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International Journal on Economics, Finance and Sustainable Development (IJEFSD)

e-ISSN: 2620 – 6269
p-ISSN: 2615 - 4021

Volume: 6 Issue: 5 | May 2024

https://journals.researchparks.org/index.php/IJEFSD

Article

Using Geographic Information Systems (GIS) for Landfill Site Selection (Babylon Governorate)

Mustafa Aqeel Abdel-Razzaq[1], Zahraa Yasser Sawadi[2], Zainab Reda Sawadi[3], Fatima Qassem Hussein[4]

1. Department of Environmental Health, College of Applied Medical Sciences, University of Karbala, Iraq

Abstract: The process of disposing of municipal solid waste through burial or sanitary landfill is one of the most common practices in various countries of the world. However, designing landfill sites and choosing the best site is not an easy process, because the identification and selection process includes strict rules and regulations. Geographic Information System (GIS) and Analytical Hierarchy (AHP), a Multi-criteria Decision Analysis (MCDA) approach, allowed for the identification of an appropriate dump site in Babil Governorate, about 35 km south of Baghdad. Ten factors were used to choose the ideal burial place; each criterion was shown on a map on the geographic information system (GIS). The AHP matrix was then used to establish the weights of the 10 criteria, which include land use, settlements, rural regions, highways, irrigation networks, groundwater depth, rivers, land slope, and governorate and municipal boundaries. The consistency ratio was another tool used to evaluate the appropriateness of the weight scales; it was found to be 0.08371, which was less than the value of 0.1. This indicates that the hypotheses selected by the AHP matrix were suitable for the study. The results of the research show that a site of 10,563,143 square meters is ideal for meeting the governorate's land need of 7173372 square meters between 2025 and 2040. Four more factors were added to the procedures used to choose the locations of the intermediate collection stations: residential areas, garbage production hubs, highways, and proximity to the disposal site. Furthermore, the AHP matrix was used to evaluate it and calculate the weights of the previously specified criterion. The results of the research suggested that the ideal locations to facilitate the collection and disposal of municipal solid waste are seven intermediate collection sites.

Citation: Abdel-Razzaq, M. A., Sawadi, Z. Y., Sawadi, Z. R., & Hussein, F. Q. Using Geographic Information Systems (GIS) for Landfill Site Selection (Babylon Governorate). International Journal on Economics, Finance and Sustainable Development (IJEFSD) 2024, 6(5), 68-78.

Received: 21st June 2024
Revised: 28th June 2024
Accepted: 5th July 2024
Published: 12th July 2024

Keywords: Geographic Information System (GIS), landfill, Babylon Governorate

1. Introduction

The increasing human population, changing habits and lifestyles, rising disposable income, advances in science and technology, and the increased production and consumption of new goods present substantial challenges for almost every community in the world today when it comes to the proper management of solid waste. The quantity and complexity of waste generated have risen as a result of these factors combined [1].

In most urban areas, one of the main problems is a lack of space for trash disposal. Despite some efforts to collect and reduce waste, landfill dumping remains the most common and economical method of disposal. The ecology, the economics, and the environment may all suffer from inappropriate waste sites. As such, it has to be selected carefully, considering both constraints and limits on other sources.

The Babylon Governorate is located in the center of Iraq, around 35 kilometers south of the capital city of Baghdad. It occupies 5,119 km^, or around 2% of the country [2].

In 2016, the Babylonian Directorate of Census projected 2,121,889 inhabitants for the whole city of Babylon based on the Ministry of Planning's 1997 census [3].

Al-Hilla, Al-Mahaweel, Al-Hashimiya, and Al-Mussayab are the four main districts that make up the governorate of Babylon. According to the Iraqi Ministry of Municipalities and Public Works (2009), there are 16 townships in total, with each district further divided into sub-districts.

2. Materials and Methods

Field Work

1. Stages of choosing solid waste landfill location**.**
2. Selecting criteria and enter the spatial information to ArcGIS and production of maps.
3. Calculating the weight of each criteria by using multi-criteria decision analysis (MCDA).
4. Selecting optimum site for solid waste landfill.

3. Results and Discussion

1. Land use

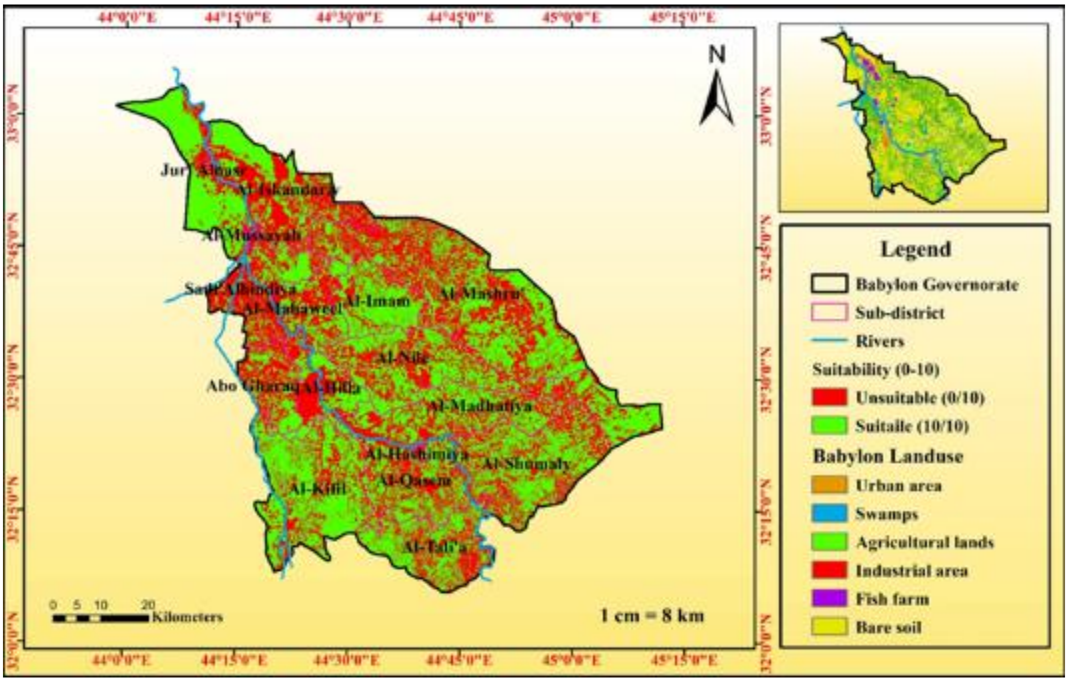


Figure 1. Land use

2. Villages and rural areas

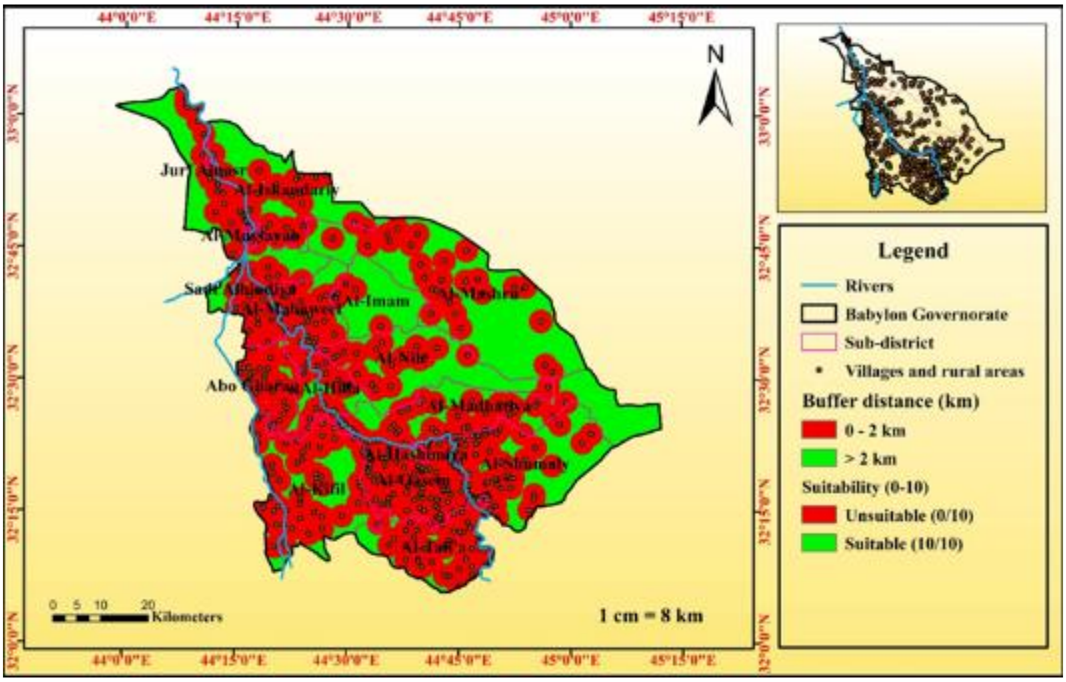


Figure 2. Villages and rural areas

3. Soil permeability

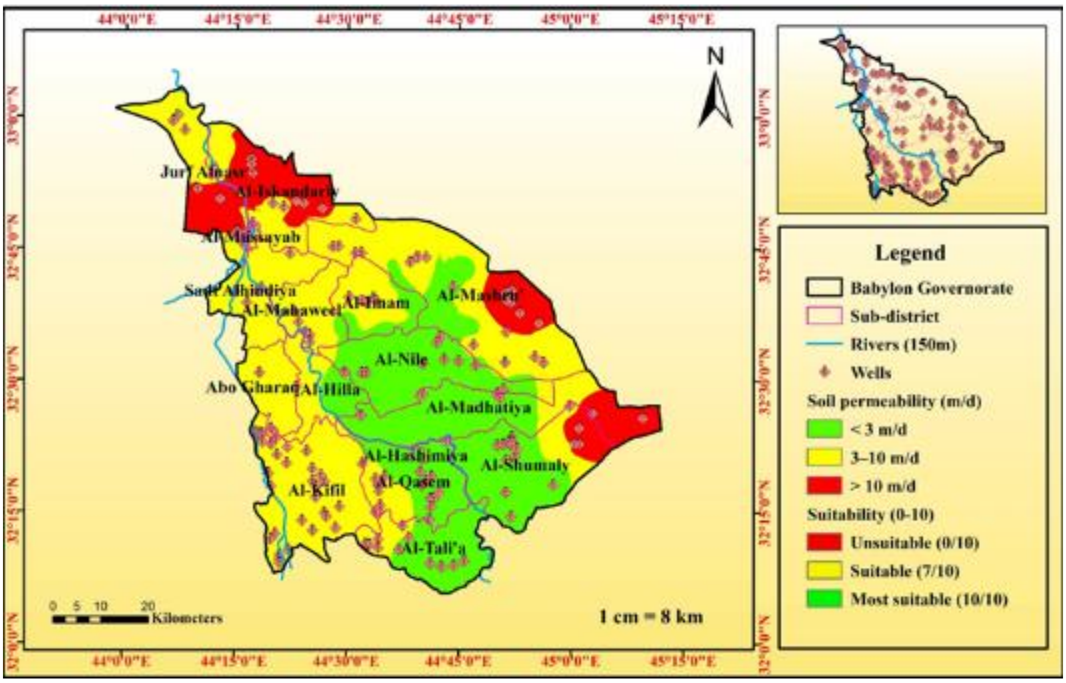


Figure 3. Soil permeability

4. Land slope

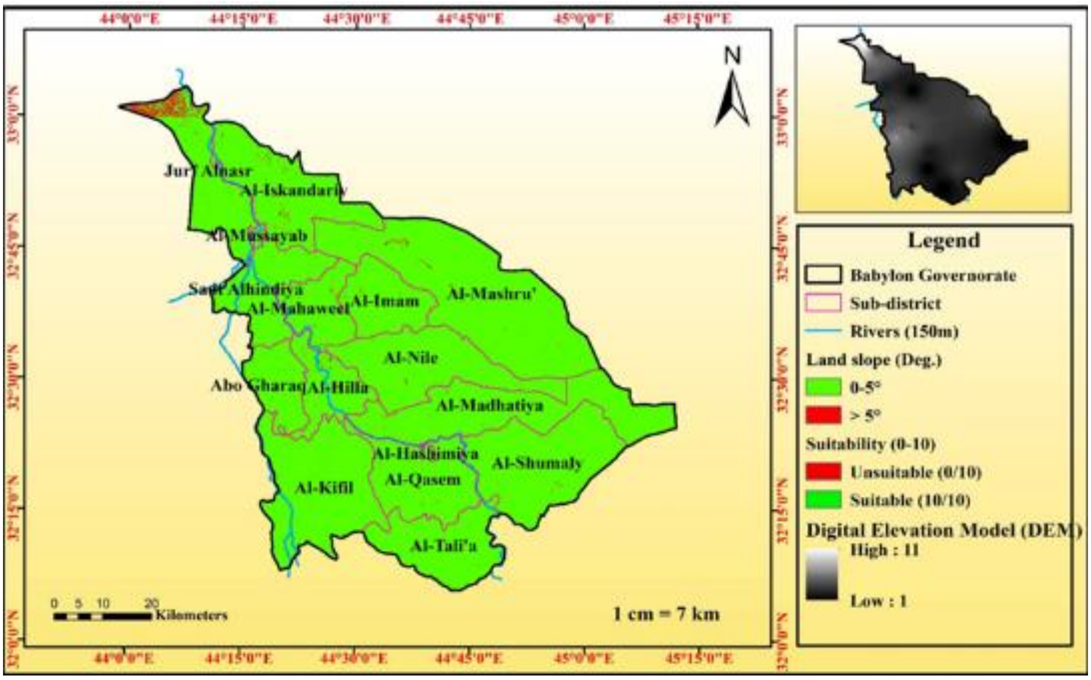


Figure 4. Land slope

5. Rivers

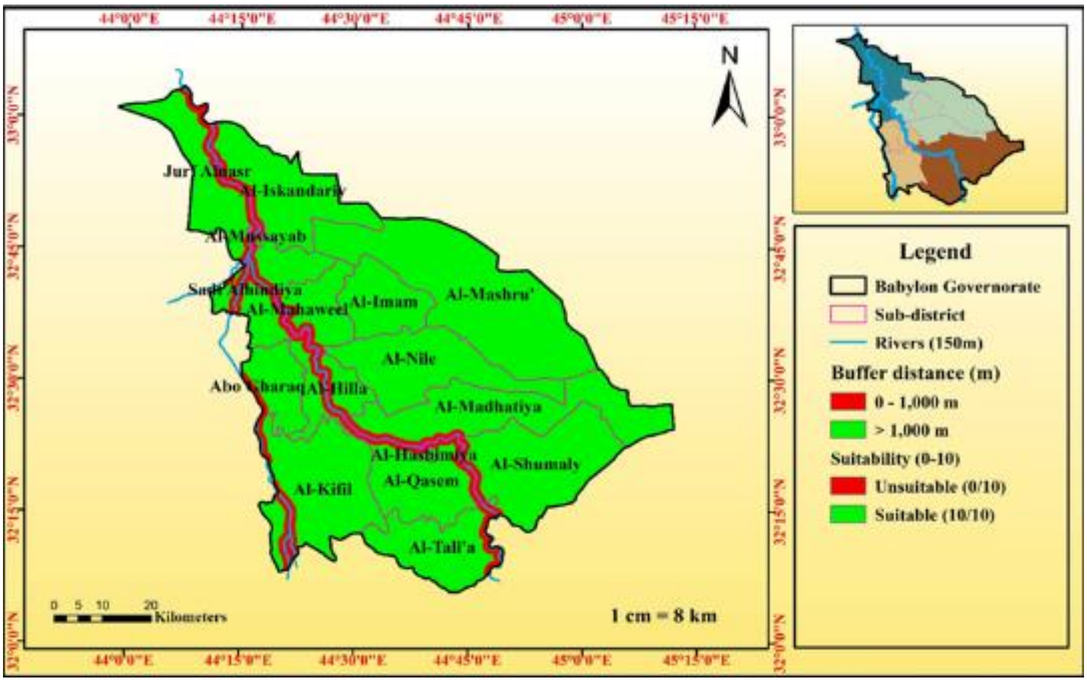


Figure 5. Rivers

6. Groundwater depth

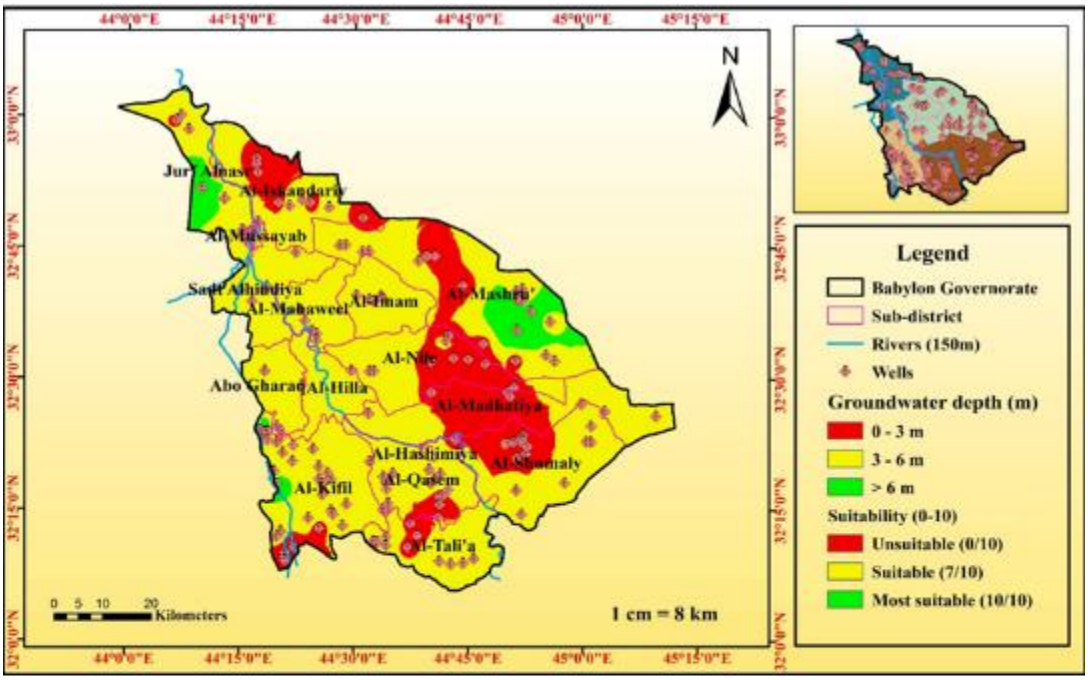


Figure 6. Groundwater depth

7. Irrigation network

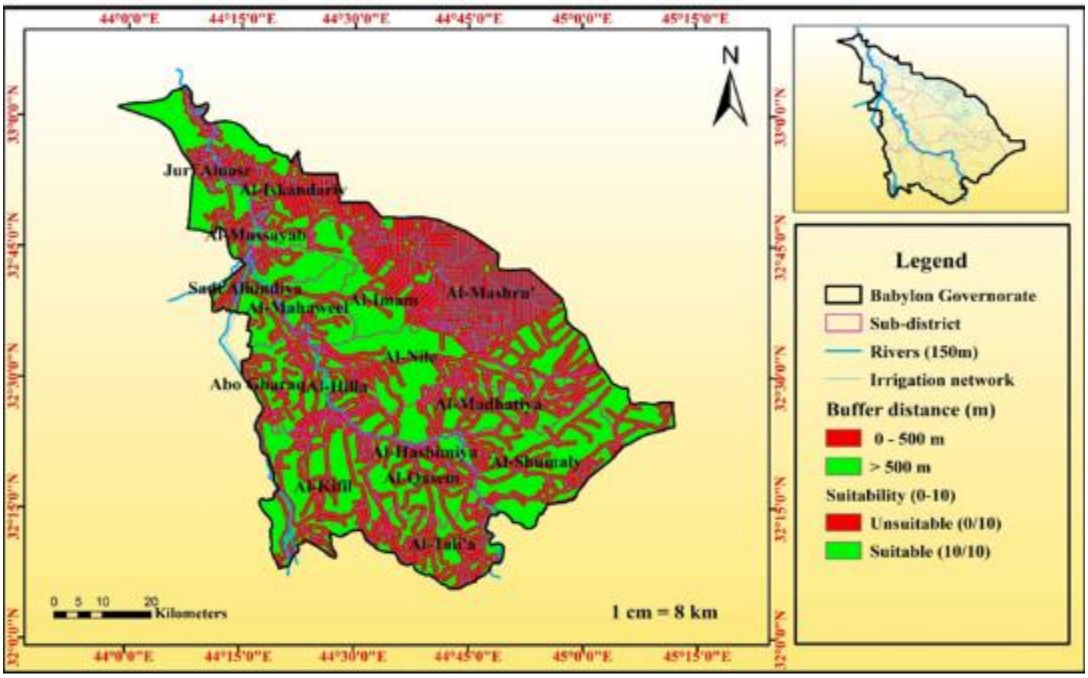


Figure 7. Irrigation network

8. Roads

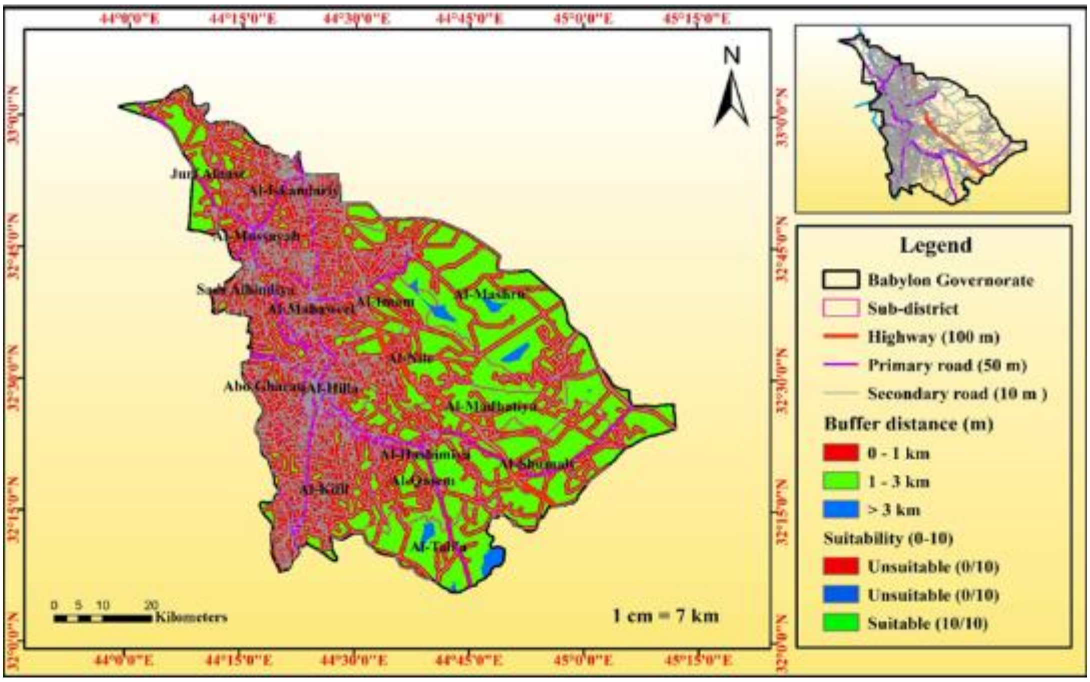


Figure 8. Roads

9. Governorate border

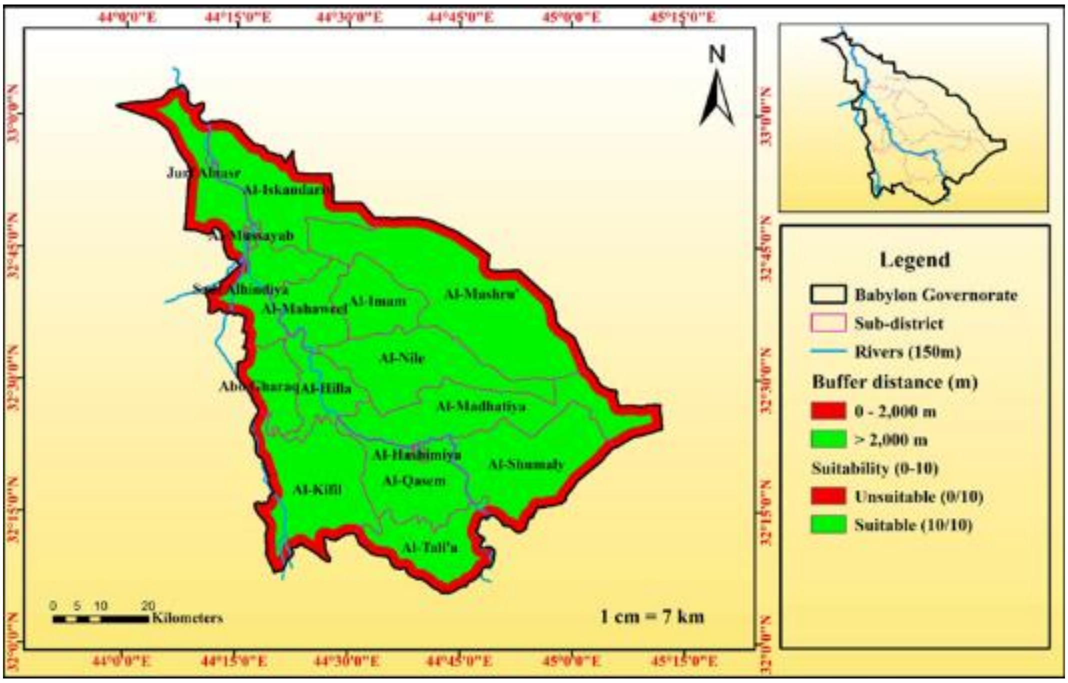


Figure 9. Governorate border

10. Municipal borders

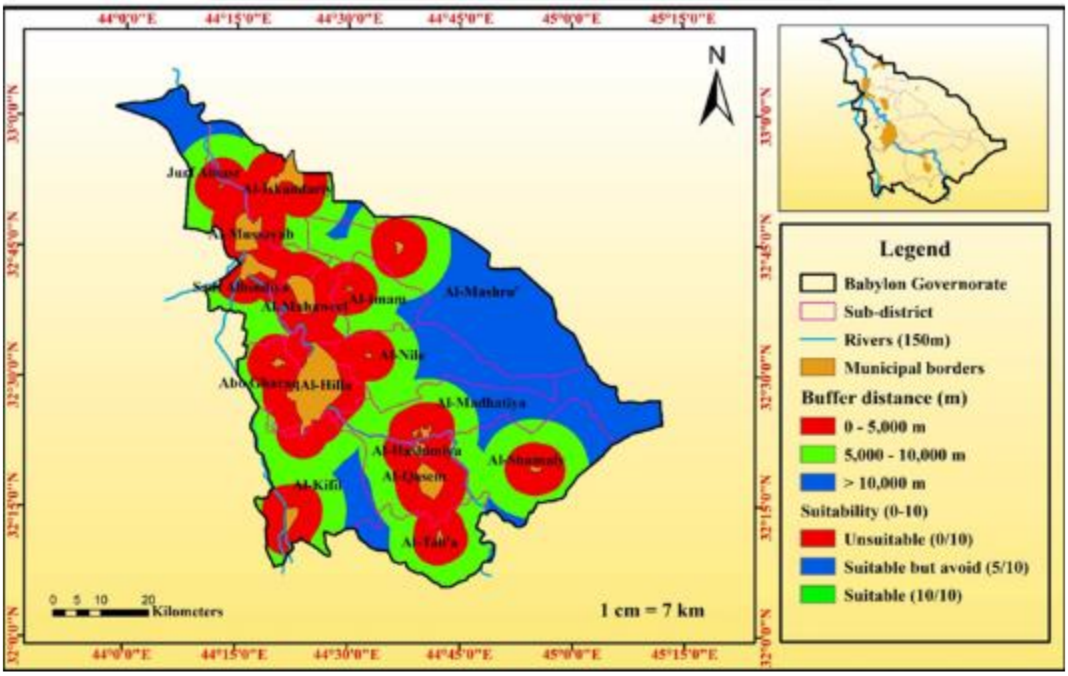


Figure 10. Municipal borders

Weigh the importance of each criterion using MCDA, a method of multiple criteria decision making (MCDM)

(MCDA) may be viewed as a ways that deal with a huge complicated issue by splitting it into smaller components. The most common methods of MCDA are:

1. Analytic hierarchy process (AHP)
2. Analytic network process (ANP)
3. Simple Additive Weighting (SAW).

Analytic hierarchy process (AHP): (Adopted Method)

An approach that is often used in (MCDA) is the Analytic Hierarchy Process (AHP). It offers a lot of benefits. The hierarchical structure is scalable, user-friendly, and can handle a wide range of issues without requiring a lot of data. (AHP) entails three actions:

1. Creation of a matrix for pairwise comparisons
2. The weight calculations
3. Consistency ratio estimation.

	L.U	V.R	S.P	L.S	R.I	G.W	I.N	R.D	G.B	M.B
L.U	1	1/2	3	5	1/3	2	1	1	3	1/4
V.R	2	1	3	6	1	3	2	2	5	1/2
S.P	1/3	1/3	1	5	3	2	2	1	4	1/2
L.S	1/5	1/6	1/5	1	1/7	1/4	1/4	1/5	1	1/8
R.I	3	1	1/3	7	1	1	1	1	3	1/2
G.W	1/2	1/3	1/2	4	1	1	5	1/3	4	1/2
I.N	1	1/2	1/2	4	1	1/5	1	1/2	3	1/2
R.D	1	1/2	1	5	1	3	2	1	5	1/2
G.B	1/3	1/5	1/4	1	1/3	1/4	1/3	1/5	1	1/4
M.B	4	2	2	8	2	2	2	2	4	1
SUM	13.37	6.53	11.78	46.00	10.81	14.70	16.58	9.23	33.00	4.63

L.U: land use, V.R: villages and rural areas, S.P: soil permeability, L.S: land slope, R.I: rivers, G.W: groundwater depth, I.N: Irrigation network,R.D: roads, G.B: governorate border, M.B: municipal borders

Figure 11. Matrix for pairwise comparisons

Selecting optimum site for solid waste landfill

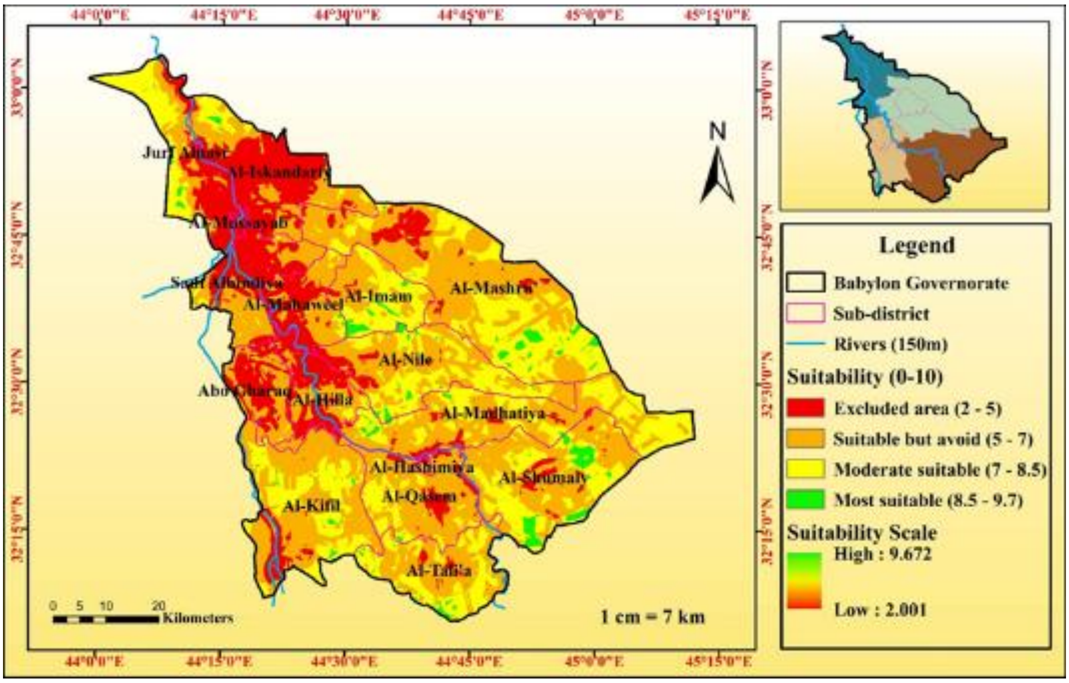
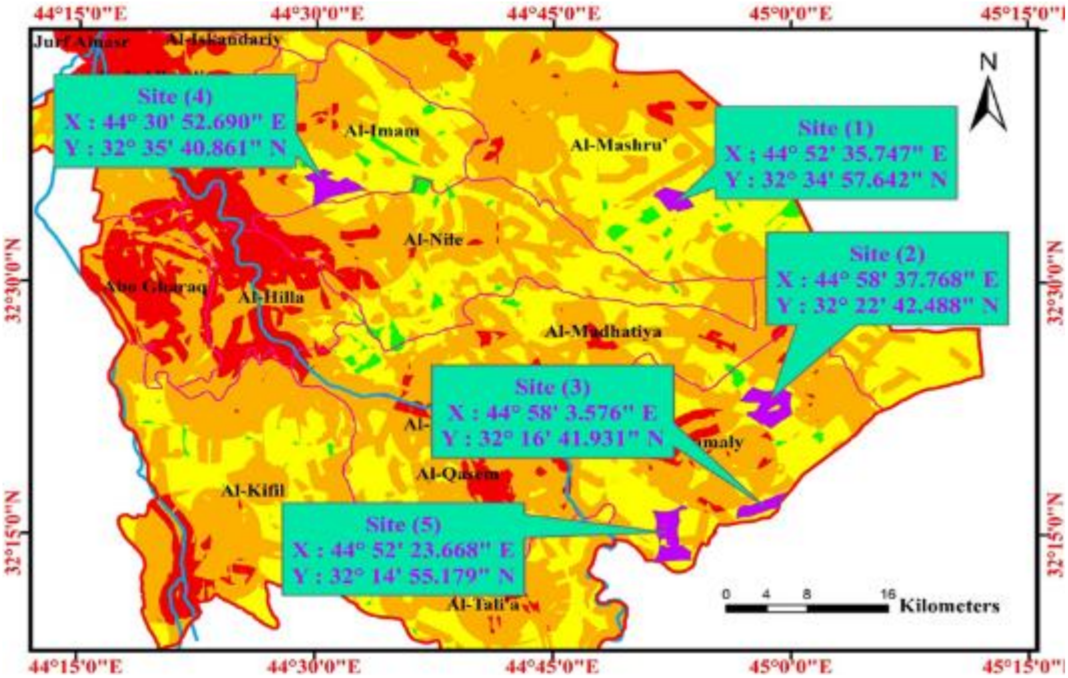


Figure 12. Optimum site for solid waste landfill

On a 10-point scale, the landfill appropriateness index varied from 2 to 9.7. Using an interval classification approach, the landfill suitability ratings for the basin were categorized into four groups: excluded area (2–5), acceptable but avoid (5–7), moderate suitable (7–8.5), and most suitable (8.5–9.7).

The study area's 20.3% unsuitability for disposal sites, 47.8% very low suitability, 29.7% intermediate appropriateness, and 2.2% highly suitable are the results.



I	Sites	Area (m²)	Groundwater depth	Property type
1	Site (1)	6,359,212	> 6 m	Private property
2	Site (2)	14,054,122	3 - 6 m	Private property
3	Site (3)	5,505,477	3 - 6 m	Public property
4	Site (4)	10,563,143	3 - 6 m	Public property
5	Site (5)	13,254,092	3 - 6 m	Private property

Adopting 0.802 kg per capita per day as a MSW generation rate and a compacted density of 600 kg/m^3, the amount and volume of accumulative MSW was calculated for the period from 2025 to 2040. The area required for landfilling MSW in Babylon Governorate will be 7173372 m^2.

4. Conclusion

The spatial analysis indicated that out of Babylon Governorate area (5,119 km^2), there are only 2.2 % (112 km^2) available for sanitary landfill siting as scattered plots.

There are nine existing landfills but they were out of standards. They were selected according to very restricted basic landfill siting and poor construction guidance. GIS siting analysis proved that they were all out of proposed optimum plots.

A total of 7173372 m^2 of landfilling space is needed to accommodate the MSW volume produced over the course of 15 years. Site (4) in Al-Imam City was determined to be the best location (10,563,143 m^2).

GIS software and MCDA provided an effectiveness and efficiency in siting appropriate sites, it is a decision support tools to select suitable locations for landfill.

5. Recommendations

Recycling of Babylon MSW needs to be on the scope of future waste management studies and should be in the vicinity of transfer stations and sanitary landfill site that were concluded in this research.

A similar approach will be required to be undertaken to assess the landfill requirements for industrial and hazardous waste streams, however at present there is insufficient reliable data to undertake such an exercise.

Together with the business sector, the public and municipal sectors should promote source separation, boost recycling rates, and turn organic waste into premium compost. Plans must be made for how to handle the non-recyclable waste that is now being generated and will continue to be produced in the future, even if recycling is rising and this is being achieved.

6. Acknowledgements

We were victorious at the conclusion of our research after a journey of hardship and tenacity. We are appreciative of the gift that God Almighty has given us since He is Almighty.

It is also with great thanks and admiration that we acknowledge Professor Mustafa Aqeel Abdel-Razzaq.

Thank you for all of your efforts, advice, and knowledge over the course of the study. We could not have finished this assignment without his persistence and unflinching support.

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