق التي تؤدي إلى الإدارة البيئية المتكاملة واللازمة للسماح في النظر بجميع المكونات والعمليات في البيئة. لهذا الغرض تم ادخال طبقات الخرائط الرقمية بما في ذلك تسوية (مركز حضري والقرى والمناطق الصناعية)، والطرق الرئيسية، والمطارات، والأراضي الرطبة، نموذج الارتفاع الرقمي واستخدام الأراضي (النباتات المخيمات القصر والمياه ومعالجة مياه الصرف الصحي، منطقة زراعية وحدائق وتعد المباني) والمياه السطحية (الجداول وقنوات الري الرئيسية) ويتم تنفيذ الوزن

النسبي للمعايير مع نظام المعلومات الجغرافية. وقد تمحورحول صياغة معاييرتخطيط مكبات النفايات،واعطائها رتب الملاءمة الخاصة بكل معياروتوزينها،ثم بناء النموذج والخروج بخارطة تمثل أكثرالمواقع ملاءمة لإقامة مكبات نفايات صحية في ولاية الخرطوم .

1. Introduction

It is evident that many factors must be incorporated into landfill siting decisions, and geographic information system (GIS) is ideal for this kind of preliminary studies due to its ability to manage large volumes of spatial data from a variety of sources. It efficiently stores, retrieves, analyze and displays information according to user-defined specifications [1]. Multicriteria decision analysis (MCDA) is used to deal with the difficulties that decision-makers encounter in handling large amounts of complex information. The principle of the method is to divide the decision problems into more smaller understandable parts, analyze each part separately and then integrate the parts in a logical manner [2].To integration of GIS and MCDA is a powerful tool to solve the landfill site selection problem, because GIS provides efficient manipulation and presentation of the data and MCDA supplies consistent ranking of the potential landfill areas based on a variety of criteria. Preparing analysis of digital environmental maps illustrated in this paper.

2. Study Area

The study area known as Khartoum state is in Sudan country. It is located in the center of Sudan bordered on the northeast side River Nile State and the North West, Northern State and the eastern and south-eastern states of Kassala and Gedaref and the state of the island (Figure 1).

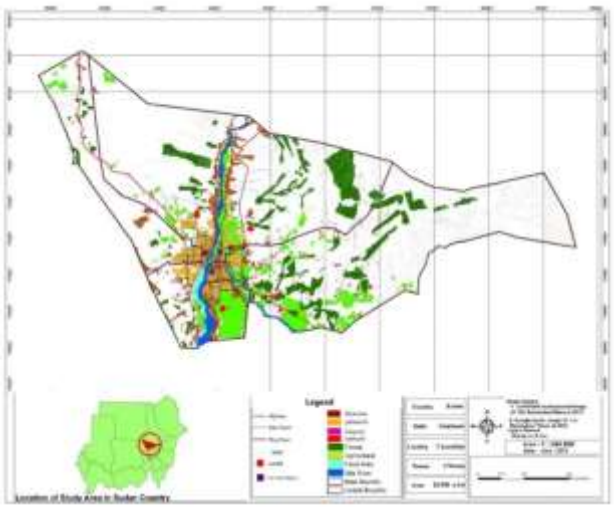


Fig (1): Location Map of study area

It is located between latitude 16 degrees north and latitude 15 degrees south and longitude 21 degrees west and 24 degrees east longitude . It is covers an area of a bout 22.122 km^2.[3]Moreover, the current Landfill in Khartoum state are three as shown in the below: [4]

1. Khartoum LFS (25Km north Khartoum) .
2. Omdurman LFS (30Km north Omdurman).
3. Khartoum Bhari LFS (25Km east of Bhari center).

3. Materials and Methods

Differentiation process depend on local conditions , and sufficient knowledge of the region , and the study and survey and detailed mapping and properties of sites, although the local economic and social conditions and some formal considerations influence the choice of the most appropriate site , making trade-offs between the sites are very different from one area to another. Here we relied on some standards in the planning process through the layers and the base of available data, which will be equipped with GIS program.

The program will then select appropriate locations to be garbage dumps, and will be given to each criterion rank given by its importance, sensitive criteria and the most important and that negatively affect the environment and human larger take a lower rank, least important criteria or that do not pose a direct threat to the environment and people of the region

take a higher rank since it's more convenient.These standards have been designed on the basis of the World Bank Standards. We have the selection criteria from different sources and depending on the study area conditions, the possibilities of the researcher, the base of available data.

The methodology followed in the best landfill sites on some of the methods of analysis Planning Spatial and statistical data analysis and processing, which owns GIS could be held objectively by using 9.3 Arc GIS which was used in this study.Since this study data came in two main types: : linear pattern and style networking , it is necessary to clarify the place of how to carry out the analysis , as appropriate to each style of these two types.

a- Rasterization:

Modeling operations make it easier to deal with the data in a Raster form, so all the maps have been converted from Vector to Raster.The process of modeling is only a generalization of the characteristics of the phenomena in order to determine its behavior, and the way cells in the data storage in the Raster form is also generalization of the recipes phenomena.

b- Reclassification:

This steps is useful in rearrange and distributed the cells ; making it easier to deal with them, in addition to being used as a criterion in the model, and therefore it is classified into categories standards, and are given the most appropriate cells rank 10 , and the least appropriate rank 1 according to common scale , to result in re-classify for each criterion new layer are automatically added to the interface of the program.

c- Weighted Overlay:

GIS plays a large role in the planning and determine the best landfill sites during that enjoyed by the technique of holistic and wide, and its ability to link all the factors and a variables in determining the best locations, which vary in nature between the economic, social, geological and geomorphological criteria, environmental criteria, and criteria of climate and public acceptance criteria.This is through the weights analysis, collection and thus aligned with the standards, which took the highest ranks and access to accurate results by researcher planning trends; by weakening the role of the sensitive or that could pose a threat to the environment and humans in the event of chosen criteria them, and aligned with the standards and conditions which have little negative impact or non-existent.

Therefore, GIS has provided the flexibility to trade-off variables and give one of the criteria affecting more weight than the rest of the standards and the percentage , and this point of the study have resorted to the use of weighted values to give actors in the success of the best locations and the greater weight of the other elements, were numerous GIS tools to calculate the impact of the weights of the criteria, it is these many Weighted Overlay function falling under the list of Spatial Analyst tools which enables the user to insert the weights of the criteria provided that the total sum of the weights is equal to 100% [5].

d- Buffer:

Measures the campus spatial scale or scope of service to influence a certain milestone on the surface of the surrounding area to build a certain distance is entered him based on planning standards; for these distances are excluded from the analysis and modeling processes [6]. So do not fall milestones which we plan to her and the transfer of waste dumps within this buffer zone, but the areas of the planning process, including the exclusion .

a- Digital Elevation Model:

Digital Elevation Model (DEM), also referred as the Digital Terrain Analysis, is a digital representation of earth's topography in a continuous way. Landfill and running costs, so prefer areas that contain a few terrain. It can be the same decline that exceeds 25% excluding land, the tendency of 5% is suitable for the establishment of waste dumps and longer, Fig (2).

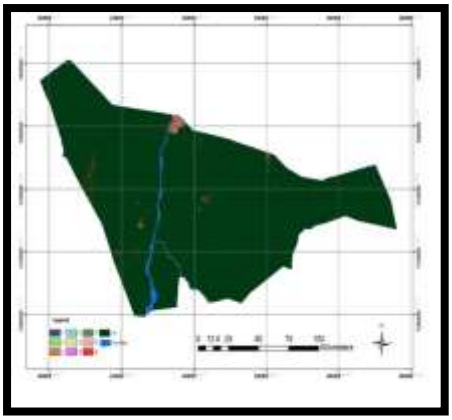


Fig (2): Map for DEM in

b- Land use:

The land use map obtained from a Merag company , imported to GIS environment, registered and then digitized. A database is created and attached to the map ,Table (1).

Table (1):Landusetypesandtheirrankings

Land Use Type	Symbol	Rating
OrganizedIndustrialArea	QIA	0
Agriculturallands	AG	0
UrbanCenters	UC	0
Villages	V	0
Stream & Channel	SC	0
Forest	F	5
Unoccupied land	UL	10

Convert the map to grid system (Raster) , and then work with grades of convenience so that the use of who gets the rank 10 is the highest suitable to the landfills sits , while the use of who gets the rank 1 is the lowest suitable, Fig. (3).

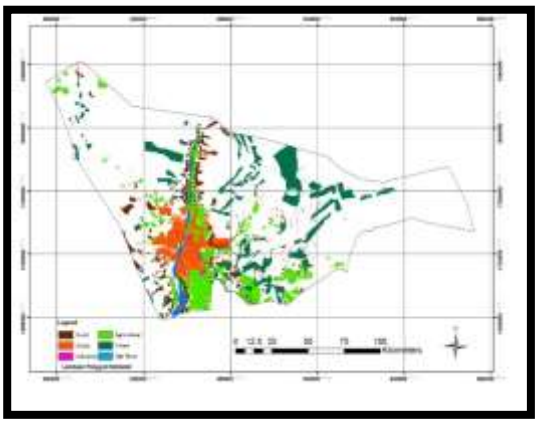


Fig (3): Map for Landuse in Khartoum State after re-classified

c- High way Roads :

It has been re- classified this map and give it ranks as common gauge (1- 10) where data that gets the rank 10 is the highest suitable to the landfills sits, while the data gets the rank 1 is the lowest suitable, Fig (4).

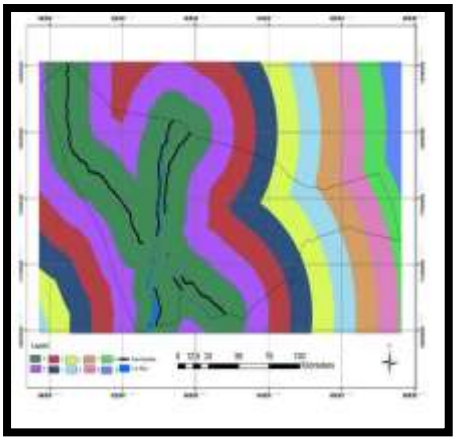


Fig (4): Map for High way
Roads in Khartoum State after

d. Valleys :

As the above layers it has been re- classified this map and give it ranks as common gauge (1-10) where data that gets the rank 10 is the highest suitable to the landfills sits , while the data gets the rank 1 is the lowest suitable, Fig.(5).

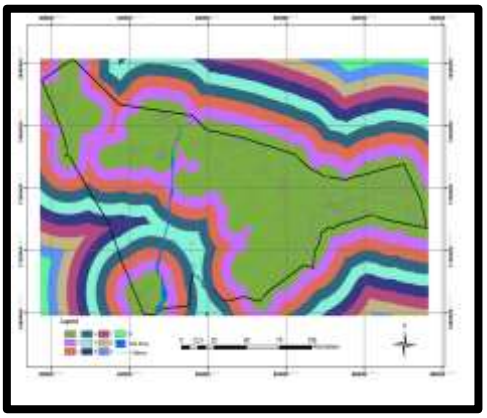


Fig (5): Map for Valleys in
Khartoum State after re-classified

e- Mean Annual Precipitation:

After converting map of rain to Raster system it has been reclassified and give it ranks, has been give it ranks here gradually; areas with most rain took

a lower rank, and areas with least rain took the higher rank, On the grounds that it reduces the amount of leachate that reaches the landfill, Fig.(6).

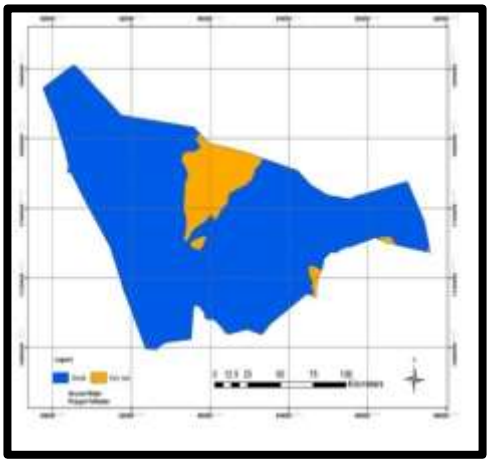


Fig (6): Map for Mean Annual

f- Ground Water:

For ground water such as the a above layer converting map of ground water to Raster system, it has been reclassified and give it ranks; areas with most ground water took a lower rank, and areas with least ground water took the higher rank, Fig.(7).

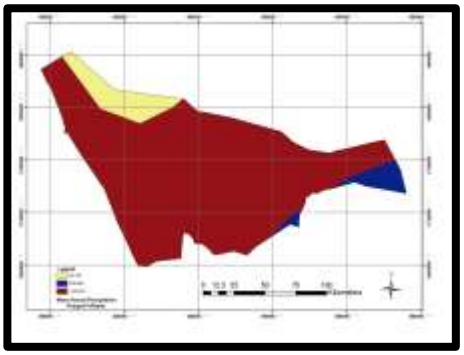


Fig (7): Map for Ground Water

4. THE RELATIVE WEIGHT FOR STANDARDS:

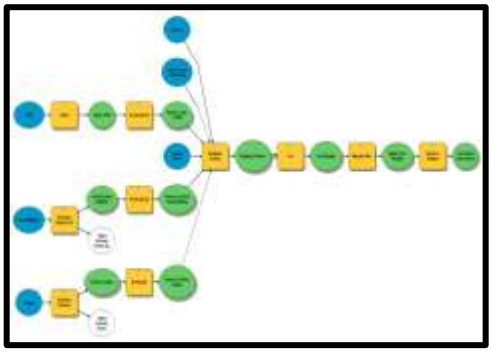
Already mentioned to a holistic view of GIS in assessing the suitability of the land for better planning landfill sites of various planning and processes , they are enjoying high flexibility by giving influential standards greater weight than

the rest of the criteria , and therefore there are many tools that are usedfor this purpose , but we chose function of(**Weighted Overlay**) which enables the user to insert various weights provided that the total of 100% , and the ability to use this function in a (**Model Builder**).We have adopted in the preparation of weights for different standards on personal experience, and read it for many Arab reference and foreign in this aspect, as well as consulting professor supervisor studying. And finally been given access to all the standard a certain weight according to the degree of importance and influence so that equals the sum of the weights of 100 % and table (2) illustrates these weights

Table (2): The relative weight of the main criteria

No.	Standards	Relative weight %
1	Roads	30
2	DEM	10
3	Valley	30
4	Land use	18
5	Mean Annual Precipitation	6
6	Ground Water	6
7	River	Restricted

In this study, after determine the criteria and its classification, important, weighting, we build model in Arc GIS environment through Model Builder that depend on simplify complex problems and overlap in data and its relationship with the spatial and descriptive, So is the formulation of this model to simplify the basic problem and solve it through that called (Flow chart), Fig (8).



Fig(8): Model Builder in Arc GIS

5. Results and Discussions:

Landfill location sites were determined through series of analysis of data layers. Urban, Village, industrial area, roads, Airport, Valley, Landuse, DEM, Surface Water, Ground Water, Mean Annual Precipitation were reclassified and relative weight and buffered to determine the best sites as follow:

Urban Area: Urban area with a minimum distances for the study area are determined as 10 km for urban centers [7] and 2 km for villages and 250 m for industrial areas.

Roads: According to [8], distance greater than 1 km from main roads and highways should be avoided. Roads with a minimum distances for the study area are determined as 2 km on both sides.

Airports: Airports with the safe distance for an airport is determined as 3.000 m according to [9].

Surface Water: Buffer zone for stream is determined as 1 km on both sides.

Valley: Bufferlocated within 300 m of the waterway line from both sides.

The suitability map was converting from raster to polygon and the suitable sites were extracted by using selection function in analysis tools embedded in Arc Toolbox. The areas of suitable sites for landfill were calculated in the study area, Fig (9).

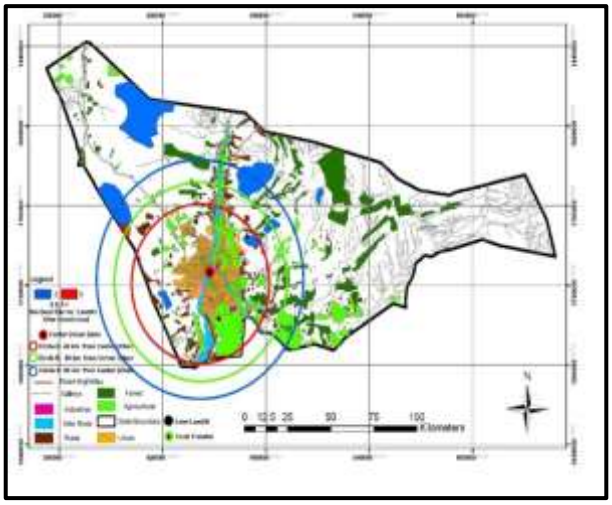


Fig (9): Suitability Map

6. Conclusion

If we apply the abovementioned conditions to Khartoum State, for example to be at 10 km from the urban center, we will see the following:

1. The dumping sites existing in Khartoun State are suitable in terms of the abovementioned conditions. However, if we take the present and future growth of population into consdieration, we will see that the suitable site is merely a wreckage dumping ground. As regards Teiba and Abu Walidat dumps, the first is located within agricultural lands and the second is in the nearby of housing compounds.
2. Since Khartoum State is large in area, and with a view to taking into account the future expansions, we will put specific conditions for it. For example, if we choose to be at 40 km from the urban center, we will achieve the dumping sites (5 and 6) shown in figure 7. Additionally, Hattab dumping site will remain a suitable one.
3. If we choose to be at 50 km from the urban center, we will achieve the dumping sites (5 and 6) but with larger area and so on if we choose to be at 60 km etc.

7. References:

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