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Landfill site selection for sustainable solid waste management using multiple-criteria decision-making. Case study: Al-Balqa governorate in Jordan

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CLSS: Convenient Landfill Site Selection
MCDM: multi-criteria decision-making
AHP: Analytic Hierarchy Process

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ABSTRACT

Landfill site selection is an essential aspect of sustainable solid waste management as it ensures that the waste generated by a community or region is disposed of in an environmentally friendly and safe manner. The approach for selecting landfill sites seeks to choose locations that provide the least risk to the environment and public health while still satisfying the demands of the local community. This research aims to use a multi-criteria assessment to determine a landfill location in Al-Balqa Governorate in Jordan to ensure that the chosen site meets the needs of all stakeholders while minimizing the negative impact on the environment and the community. This research developed a hierarchy structure to make landfill site selection decisions, which involves identifying parameters such as distance to surface water, land cover, distance from urban and rural areas, distance to roads, slope, and soil permeability. A rating system was used to evaluate each criterion, and weights were assigned to reflect their relative importance. An overlay weighting technique was then used to assess site suitability based on expert opinions from related fields. In this studied area, about 204,283 m^2 is required to address 25 years of municipal solid waste volume, whereas this technique identified around 79,210,000 m^2 of potential landfill sites. Overall, the research highlights the importance of using a multi-criteria assessment approach for landfill site selection to ensure that the chosen site meets the needs of all stakeholders while minimizing negative impacts on the environment and public health. The study provides insights that can be useful for decision-makers involved in sustainable solid waste management in Jordan and other similar regions.

- How to Find the suitable landfills to achieve sustainable development.
- What aspects and criteria were comsidered in choosing the landfill site.

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Name and references of the originel method:	- Şener & Şener [1]. Landfill site selection using integrated fuzzy logic and analytic hierarchy process (AHP) in lake basins. Arabian Journal of Geosciences, 13(21), 1130. - Babalola, & Busu [2]. Selection of landfill sites for solid waste treatment in Damaturu Town-using GIS techniques. Journal of Environmental Protection, 2(01), 1. - Chang et al. [3]. Combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast-growing urban region. Journal of environmental management, 87(1), 139–153.
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Introduction

Due to the rapid economic expansion, urbanization, population growth, and rising waste types, rather than a separate management system for each type of waste, an integrated, sustainable approach that incorporates all trash is necessary [1]. The assessment of a waste disposal site is a complex process that involves a thorough understanding of a wide range of social and environmental subjects including soil science, engineering, hydrogeology, topography, land use, sociology, and economics [3–6]. Policies and procedures such as recycling, reuse, waste reduction, thermal treatment, landfilling, and others must be in place for a sustainable solid waste management system. Of these, the landfill approach is primarily acknowledged as the most extensively employed of all waste management methods [2].

Solid waste (SW) has traditionally been deposited on or in the Earth's surface soils or seas. Landfills are physical structures used to dispose SW in the earth's surface soils. They have also been the most cost-effective and ecologically friendly technique for disposing of SW worldwide throughout the previous century [7,8]. A waste management system must be socially acceptable, economically practical, and environmentally friendly in order to be sustainable. In fact, it is possible to lower the cost of delivering services while simultaneously optimizing the impact that solid waste and its disposal have on residents and other aspects of the environment, thereby creating waste management that is both effective and sustainable [9].

Finding suitable landfills is one of the main goals of achieving sustainable development [10]. Convenient Landfill Site Selection (CLSS) is based on several factors, including land slope, geography, land usage, climate, earthquakes, and distance from metropolitan areas and major highways. As a result, site selection is seen as a multi-criteria decision-making (MCDM) issue [11]. Previously, landfills were selected exclusively based on land availability, not scientific or socio-environmental grounds [12]. Nowadays, however, GIS software can handle vast amounts of spatial data from many sources [13]. Therefore, by monitoring changes in land use inside and around hazardous waste and sanitary landfills, data can be gained through remote sensing aids in identifying and locating such dump sites.

Multiple-criteria decision-making (MCDM) methodologies can be used to select landfill sites for sustainable solid waste management. These methodologies help in reaching a compromise solution by considering various conflicting objectives based on environmental, economic, social, and technical metrics [14]. The Analytic Hierarchy Process (AHP), Multi-Attribute Utility Theory (MAUT), Outranking procedures, and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) are identified as relevant MCDM methodologies for assessing solid waste management systems [15]. The use of Geographic Information Systems (GIS) integrated with MCDM methodologies, such as AHP, can help in quantifying qualitative features and evaluating the suitability of landfill sites based on parameters like geology, hydrology, land use, and exclusion factors [16]. By integrating data and using weighted overlay techniques, landfill suitability index maps can be generated to classify areas into suitable and unsuitable locations for landfill sites [17] These methodologies and tools can assist decision-makers in selecting appropriate landfill sites that meet scientific, environmental, and sustainability requirements [18].

This work aims to develop a decision-making model for selecting sites for an appropriate landfill area in the Al-Balqa governorate of Jordan. The purpose is to build an MCDM model using the Analytical Hierarchical Process (AHP) based on environmental management-related criteria including social, economic, and environmental factors. In addition, this model will be used to evaluate the trade-offs between different criteria and identify any conflicts that may exist between them.

This research aims to bridge the gap in landfill site selection and waste management by introducing a systematic decision-making model that incorporates environmental, social, and economic factors specific to the Al-Balqa governorate. It also addresses the gap in considering trade-offs and conflicts, ensuring a more sustainable approach to waste management.

Geo-environmental setting of the study area

Al Balqa governorate has an area of around 1123 km^2 (432 sq mi); it lies approximately between latitudes 32° 02′ 0″N and longitudes 35°44′0″E as shown in Fig. 1. It is located northwest of Amman, the capital of Jordan, with a total population of 492,000

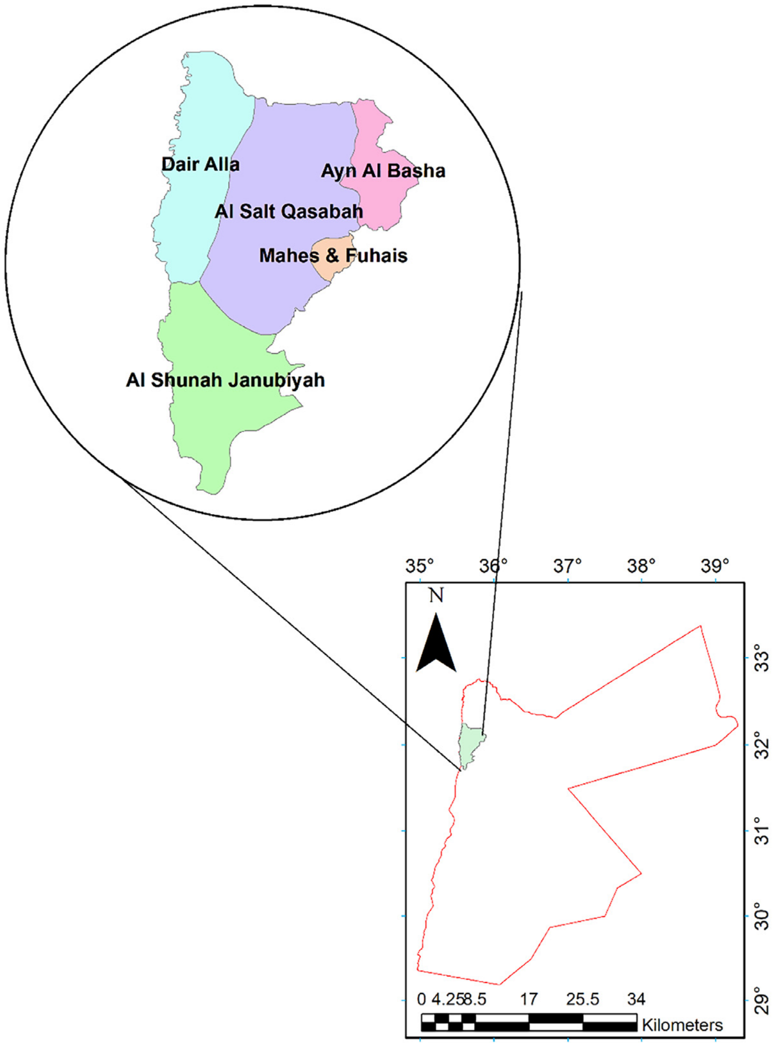

Fig. 1. Map of the study area (Al-Balqa governorate in Jordan).

and, according to the Jordan Department of Statistics, a growth rate of 2.02%, [19]. The climate in Jordan is arid with annual precipitation of less than 50 mm across 41% of the entire area. Ninety percent of Jordan's land gets less than 200 mm of annual precipitation. Over 83% of the nation's yearly average temperatures vary from 16.5 °C to 20.5 °C. During the winter, the western, mountainous area gets precipitation while Al-Balqa is classified as a semiarid region since the average annual rainfall is about 350 mm per year [20]. Elevation within the kingdom varies from 408 m below sea level near the Dead Sea to 1100 m in the Zai area just northwest of Amman.

Desertification and the deterioration of rare agricultural areas along with water shortages are all issues that need to be addressed. A considerable and persistent human population expansion and quality difficulties are some challenges that must be addressed. Jordan has one of the most serious environmental concerns in the world [21]. The area has a Mediterranean dry summer subtropical climate with mild winter; this is because of its location as a transitional zone between a semi-humid Mediterranean climate and an arid desert climate. The highest mean annual temperature recorded in the area during the summer semester is 30.85 °C, while the lowest recorded mean annual temperature is 13.50 °C in January. In general, the mean annual temperature of Al Balqa governorate is around 19.90 °C.

Literature review

Many landfill site selection studies have been conducted within the GIS environment [3,22,23] with the AHP technique being utilized in some of them [13,24,25]. A few prospective site choices were investigated using GIS analysis by considering numerous criteria and contradicting aims in a GIS-based multi-criteria approach [3,26]. Data was collected from various sources and stored in a GIS system before being utilized in site selection studies. The ArcGIS software program and its extensions were used to implement the analysis. Simsek and Alp [9] conducted a study to evaluate and identify potential places that might be suitable for disposing of municipal solid waste in Diyarbakır, Turkey. For this reason, a criteria determination and evaluation commission comprises experts from different universities and fields. Through the expertise of a knowledgeable team and a thorough literature investigation, 14 criteria were chosen, including social, economic, and environmental sensitivities. Feature data were converted into continuous values, and fuzzy membership functions were employed to standardize the criteria in this investigation. This analysis indicated that 3.44% of the entire study area would be appropriate as a solid waste storage facility. Le et al., [27] discussed the most relevant multi-criteria decision-making (MCDM) methodologies and tools for assessing solid waste management systems. It identifies the Analytic Hierarchy Process (AHP), Multi-Attribute Utility Theory (MAUT), Outranking procedures, and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) as the most relevant MCDM methodologies for this purpose. The paper contributes to the understanding of how MCDM can be applied to address the complex and conflicting objectives in solid waste management, considering environmental, economic, social, and technical metrics.

Multiple-criteria decision-making (MCDM) can be used to select landfill sites by considering various factors and evaluating their suitability. MCDM methods such as Analytical Hierarchy Process (AHP) can handle complex problems with uncertain and inconsistent information, allowing decision makers to integrate economic, environmental, and social perspectives in the site selection process [28]. Factors such as proximity to rivers, roads, residential areas, groundwater depth, and land use/land cover are commonly used in the evaluation process [29]. The use of Geographic Information Systems (GIS) and remote sensing techniques can aid in the analysis and visualization of these factors, resulting in the identification of suitable landfill sites [10,30]. MCDM methodologies can also consider constraints and generate optimal sites for landfill construction. The integration of MCDM with GIS provides a promising approach for obtaining suitable landfill sites and can be applied in various regions and countries.

Similarly, several studies were previously conducted in Jordan; [31] presented a fundamental design study for improving rural waste treatment in Jordan's key local districts. Their research considered geography, geology, solid waste amount and categorization, existing facilities, landfill conditions, and environmental implications. The investigation led to the recommendation of the most sanitary landfill approach. Chopra et al., investigated solid waste management and disposal in Mafraq City. They reported that solid waste management in Jordan had been complicated by sharp increases in the volumes of generated solid wastes and qualitative changes in the composition of these wastes due to significant changes in Jordan's living standards and conditions [32]. Financial restrictions, a lack of suitable and proper equipment, and a scarcity of educated and professional staff have all played a role in Jordan's substandard solid waste management programs.

Mrayyan and Hamdi [26] developed criteria for a solid waste disposal dump site for Mafraq city based on well-known worldwide standards appropriate for the local environment. Using remote sensing and geographic information system methods, these criteria were utilized to choose the most appropriate solid waste disposal location. The places chosen are safe for people, natural resources, and the environment. Planners and decision-makers may utilize the suggested method as a tool used in the first screening phase to find a suitable dump location. According to [33], Jordan generates roughly 3800 tons of municipal solid trash daily which is disposed of at 24 locations. The northern area provides around 780 tons per day, the center region approximately 2620 tons per day, and the southern part around 400 tons per day. Aljaradin [34] discussed the challenges Jordan faces regarding solid waste management (SWM), including financial constraints, a lack of proper equipment, a scarcity of trained and skilled human resources, and a massive and sudden population, increases due to several waves of forced migration. Furthermore, their analysis also includes suggestions and recommendations for the development of the industry.

Method and materials

Finding an appropriate waste disposal area is a public health issue. Given the rapid pace of urbanization, the long-term land-use planning of suburbs should be considered when determining where the disposal area should be located. Furthermore, the current and future traffic of waste trucks must be considered. There are numerous aspects to consider when finding a waste disposal site [35]. Different parameters have been implemented for site selection based on their importance in minimizing environmental and public health hazards. These parameters were selected based on environmental and economic criteria, as a technical criterion is the same for the whole area.

The general methodology, shown in Fig. 1 below, was followed in this research.

Initially, a rigorous literature assessment of Jordan's environmental sector situation was conducted. Likewise, research was carried out on site selection planning challenges and prioritizing the utilization of multi-criteria decision support technologies. Data about Jordan's environmental sector, specifically on solid waste and its amounts and composition, were collected. The design of the AHP model consisted of the following structure: the goal to be reached (selection of the best location for the landfill in Al Balqa) and three criteria used to conduct the evaluation: technical, environmental, and economic criteria. Then, pairwise comparison matrices for criterion and sub-criteria were created to assess weights. The pairwise comparisons were conducted using input from experts. Finally, the model was evaluated using expert feedback, and the findings were summarized. Academics and researchers, the private environmental sector, regulatory agencies, and nongovernmental organizations (NGOs) working with solid waste concerns were among the experts included in the request process.

Analytical hierarchy principle (AHP)

The Analytic Hierarchy Process (AHP) is a theory of measurement based on pairwise comparisons that use expert opinion to create priority scales. The comparisons are conducted using an absolute judgment scale that shows how much one element dominates

Table 1
The fundamental scale of absolute numbers for the applied factors.

1/9	1/7	1/5	1/3	1	3	5	7	9
Extremely	Very Strongly	Strongly	Moderately	Equally	Moderately	Strongly	Very Strongly	Extremely

Less important More important.

Table 2
Random index.

Order of Matrix (n)	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

another in terms of a specific characteristic. AHP uses a consistent method for transforming pairwise comparisons into a collection of integers that indicate each criterion's relative importance [36,37]. Each class is assigned a particular weight ranging from 10 to 100 based on its potential level in landfill site selection, and then each value is scaled based on its weight in the matrix. These weights were assigned per the experts' judgments, the literature in geology, agriculture, and hydrology, and some weights based on previous studies in related subjects.

A nine-point scale was given to assess pairwise relevance, as illustrated in Table 1. This scale is used to determine how much each criterion dominates each other factor or vice versa [37]. You can refer to [38] for a detailed explanation of the AHP.

The last stage in the AHP analysis is calculating the Consistency Ratio (CR) which measures how consistent the assessments have been compared to vast samples of merely random judgments. If the CR is substantially higher than 0.1, judgments are unreliable because they are too near to randomness, and the exercise is either useless or must be redone. Finally, the AHP analysis is presented in the steps below:

1. Principal Eigenvalue ($\lambda_{\max}$) is computed by the eigenvector technique.
2. Consistency Index (CI) is calculated using the following equation [36]:

$$CI = (\lambda max - n)/(n-1)$$

where n is the number of factors.

3. Consistency Ratio (CR) is calculated as:

$$CR = (CI)/(RCI)$$

where RCI = random consistency index which can be obtained from Table 2.

Traditional methods used for identifying viable locations for landfilling often suffer from several limitations, including their simplicity and subjectivity, as they often rely on simplistic criteria like proximity to urban areas or cost of land, which may lack comprehensive analysis of various factors, thereby leading to suboptimal site selection. Additionally, these traditional methods may not adequately account for environmental factors, potentially resulting in the selection of sites that could negatively impact ecosystems, water quality, or air quality. Moreover, they tend to lack stakeholder involvement, which can result in community resistance, legal challenges, and conflicts. Importantly, these traditional methods may not effectively consider trade-offs between economic, social, and environmental factors, making it challenging to make informed decisions that balance these diverse considerations. The use of multi-criteria decision-making (MCDM) is essential to address these limitations, offering a more comprehensive and objective decision-making process that incorporates various criteria and expert opinions. The five distinct steps in MCDM, as suggested by Hanine et al., have important implications. Problem formulation ensures clear problem definition and objective setting, promoting a comprehensive and systematic approach to landfill site selection. Criteria selection helps identify and select appropriate criteria (e.g., environmental, social, economic), addressing the limitations of traditional methods by incorporating a broader range of considerations. Weight assignment reflects the relative importance of criteria, facilitating trade-off considerations and ensuring that no single criterion dominates the decision. The importance of these five steps lies in their ability to provide a structured and systematic framework for decision-making, which, by addressing the limitations of traditional methods, promotes informed, transparent, and balanced site selection, aligning with broader goals of environmental protection, community well-being, and economic efficiency while minimizing conflicts and enhancing the likelihood of public and environmental acceptance.

AHP selection criteria

The proximity of landfills to main roads is considered as an economic factor. It reduces the cost of transport and the creation of new infrastructure, but it is not recommended to have landfills very close to main roads for safety reasons. Thus, according to the proximity to main roads, the study area was classified into five buffer zones as shown in Table 3.

Zones with a distance from the road of less than 250 m were given the highest weight whereas zones over 1000 m were given the lowest weight. The consistency ratio CR for this matrix was computed and found to be 0.082.

Table 3
Paired comparison matrix of the proximity to roads.

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Economic Criteria	0.25	Distance from roads (m)	0.761	0.01	< 250 m	0.457	0.082
					250–500 m	0.308	
					500–750 m	0.118	
					750–1000 m	0.089	
					>1000 m	0.029	

Table 4
Paired comparis on matrix of elevation.

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Economic Criteria	0.25	Elevation (m)	0.158		>1000 m	0.03	0.069
					750–500 m	0.084	
					500–250 m	0.119	
					250–50 m	0.308	
					<50 m	0.459	

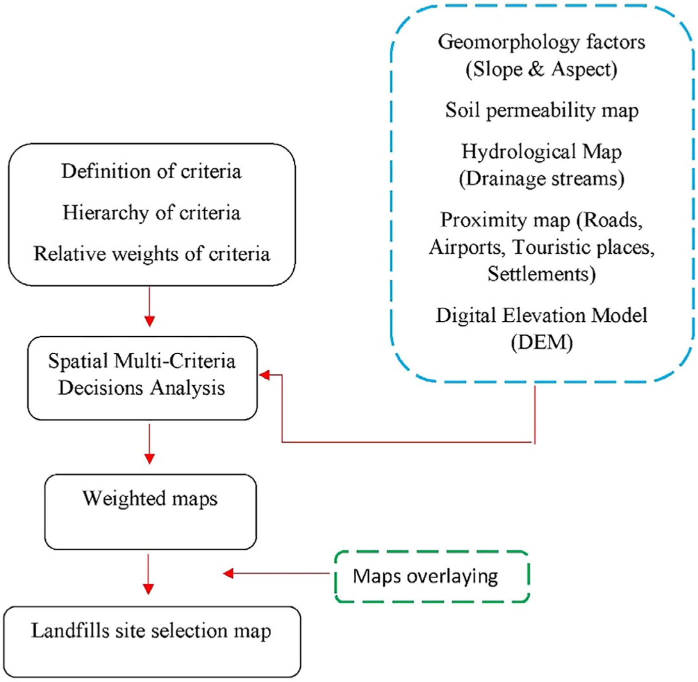

Fig. 2. Flow chart of the used methodology.

High-elevation sites have the strongest winds since these are exposed surfaces near mountain or ridge summits [39]. The elevations in the area range from low-level cliffs of 450 m below sea level in the Jordan Valley to higher than 1100 m above sea level in the mountains of Al-Balqa, as shown in Fig. 3. High weights were assigned to the lower areas. The area was classified into five classes. Paired comparison matrix of the classes was prepared, as shown in Table 4. The consistency ratio CR for this matrix was computed and found to be 0.069.

A slope map was generated from DEM obtained from ASRTM. The slope map was reclassified into 5 classes: 0°–2.26°, 2.27°–4.52°, 4.53°–7.54°, 7.55°–11.8° and 11.9°–38.4° as shown in Fig. 2.

The class representing flat areas (0° to 2.26°) has been selected as the most suitable and the steepest areas with the highest slope as the least suitable as shown in Table 5.

The aspect map was generated from DEM obtained from ASRTM. The Aspect map, which shows the direction of the slope, was reclassified into four classes: west (W), southwest (SW), northwest (NW), and East(E). The class representing an aspect of the west direction has been selected as the most suitable, and the areas with the east slope direction as the least suitable, as shown in Table 6.

Proximity to built-up areas is another crucial factor for landfill site selection. A buffer of 2 km is preferable to be used around settlements. The area was classified into four classes. Paired comparison matrix of the classes was prepared, as shown in Table 7. The

Table 5
Paired comparison matrix of slope.

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Economic Criteria	0.25	Slope (Degree)	0.082		0–2.26	0.63	0.068
					2.27–4.52	0.224	
					4.53–7.54	0.088	
					7.55–11.8	0.055	
					11.90–38.4	0.03	

Table 6
Paired comparison matrix of aspect.

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Environmental Criteria	0.75	Aspect	0.02	0.092	W	0.657	0.064
					SW	0.203	
					NW	0.094	
					E	0.046	

Table 7
Paired comparison matrix of distance from settlements (km).

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Environmental Criteria	0.75	Distance from settlements (km)	0.155		1>	0.04	0.087
					1–3	0.117	
					3–5	0.23	
					>5	0.613	

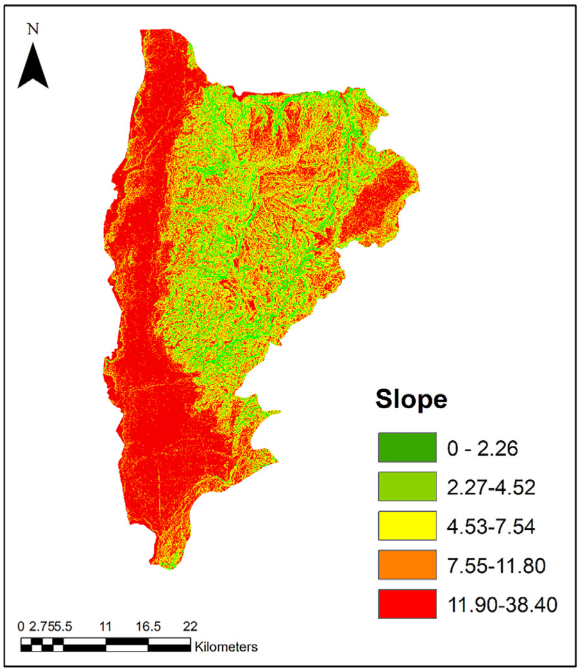

Fig. 3. Thematic map showing slope classes in the study area.

consistency ratio CR for this matrix was computed and found to be 0.087. Fig. 3 shows the distribution of the built-up area and the elevation.

A surface water drainage network was generated using a digital elevation model shown in Fig. 5 below. Selection criteria require areas far from drainage systems or streams to prevent them from pollution. Thus, a buffer of three classes has been generated based on proximity to the drainage network. Locations are assigned very high suitability if they are more than 2000 m far from the drainage network, while areas with 1000 m to 2000 m proximity are assigned moderate suitability. Finally, areas with low suitability are less than 1000 m far from the drainage network. Table 8 shows the paired comparison matrix of the classes.

Table 8
Paired comparison matrix of distance from surface water drainage network (m).

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Environmental Criteria	0.75	Distance from surface water (m)	0.247		500–1000	0.063	0.074
					1000–2000	0.194	
					>2000	0.743	

Table 9
Paired comparison matrix of proximity to airports.

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Environmental Criteria	0.75	Distance from Airports (km)	0.086		0-1	0.057	0.056
					1–8	0.364	
					>8	0.578	

Table 10
Paired comparison matrix of proximity to touristic places.

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Environmental Criteria	0.75	Distance from Touristic places (km)	0.10		0-1	0.054	0.077
					1–8	0.374	
					>8	0.571	

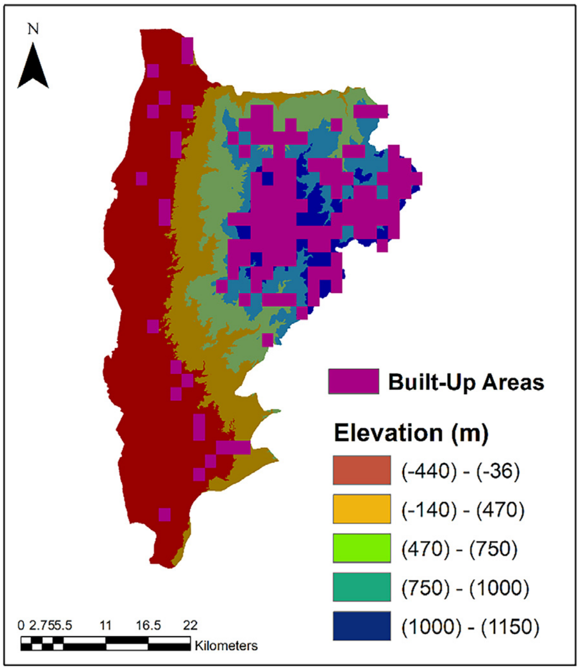

Fig. 4. Distribution of the built-up area and the elevation in Jordan.

Restricted areas like tourist places were excluded by buffer zone according to the country's regulations. Airports are also excluded from the selection for security purposes. According to the proximity to tourist places and airports, the study area was classified into three buffer zones, as shown in Tables 9 and 10. Fig. 5 represents a thematic map showing the locations of tourist places and the main road network (Figs. 4 and 6).

Soil with low permeability has the highest weight as it is necessary to prevent the leachate from infiltration into the groundwater [40]. According to this factor, the study area was classified into four classes, as shown in Table 11. The CR was computed and found to be 0.076.

The importance of land cover in this analysis comes from its role in controlling surface runoff and infiltration as it governs the water flow behavior on the terrain surface vertically and horizontally. For example, urban areas with many paved roads infiltrate less

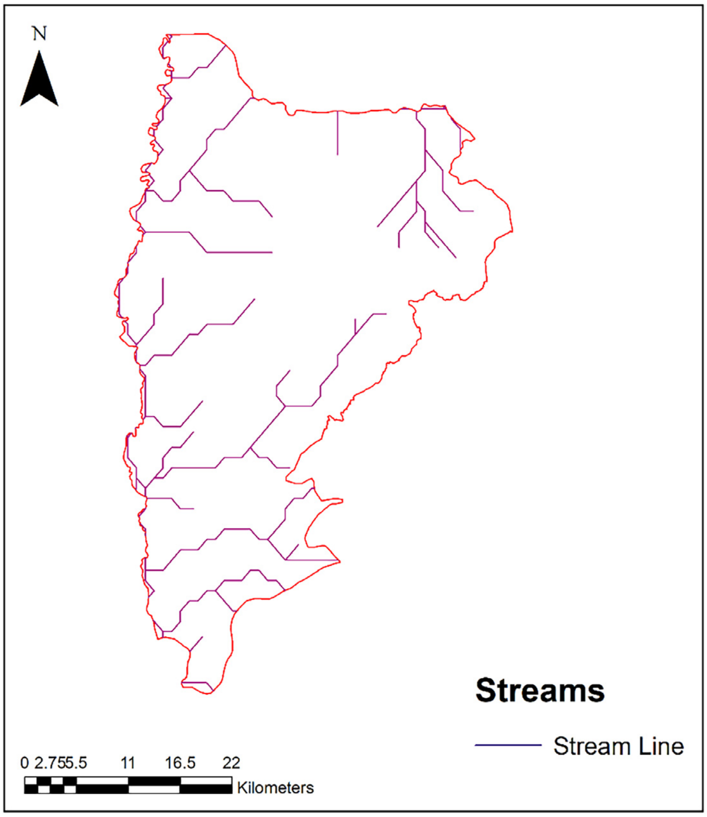

Fig. 5. Distribution of the drainage streams in the area.

Table 11
Paired comparison matrix of soil permeability.

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Environmental Criteria	0.75	Soil (permeability)	0.041		>25% 12.7–25% 2–12.7% <2%	0.046 0.113 0.213 0.628	0.076

Table 12
Paired comparison matrix of soil permeability.

Main Criteria	Weight	Criteria	Weight	CR	Sub-Criteria	Weight	CR
Environmental Criteria	0.75	Land cover	0.32		Bare Soil Settlement Vegetation Water	0.064 0.123 0.172 0.642	0.042

water than forest and green areas. Table 12 represents paired comparison matrix of 4 land cover classes: soil, settlement, vegetation, and water.

Results and discussion

The landfill site selection map is generated by integrating the parameters using the weight index overlay method to combine the thematic layers. The maps represent the relative probability of each pixel that there is a potential to have a landfill in that area. Fig. 7 shows the approach's output map which classifies the study area into five potential zones: Very Low, Low, Moderate, High, and Very High.

Using such a method for landfill site selection for the Al-Balqa area showed that the total landfill areas required to cover cumulative municipal solid waste volume generated in 25 years are 204,282.8 m^2. At the same time, the suitable selected areas determined by

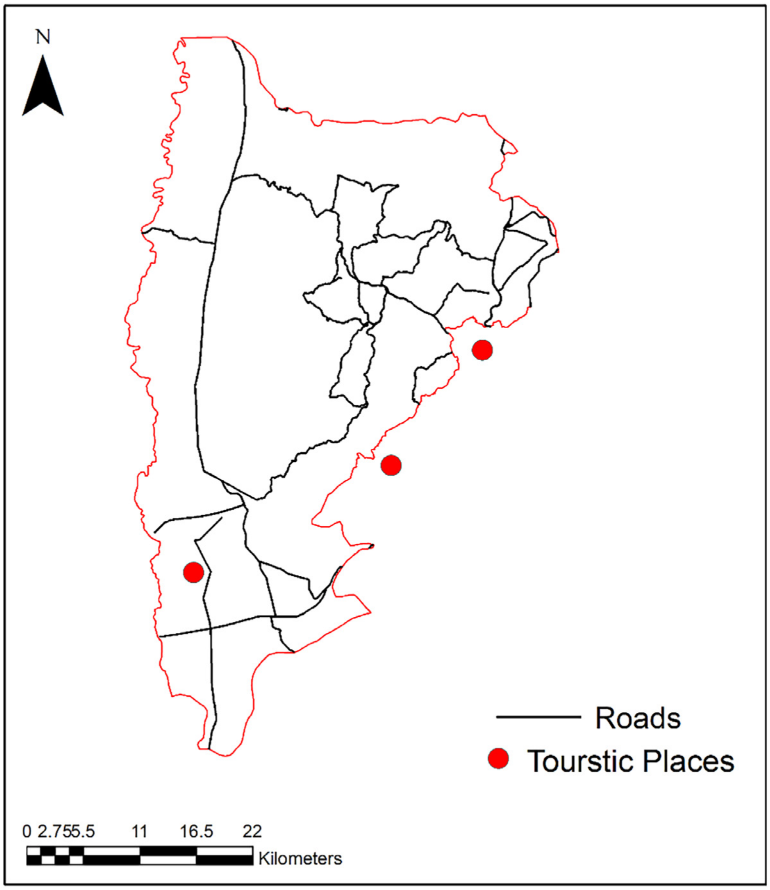

Fig. 6. Thematic map showing the locations of tourist places and the network of main roads.

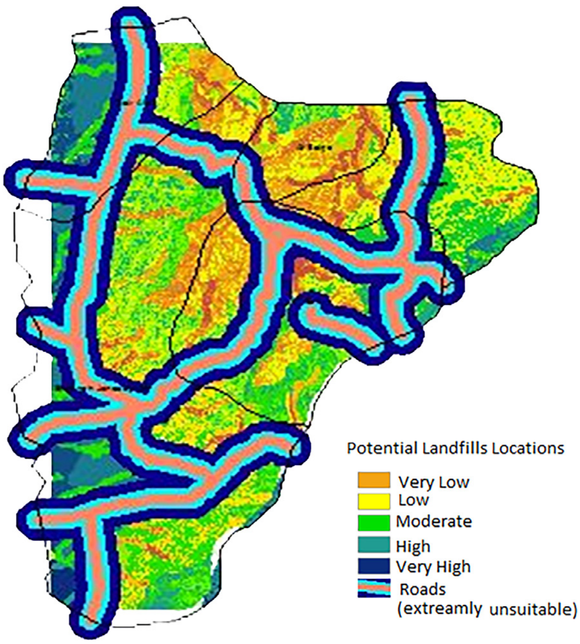

Fig. 7. Thematic map showing the potential locations of landfills in the study area.

this study are more than 79,210,000 m^2. Therefore, the chosen landfill sites will be available for more than 25 years as an estimated operation time.

Furthermore, the analysis showed that two or three locations could be selected for landfills as they have very high potential. On the other hand, according to this study, the very high and very low suitable areas could not be used for landfilling or any other similar activity.

The findings of this study significantly enhance the understanding of landfill site selection in the Al-Balqa area by providing a practical tool for land use planning, indicating that the selected landfill sites can accommodate waste for more than 25 years, thus optimizing land resources and reducing costs. The identification of two or three locations with very high potential offers flexibility and resilience in waste management, and the classification of very high and very low suitable areas protects ecologically sensitive areas. Additionally, these findings promote public transparency and engagement, which can help reduce conflicts and ensure a more economically and environmentally sustainable approach to waste management in the region.

The practical implications of these findings are significant. They indicate that Al-Balqa can establish a cost-effective and sustainable waste management system by utilizing the identified landfill sites. Similar studies such as Donevska et al. [41] showed that such method can be used for sustainable waste management. The long operational life of these sites reduces the urgency to find new locations, saving resources and minimizing disruptions, this goes with the results of Guellouh and Tebbi [17]. Additionally, the limited number of selected sites can help streamline waste collection and disposal operations. Finally, the exclusion of very high and very low suitable areas reflects an environmentally and socially responsible approach to waste management, minimizing negative impacts. These findings match with findings of Karimi et al. [42] who used similar method and found that it is not necessary to include the very high suitable areas for enivirnmental reasons as an environmental impact assessment was conducted to identify impacts and propose mitigation strategies.

Lastly, the findings of this research are consistent with established methodologies in landfill site selection as used by Dereli and Emre [43]. They provide Al-Balqa with a practical and sustainable approach to managing waste while considering economic implications. The identified sites offer operational longevity, operational efficiency, and responsible environmental stewardship, making this research valuable for guiding landfill site selection in the region.

Conclusions and recommendations

The location of a landfill may significantly influence both urban life and the environment. The location of landfills must be chosen thoughtfully to minimize environmental problems. Using AHP, a GIS-based model was utilized to analyze and identify the most cost-effective landfill sites in Jordan. GIS spatial analyst tools used overlay analysis for this section of the investigation. Optimization and suitability modeling are two examples of applications of overlay analysis. It is a method that uses a common scale of values to combine many disparate inputs into a single, concise overview. The AHP was used to prioritize values of 10 parameters employed in the criterion for landfill selection to generate a themed map that depicts the prospective sites of landfills. With the use of AHP and the assistance of this approach, landfill sites may be predicted. For this sort of study, it is advisable to utilize more parameters.

The presented approach exemplifies which areas are suitable or less suitable for landfill site selection. The criteria used in this study are not fixed since they can vary from area to area, and these criteria can be changed accordingly in the analysis. Apart from that, the presented methodology can explain clearly and directly the analysis and results in an easily understandable format. As a result, when the approach and results of the suitability map can be clearly understood, it can assist in getting full support, especially from the public.

Ethical statement

The work doesn't involve animal or human subject. Additionally, there is no data from social media platforms involved in the work.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Omar S. Arabeyyat: Conceptualization, Methodology, Writing – original draft. **Nawaras Shatnawi:** Validation, Conceptualization, Writing – original draft. **Mohammad A. Shbool:** Software, Methodology, Writing – original draft. **Ata Al Shraah:** Writing – review & editing.

Data availability

Data will be made available on request.

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