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Choosing the best site for a technical backfill center for urban solid waste using a multi-criteria evaluation technique based on geographic information systems. Case study of the city of M'sila

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Abstract. Many wastes arise from human daily activities, and solid household waste is one of the most impactful and heavy on human shoulders, as the management of solid household waste is one of the important issues that must be taken care of in order to preserve the health and safety of humans and the environment. Therefore, this study came to identify solid household waste and the methods and methods used to manage it through collection and transportation operations until its final disposal. Geographical information systems are used in the environmental planning process in order to better plan the location of containers and identify waste collection paths, and this requires collecting data and maps for the study area to be used in the process of analyzing spatial appropriateness using geographical information systems based on planning and environmental standards to reach the best results using current-day techniques from Huge software that contributes greatly to the planning process and helps in making decisions (Geographical Information Systems "GIS", Statistical Group for Social Sciences "SPSS").The selection of sites for technical landfill centers is of great importance at the present time, as the latter is an important and necessary issue for the sanitary disposal of waste, given the complexity of waste management systems, the selection of the appropriate urban solid waste landfill site requires consideration of alternative solutions and multiple and rather complex evaluation criteria. Where this study aims to assess the spatial suitability of the Technical Backfill Center in the city of M'sila, through a spatial analytical methodology, where the significant increase in the population of 1,276721 people in 2019 led to an increase in the quantities of produced waste that exceeded 382,038 tons / year, and thus increased rates of environmental pollution and distortion of the urban landscape. for the city. The poor location of the embankment center caused the residents to annoy, and demanded that they expedite the closure of the center despite the fact that its lifespan had not expired, which made the authorities in an embarrassing position. This is what the study provides, as the best sites were chosen for the establishment of a landfill center for the city of M'sila, so that it is difficult to change it in the future, based on a set of criteria approved by the National Waste Agency and analyzed in the GIS environment, by applying the spatial analyzer and giving weights to the criteria affecting the The site of the backfill was selected according to the relative importance of each of them by the hierarchical analysis (Ahp) process using Excel, then the Raster calculator process was performed. In our study, we tried to find an alternative site to the current site that would be more suitable than the previous one, where a set of criteria (economic, social, and environmental) were defined and using the integration of geographic information system (GIS) and the analytical hierarchy method (AHP where the GIS program plays a role). It is important in contributing to superposition analysis for landfill site selection because it has a high capacity to manage large amounts of spatial data and considers many factors from a variety of sources ,as well as its high ability to deal with the necessary social,

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environmental and economic constraints. this study, it was relied on using a combination of GIS and AHP programs to choose the best and most appropriate urban solid waste burial site from among the many candidate sites that meet the largest possible number of environmental and scientific criteria so that it is difficult to change it in the future, which helps officials to take the appropriate decision to achieve this goal. The processes of choosing a landfill site includes several steps that must be performed using GIS software are: **(1):** The study area is divided into categories to suit the requirements, and then an appropriate weight is given to each category **(2):** Determining the final map of the landfill sites using the special analysis tool in GIS "Map Algebra - Single Output Map Algebra". **(3):** Exclusion of unsuitable areas to simplify the process of selecting candidate sites for the urban solid waste landfill center in the city of M'sila. The results showed that the best areas are likely to be suitable for the establishment of a technical landfill center for waste in the southern side (Municipality of AWLAD MADI), in the southern eastern side (Municipality of AL-MATARFA), and in the western/south side (Municipality of AWLAD MANSOUR and the lines of Dam El Geer). The study showed the location outside the city due to the lack of real estate in the city and the lack of availability of areas that meet the necessary standards for the establishment of landfill centers, and this confirms the inadequacy of the current site and the need to find an alternative site quickly. We hope that our work will provide a methodology for siting and provide basic and logistical support to decision makers in assessing waste management problems in the city and help to choose the appropriate landfill site for the city.

Keywords. geographic information system (GIS). Analytical Hierarchy (AHP). Spatial Analysis, Convenience Analysis, Multi Criteria Decision Making (MCDM), Modeling, Urban Solid Waste, Backfill Technical Center

I. The problem of research

Adopting the negative methodologies for solid waste management, which is carried out using advanced and appropriate treatment methods, reduces environmental pollution and the emission of greenhouse gases. Reliance on correct treatment methods has many benefits, including reducing the use of natural resources through the reuse and recycling of some waste such as paper, cardboard, and plastic. glass, metal, and others, in addition to reducing the need for larger areas for landfills or collection places, as well as eliminating the proliferation of insects and harmful microbes that exist and multiply with waste, It also has a major role in reducing environmental pollution rates and the spread of greenhouse gases such as carbon dioxide and methane, which in turn reduces air pollution and unpleasant odors around landfills and collection places, as well as mitigating climate change.

The operation of urbanization and migration from rural areas to major cities in developing countries is one of the phenomena that the continent has witnessed in recent years, which has the highest growth rate in urban areas in the world, where this growth is estimated at about 3.5% annually, and it is also witnessing an industrial renaissance and Large urbanization and an improvement in the standard of living in the last decade. All these social and economic developments have contributed significantly to the occurrence of major environmental challenges resulting from the generation of large quantities of solid waste.

The urgent need to use scientific methods in analysis and planning to manage environmental problems to take appropriate decisions has emerged due to the enormity of the environmental problems, whose overlaps have become highly complex, and the traditional methods that depend on the subjective expertise and experience of the decision maker have become ineffective.

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Geographical information systems in the process of solid waste management have a very big role, because many aspects of the planning and management processes for waste depend on data and spatial information. Thus, the system stores data and processes it quickly and accurately to facilitate the collection and removal of waste and determine the best sites as transfer stations and planning the routes that the trucks will take Which transports waste to transfer stations, then to landfill centers, and finally determines new and appropriate landfill sites and monitors these landfills. The system not only saves time and cost, but also secures a bank of digital information for the future monitoring program of the waste problem.Thus, with the help of this system in solid waste management, we can dispose of waste in an effective, safe and economical manner, with the lowest environmental impact for the surrounding area now and in the future.

The process of selecting a suitable site for the establishment of a sanitary landfill for waste disposal is a very complex matter, as it is based on multiple, often conflicting, criteria. The difficulty of this process increases in the city of M’sila because it lacks databases and information related to future expansion plans for vital facilities and facilities, urban expansion in general, spatial maps and information for inventory and follow-up of natural resources and wildlife. Of them, so that it is difficult to change they in the future and that can only be done by using geographic information systems technology that allows all this. Hence, we can pose the following problem:

• How to choose the best site for the urban solid waste landfill center in the city of M'sila? What are the techniques and tools that help achieve this?

• What are the criteria and conditions that must be applied in selecting the best site for an urban solid waste landfill center?

•What are the techniques and tools that help and facilitate the process of choosing an alternative site that is more suitable than the current one and performs its function to the fullest extent so that it is difficult to change it in the future?

• Can we obtain safer and more appropriate sites that meet the largest possible number of standards and conditions for the establishment of an urban solid waste dump in the city of M'sila that would be less harmful to nature and the population than the current landfill?

II. Importance of Study

The importance of the study lies in producing a digital map of the state of M'sila showing the best sites for establishing urban solid waste dumps using GIS technology according to accurate standards that can be referenced and relied upon by officials and decision makers in the state.

III. Study objectives

The study aims to show the importance of linking modern technologies in urban planning systems in general and waste management in particular, as well as their role in facilitating the study of data of huge and variable quantity, so the study aims to:

• Create an application database for the city of M'sila that can be used by officials and authorities.

• Determinate the criteria and conditions adopted in choosing the best sites for landfill.

• Suggesting a new site for landfill that is more convenient and safe.

IV. Materiel and methods:

In this study, we relied on the descriptive analysis method through the application of the spatial analyzer (Analyste Spatial) available in the GIS and we use also the hierarchical analysis

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process (AHP) through the (EXCEL) program, in addition to the overlay weighted process in Evaluate the spatial suitability and give the best suitable sites for the establishment of the technical filling center.

- Graphic and written documents.
- Digital Elevation Model (DEM).
- Geographical Information Systems program (GIS)
- EXCEL program to perform hierarchical analysis process (AHP).

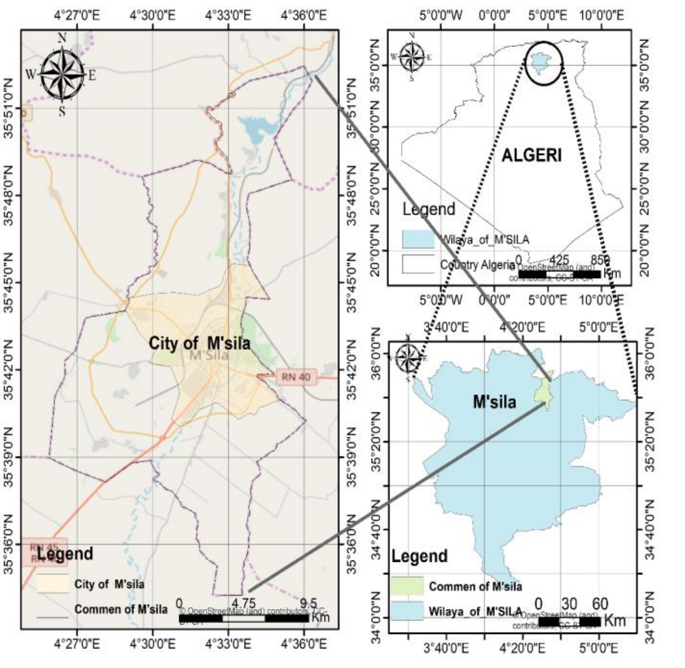
***1. Study area (M'sila City)*:**

The study area includes the city of M'sila, one of the Algerian cities, which is characterized by a distinguished geographical and administrative location belonging to the region of the high hills and known as AL-HODNA.

1.1. Geographical location of the study area:

The city of M'sila is located in the northeastern side of the WILAYA of M'SILA, where it is bordered on the north by the Hodna mountain range, and on the south by Shatt al-Hodna, which is an intersection point for both National Road No. 40 and National Road 45 in addition to National Road No. 60 and the waterway (Wad AL-KASOB) from The most important reasons that made the city of M'sila arise and develop through different periods of time **(Map No. 01)**

Map No. 1: The location of the city of M'sila
Source: S.dhimi, PhD thesis, 2020 (based on ArcGIS 10.3).



2*. Choosing the location of the solid waste technical backfill center using GIS & AHP.*

To find a suitable location for a technical backfill center

using GIS, spatial information can be used to show the layers together using a process called (Spatial Overlay).

3. Determine study criteria:

Several criteria have been adopted, through the available layers and database that are provided to the GIS system, where the system then selects suitable sites for the establishment of waste dumps, especially after excluding unsuitable areas. Each criterion will be given a certain rank according to its importance, the criteria that are sensitive and most important and that negatively affect the environment and the person in which the residence is a landfill that takes a lower rank, and the criteria that are less important or that do not pose a direct threat to the environment and the population of the region will take a higher rank as more appropriate. The criteria that are included in the differentiation process can be summarized through **. (Figure 1)**

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Criteria	**sub criterion**	**scale**
Socio-economic	Real estate nature	Land owned by the state
	land uses	Barren lands, saline and unsuitable areas
	absorption capacity	Sufficient to accommodate needs for at least 15 years.
	Distance from residential areas	It is located within 5 km from residential or under planning areas..
	land production capacity	not agricultural land
	The distance between the backfill center and the roads	* the distance from the main roads not less than 1 km. * the distance from secondary roads not less than 0.5 km
geological	the soil	The soil should be impermeable or have low permeability
	Topography and slope ratio	* 05% is an ideal slope, no more than 25%
Environmental	exploited wells	The distance between the landfill and the nearest water well is no less than 360m.
	distance from the springs	A distance of not less than 0.36 km.
	distance from the streams of valleys and torrents	A distance of not less than 0.5 km
	aquifers	* The deepest water level is at least 0.05 km. * In the case of groundwater, devices for measuring pressure must be available.
climatic	prevailing wind direction	It is located against the direction of the wind relative to the populated areas.
	Temperature	The higher temperature, which results in an increase in the evaporation rates of the juice.

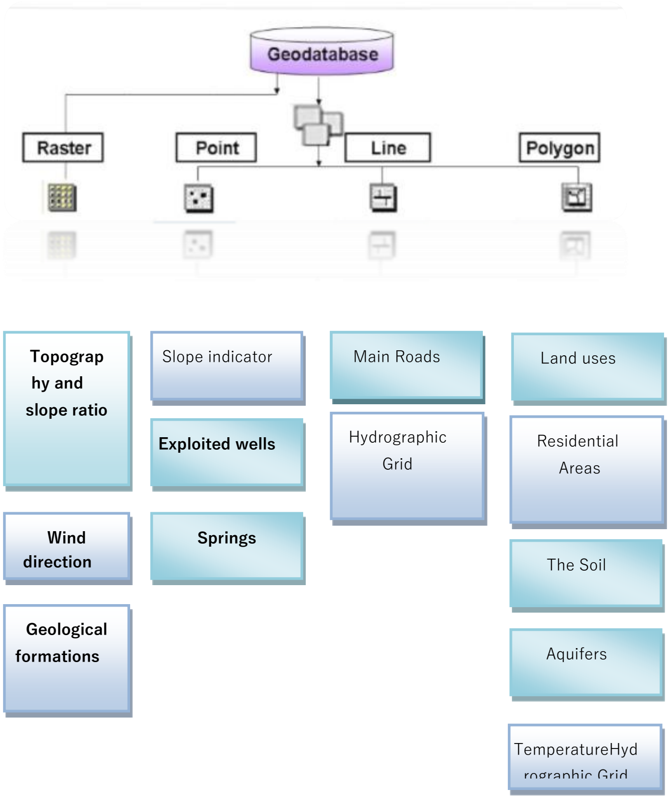

Figure 1 The criteria selected in the study.

4.Common Scale

This scale aims to determine the degree of suitability for each category or element of the map from the criteria for assessing the suitability of the land to the process of planning landfill sites within the cartographic model. Arc GIS, converts values and text inputs to numeric inputs. This scale is based on values from (1-9), where the value 9 was considered the highest degree of suitability for the establishment of the project, while the value 1 was considered the lowest degree of suitability.

5.Spatial Analysis

The methodology used in planning the best landfill sites depends on some spatial and statistical methods of data analysis and processing, as GIS has the ability to conduct it objectively. Therefore, each style was dealt with according to its suitability. Here is a summary of some of the tools and processes that were used:

1. The Data Management Tools method. THE FEATURE TO POINT tool, was used to find population centers; this is to designate waste generation centers in order to take a certain distance from them.

2. The spatial sanctuary (Buffer), and this tool has been used repeatedly in order to exclude areas within the buffer zone, which must be far from landfills.

3. Matching maps by the Union method. This method is used to match a map of spatial phenomena with a map or other spatial phenomena maps, with the aim of matching all the phenomena of the input map with all the phenomena of the existing map, and the result is that the output map appears combining all the phenomena in the two maps.

4. Terrain Analysis method, this method was used as a cellular pattern data to produce the Slope layer after processing the digital elevation model in the GIS environment.

5. Straight Line This method was used to make the distance from the coast line and the distance from the waste generation center.

6. Transformation to Rasterization The modeling operations facilitate dealing with the data in the network mode, so all the vector maps of linear variables have been converted to the Raster network.

7. Reclassification, This step is useful for rearranging and distributing cells; This makes it easier to deal with it, in addition to using it as a criterion in the model, and thus the criteria are categorized into categories, and the cells are given the most appropriate rank (9), and the least appropriate rank (1), according to the Common Scale, resulting in the reclassification of each new layer criterion Automatically added to the program interface. In the process of assigning ranks, two methods were used, the first is the Weighting point method, through which zero one maps were produced. The second is the Rankingmethod, in which the data in the standard is given ranks from 1-09 according to its importance and sensitivity to the establishment of landfills, and in both cases each element in the layer is treated as having a certain weight

The Weighted Overlay criteria tool, the GIS has provided the flexibility to compare variables and give one of the influential criteria a greater weight and percentage than the rest of the criteria. There are many GIS tools in calculating the impact of standards weights. Among these many tools is the Weighted Overlay function, which is included in the spatial listANALYST TOOLS, which enables the user to insert the weights of the criteria provided that the sum of the total weights equals 100%.

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6.Site analysis

The site analysis is defined as the vital step in the planning process, which works to manage the resources available in the study site and which are geographically proven, and it analyzes the information stock for the group of studies available to the site, which leads to showing the potentials and obstacles to the development of the site under study. Therefore, when analyzing any site, computer technologies can be used to prepare data and studies in a digital form that contributes to the formulation of a digital information system for site studies and analysis, which leads to raising the efficiency of the site analysis process and obtaining accurate, correct and spatial reference results.،Therefore, each criterion was analyzed separately and an appropriate map was produced for it by giving each cell or group of cells in the layer an appropriate degree according to its importance or sensitivity to the establishment of landfills. Two methods were used, the first is zero one map, where the appropriate areas for landfills were given the number (09) and the unsuitable areas were given the number (01), and this was applied to the layers of roads, residential communities, underground wells, valleys and springs. As for the second method, it is the Rankingmethod, through which the landmarks were given in the layer, ranked according to their importance.

7.Relative weight of criteria

Geographical information systems are characterized by a holistic view in assessing the suitability of the land for planning the best landfill sites and various planning processes. Which enables the user to include the different weights provided that their sum is 100%,In addition to the possibility of using this function in the structural model Model Builder, and this stage comes after processing each criterion separately and giving the data in it certain ranks, and here the main criteria are taken and given a rank based on the extent to which they are affected by the establishment of landfills. Finally, it was reached to give each criterion a specific weight according to its degree of importance so that the sum of the weights equals 100%, and the table (24) shows these weights.

8.Model Builder

After determining the criteria, their types, their degree of importance, and their weights, the cartographic model was built in the Arc GIS software environment through the structural MODEL BUILDER, which is based on the simplification of complex problems and data overlap and their spatial and descriptive relationships, so this model is formulated to simplify the basic problem and formulate the way to solve it through The so-called flowchart of the stages of work, Figure (15), this graphic layout depends in its entirety on the stages and functions of spatial analysis, with the addition of other methods, and simplifying the main problem into several sub-problems, as it explains the steps of the analysis process in detail

9.Criteria for choosing the best landfill site:

twelve (12) criteria were defined for choosing the best landfill site by making each criterion represented by a map on the Geographic Information System (GIS) and then resorting to the AHP matrix to evaluate the weights of the twelve (12) criteria, which is land use Distance from areas, distance from roads, soil quality, soil permeability, slope, rivers, depth of groundwater, distance from Hydrographic networks, distance from water bodies, wind direction, temperature, greenness index and geological formations.The model, after the process of analysis and modeling in the GIS environment, concluded to produce a map showing the degrees of suitability of the best landfill sites in the city of M'sila, where the yellow color represents the least suitable, while the brown color represents the most appropriate. In producing these results, the study relied on a wide range of criteria that included social and economic criteria, geological and geomorphologic criteria, environmental criteria, and climatic criteria. And after applying the model based on these criteria and the ranks you obtained through AHP using the EXCEL program And within well-studied and regular stages and steps and on a scientific basis, the study concluded the best landfill sites in the city of M'sila, which can be seen through map No. (09), where the brown color No. 9 represents the most suitable sites ever, followed by the color Orange in terms of the degree of suitability, which bears the number 8. In the event that it is not possible to establish dumps in the region of rank 9, it can be replaced by the region of rank 8 and the next in the degree of suitability. Thus, regions with a score of 98 are considered to have a very high favorable score. The degrees of adequacy decrease then gradually down to the number 1 which represents the weakest favorable area and is represented in yellow on the map.

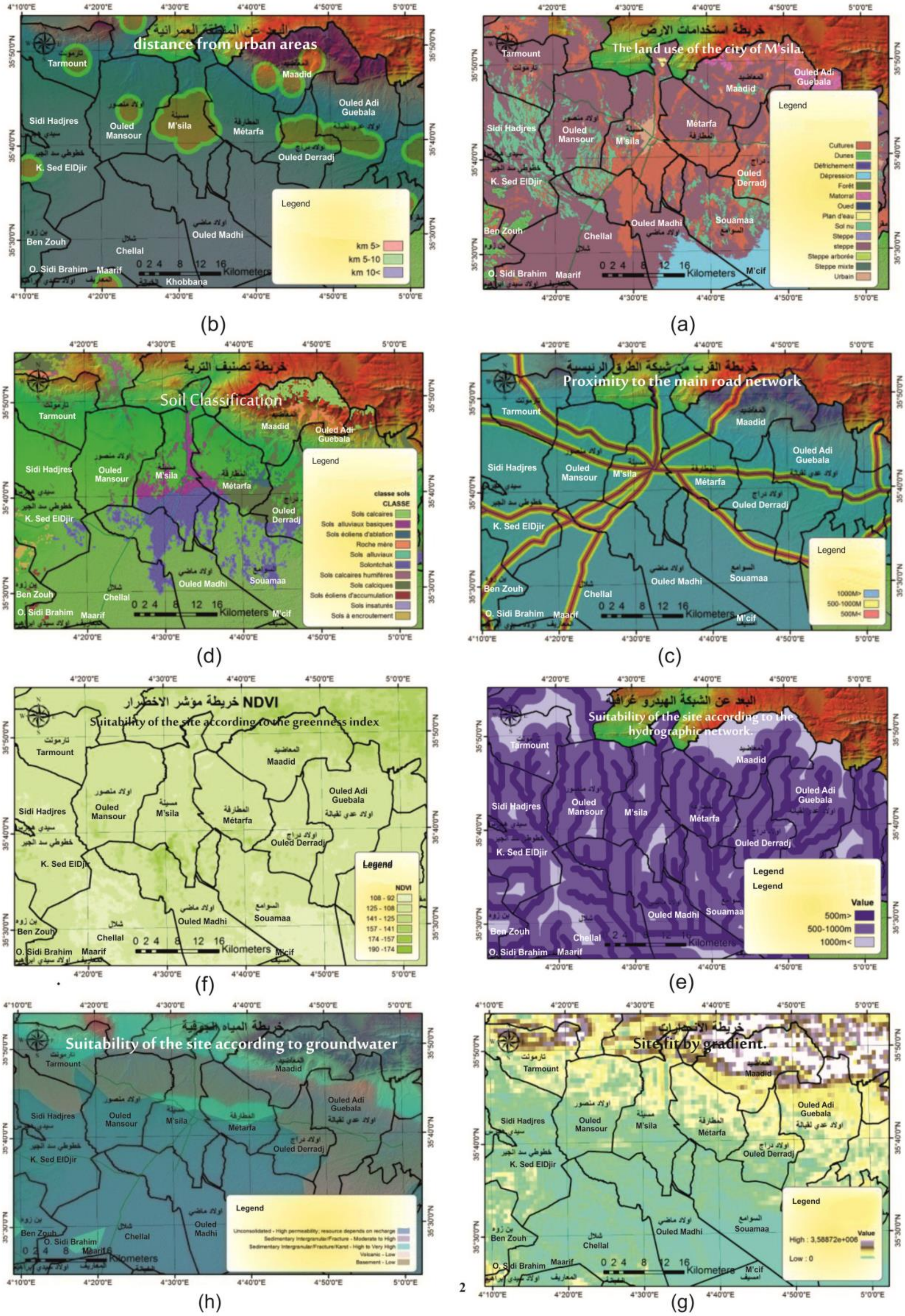
10.Hierarchical Analysis Process:

In the 1980s, Thomas Saaty developed an AHP analytical hierarchy method, this process paving the way for the incorporation of provisions regarding intangible quality standards into tangible quantitative standards. It is a quantitative method of evaluating and arranging alternatives for a specific goal, for Saaty it is "an integrated framework that combines objective and non-objective criteria," Based on pairwise comparison and relative scale. AHP is a powerful and flexible technology that formulates the problem into a hierarchical structure. It combines the qualitative and quantitative aspects of a decision and provides a simple method for evaluating selection criteria, thereby reducing decision-making bias. It also describes an interactive map-focused application to support spatial decision. At the end of the process, weights of criteria are produced. The procedure is summarized in the following steps:

11.Define the priorities

After creating the hierarchical structure, the relative importance of all decision elements is captured and discovered through pair wise comparisons, which are used to construct the ratio matrix.

Pairwise comparisons are made between the main criteria and the sub criteria within the same hierarchical level; the numerical scale was used as suggested by Ouma and Tateishi (Saaty 2014),It ranges from (1 to 9), in pair wise comparisons of matrices and results are based on questionnaires in comparing primary and secondary criteria to give them more credibility and impartiality in decisions regarding preferences. Questionnaire scores were applied to each of these items according to the degree of importance to Saaty in the matrices to be translated into weights. A two-way comparison is made between the main criteria and then between sub-criteria of the same level. Finally, the weights are extracted. The consistency ratio value CR = 0.09 was less than 0.1 of the Saaty values in the AHP process for the first hierarchy level which means that the distribution of weights between factors is very acceptable.


distance from urban areas
Legend
km 5>
km 5-10
km 10<
(b)
The land use of the city of M'sila.
Legend
Cultures
Dunes
Défrichement
Dépression
Forêt
Matorral
Oued
Plan d'eau
Sol nu
Steppe
steppe
Steppe arborée
Steppe mixte
Urbain
(a)
Soil Classification
Legend
classe sols
CLASSE
Sols calcaires
Sols alluviaux basiques
Sols éoliens d'ablation
Roche mère
Sols alluviaux
Solontchak
Sols calcaires humifères
Sols calciques
Sols éoliens d'accumulation
Sols insaturés
Sols à encroutement
(d)
Proximity to the main road network
Legend
1000M>
500-1000M
500M<
(c)
NDVI
Suitability of the site according to the greenness index
Legend
NDVI
108 - 92
125 - 108
141 - 125
157 - 141
174 -157
190 -174
(f)
Suitability of the site according to the hydrographic network.
Legend
Value
500m>
500-1000m
1000m<
(e)
Suitability of the site according to groundwater
Legend
Unconsolidated - High permeability; resource depends on recharge
Sedimentary Intergranular/Fracture - Moderate to High
Sedimentary Intergranular/Fracture/Karst - High to Very High
Volcanic - Low
Basement - Low
(h)
Site fit by gradient.
Legend
Value
High : 3,58872e+006
Low : 0
(g)

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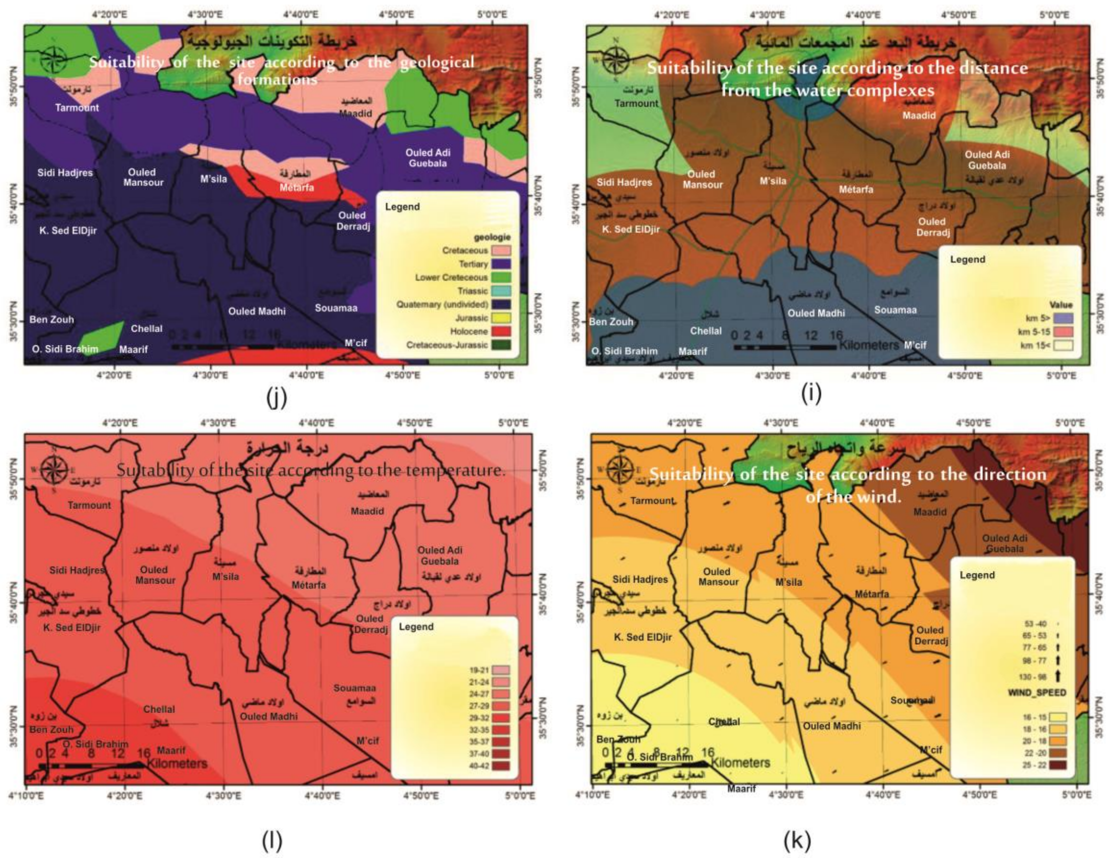
Maps: (a)The land use of the city of M'sila, (b) distance from urban areas, (c) Proximity to the main road network, (d) Soil Classification., (e) Suitability of the site according to the hydrographic network, (f)Suitability of the site according to the greenness index, (h) Site fit by gradient., (g) Suitability of the site according to groundwater, (g) Site fit by gradient.



Maps: (i) Suitability of the site according to the distance from the water complexes, (j) Suitability of the site according to the geological formations, (k) Suitability of the site according to the direction of the wind, (l) Suitability of the site according to the temperature.

12.AHP evaluated the criteria for selecting a technical waste landfill center in the city of M'sila.

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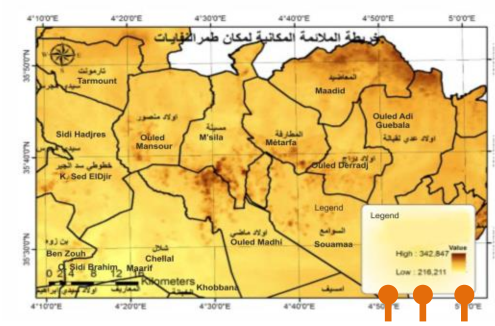

	absorption capacity	Temperature	geological	wind direction	water complexes	green index	streams of valleys and torrents	aquifers	slope ratio	Road distance	the soil	residential areas	land uses
land uses	0.058	½	2	3	1	2	2/1	2/1	2/1	2/1	¼	3/1	1
residential areas	0.125	½	3	5	1	3	1	2/1	2	3	4	1	3
the soil	0.067	½	4	2	1	1	2/1	4/1	3/1	3/1	1	4/1	4
Road distance	0.072	½	2	3	4/1	2	1	3/1	2/1	1	3	3/1	2
slope ratio	0.089	1	3	3	2/1	2	2/1	2/1	1	2	3	2/1	2
aquifers	0.136	½	4	3	2	2	1	1	2	3	4	2	2
streams of valleys and torrents	0.100	½	3	3	1	2	1	1	2	1	2	1	2
green index	0.060	1	2	3	1	1	2/1	2/1	2/1	2/1	1	3/1	½
water complexes	0.096	½	4	2	1	1	1	2/1	2	4	1	1	1
wind direction	0.040	1	1	1	2/1	3/1	3/1	3/1	3/1	3/1	½	5/1	3/1
geological	0.029	½	1	1	4/1	2/1	3/1	4/1	3/1	2/1	¼	3/1	½

criteria	% ahp	Rank
aquifers	13.6	01
Temperature	12.6	02
residential areas	12.5	03
streams of valleys and torrents	10.0	04
water complexes	9.6	05
slope ratio	8.9	06
Road distance	7.2	07
the soil	6.7	08
green index	6.0	09
land uses	5.8	10
geological	4.0	11

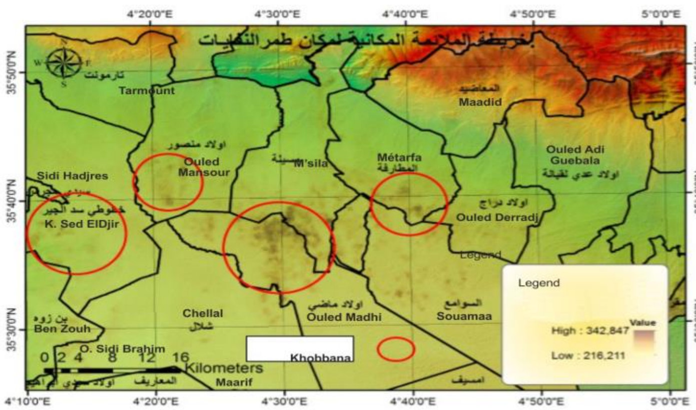

Figure 1. Results of AHP comparison

Results:

Multi-criteria spatial analysis requires data regarding criteria values and their geographic location in a multi-criteria spatial decision-based GIS process. GIS technology provides access to data storage, retrieval, processing, and analysis to develop information that can support decisions. Additionally, the use of GIS in spatial data models provides a system and method for entering and displaying spatial data and tools for spatial analysis. For the analytical hierarchy process

The pair wise comparison starts from the average level to the lowest level. Standards are compared in pairs on the basis of competency and according to higher-level criteria; AHP's multiple pair wise comparisons are based on a standardized eleven-level comparison scale.

Suppose C = {Cj / j = 1,2, ...n}, is the set of criteria, and the result of the pair wise comparison on the criteria can be summed up in an evaluation matrix (n × n) Eq. (1) where each element (a = 1,2 ... n) is part of the criteria weights.Eq (1)

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}, a_{ii} = 1, a_{ji} = \frac{1}{s_{ij}}, a_{ij} \neq 0$$

Finally, the normalization depends on the mathematical procedure and that each matrix has relative weights. The integer eigenvector (W) gives the relative weights corresponding to the largest Eigen value, (λmax) as in Eq. (2)
A W = λmax W Eq. (2)

As long as the pair wise comparisons are completely consistent, the matrix 'A' has rank 1 and max = n. So, by normalizing any of the rows or columns, the weights can be accessed.

Thus, the quality of the AHP results is related to the consistency of pairwise comparison judgments. Consistency is determined by the relationship between acceptability: A: aij × ajk = aik. Accordingly, the consistency index (CI) is Eq. (3)

CI = (λmax - n) / (n-1)Eq. (3(

The consistency ratio (CR) is calculated as the ratio (CI) divided by the random index (RI), as shown Eq. (4)) CR = CI/RI Eq. (4)

For Saaty, if the ratio exceeds 0.1, the set of judgments may not be consistent and unreliable. Therefore, a commercial registration rate of less than 0.1 or 10% is accepted, but the procedure is repeated if the commercial registration evaluation is inconsistent.

Then we extracted the scales. The consistency ratio (CR = 0.09) was less than (0.1), in the first hierarchical level of AHP, which means that the weight distribution between the factors was acceptable and showed good consistency. Groundwater takes priority with a rate of 13.6%, followed by temperature at 12.6%, followed by distance from residential areas by 12.5%, so that the hydrographic network and water complexes come in the fourth and fifth rank, respectively, with a rate of 10.0% and 9.6%, and the regression takes the sixth rank with a rate of 8.9%

As for roads, it ranked seventh with a rate of 7.2%, followed by soil in the eighth rank with 6.0%, while the land uses took the ninth rank with 5.8%, and the tenth rank was for the greenness index by 6.0%, so that the geological formations and winds came in the eleventh and twelfth rank with a rate of 4.0% and2.9%, respectively. As shown in the following table:

The results describe the best site for a technical landfill center for urban solid waste in M'sila City. Available tools are important for decision makers to solve spatial problems. After converting the best CET sitemap from Raster file to Shape in its triple classification, each rating was calculated. The results are summarized in Table (26). By reading the map of the best CET site, it can be seen that the areas suitable for erecting the best landfill sites according to the AHP analysis are outside the city. That is, it is not possible to establish a center for landfill within the city of M'sila, but in the areas surrounding the city, such as AWLAD MANSOUR, AWLAD MADI, EL MATARFA, and KHETOTTI SADALGIR

In this study, the results show that the applications of decision-making in GIS are multifunctional. They incorporate different stages in the complexity of a decision problem. Accordingly, the choice of weights and AHP techniques played a major role. It is clear that decision-makers, who prefer subjective scale, may not reach the same weighting of criteria; Which in turn may lead to different outcomes and influence the final decision. In this regard, says DROBNEY, “The presented methods are only tools to assist decision makers. They are not the decision itself.”

In this study, a practical scientific method is proposed to model and analyze the selection of the best landfill center site by combining Delphi approach, AHP and GIS techniques. M'sila city was selected as a case study for this research. A Delphi-based survey was conducted on a

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set of criteria to model and analyze the selection of the best CET site in the city. The AHP was used to extract the weights of the analysis criteria for selecting the best site.

The consistency ratio was (0.09) less than (<0.1) and is therefore acceptable. After creating a geographic database for the predefined criteria, the weights derived from AHP in a GIS environment were used in spatial analysis to extract a map of the best CET site in the city with three classifications: good fit, medium fit, and poor fit.

The results of the spatial fit for the site of the technical landfill center in the city of M'sila:

After defining the standards applied by the National Waste Agency, and studying and analyzing them by integrating GIS technology with multi-standard technology (AHP), the best sites where waste disposal centers can be established in the city of M'sila have been reached. A landfill center inside the city because the land is not suitable there, and because the real estate container is running out inside the city, so the study concluded that the best site to establish a landfill center in it went to the municipality of AWLAD MADI (high suitability), while the municipality of AL-MATARFA and AWLAD MANSOUR came in the second rank (medium suitability) As for the third rank, it went to the municipality of KHATIATI SAD AL-JER (poor fit), as shown in **Figure 1**.

Conclusion

Through the final map of the proposed sites suitable for the establishment of waste dumps in the city of M'sila, we find that it is not possible to establish a landfill within the city because there are no areas that meet the specified standards, which confirms the necessity of finding an alternative site for the current landfill. The solidity of the city of M'sila according to multiple standards and modern technologies, so that it is impossible to change or difficult to change in the future

The most suitable sites for the establishment of a landfill center came outside the city of M’sila, so the southern area of the city up to the municipality of AWLAD MADI was the best place to reside, so that the municipality of AL-MATARFA and AWLAD MANSOUR came as good areas to set up a waste center on them, and the municipality of KHATITI SAED AL-JER is less suitable.

Finally, the technology of geographic information systems (GIS) combined with the hierarchical process (AHP) has achieved a great development, accompanied by the increasing and urgent need for the proper management of waste by using these computer technologies.

The sanitary landfill process is considered one of the best ways to dispose of waste, whether from an economic or environmental point of view, and the multi-criteria analysis technique has formed a contemporary technical integration with geographic information systems programs to study and model natural and human study variables, and to provide a broad and good information base for the study area that can be updated and used in other studies.

It also facilitates the local authorities and decision makers in the state to take the right decision in finding an alternative site for the current technical backfill center that is more suitable and has no impact on the environment and the population or has minor effects and meets the city’s need for waste in the long run, and it is also difficult to change in the future. Through our study, we developed a set of recommendations and suggestions, which are:

1: Urging officials, especially officials in the field of environment and local authorities, to follow health foundations and standards in choosing waste dumps, and to adopt what comes from studies and universities from health conditions and standards to choose the best sites for

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health waste dumps. As well as the necessity to work on rehabilitating the random waste dumps that are left and stopping their use, in order to reduce their negative effects to the lowest levels.

2: The study recommends the need to develop legal legislation in the field of solid waste management, which clarifies the responsibility and role of each entity in the waste management process, as well as setting deterrent penalties for anyone who violates the instructions and instructions for the proper management of solid waste.

3: The necessity of carrying out a process of public awareness, dissemination of knowledge and education about the risks and damages resulting from environmental pollution and the subsequent potential health and environmental risks to humans and the environment.

4: Encouraging researchers and research centers to carry out similar studies in this field to determine the risks arising from landfills, and plan them based on modern technologies such as GIS, and AHP.

5: The study recommends the necessity of merging GIS with AHP to study and select the best sites for landfill centers in the future.

6: Providing training courses for the officials, familiarizing them with the importance of the role of the SIG in all areas and its importance in the process of planning and making the right decision.

7: The study recommends the continued use of geographic information systems in the environmental decision-making process.

8: The local population must be involved in any process related to their environment, because its goal is to build a close relationship between man and his environment.

Finally, I hope that this study will be an inspiring nucleus for other studies in the field of planning the most appropriate landfill sites and environmental planning in general, to assist municipalities and responsible authorities in planning and making the right decisions in the state of M'sila.

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