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Landfill site selection using GIS based Multi Criteria Evaluation Technique. A case study of Bundi city

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ABSTRACT
The environmental degradation issue, which is brought on by overpopulation, urban sprawl, and industrialization, which results in the production of enormous amounts of solid wastes, is one of those issues that affects humans today. Therefore, it is necessary to have effective solid waste management and disposal plans. Due to their low cost and technical requirements, landfills are the most popular approach for dumping of municipal solid waste globally, and even in India. Because it must be considered social, environmental, and technical factors, choosing a suitable site for a landfill is a challenging task. The scientific selection of a landfill site is based on a variety of factors, including laws, rules, and the level of the groundwater table, surface water, and the distance between the roadways. The study discusses the selection of a site for the development of a landfill based on several factors utilising multi criteria decision making, analytical hierarchy process (AHP) and geographic information system (GIS) based site suitability modelling.

Keywords: Landfill, AHP (analytical hierarchy process), GIS, Multi criteria decision making(MCDA)

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I. INTRODUCTION

Municipal solid waste management issues are a result of growing urbanisation and population (Sumathi et al., 2008). Waste has grown in both amount and composition.The term "solid waste" (SW) refers to all types of waste, including litter, waste, slurry, and a few other types of solid garbage, that are produced by human and other living things and are typically rejected for reuse or recycling. This includes operations in industry, agriculture, business, and society, but excludes sewage material from residential areas, silt in water, wedged solids in untreated sewage from businesses, colloidal solids in irrigation systems, and other numerous common wastes.Solid waste is increasing day by day because the world is plunging towards an urban future. Globally the solid waste generation rates past 0.75 kg per person per day.

The Bundi Municipal Board (BMB), which is led by the Chief Sanitary Inspector and backed by 144 sweepers for the collection of garbage from bins and street-sweeping, oversees managing the Solid Waste Management (SWM) in Bundi town.Bundi generates approximately 52 metric tons (MTD) of municipal solid waste per day. It consists of biodegradable and non-biodegradable ingredients. Generation is expected to increase to 76 MTD by 2026. Sources of solid waste are households, streets, alleys, vacant plots, construction and demolition areas, parks, gardens, and commercial facilities such as roadside trees, hotels, shops, restaurants,market.

There are six collection zones inside Bundi. In Bundi, no waste isolation is being practised. Squanders are gathered and transported in single compartment vehicles as blended waste. Collection occurs only once a day or less frequently. Family units must keep their waste in designated areas, therefore house to home collection is not done. Due to unclean circumstances, solid wastes within slum areas are not collected.Site selection is regarded as one of the most challenging processes in relation to solid waste management systems and is of great concern to policymakers and officials. This is because this process is influenced by several factors, including government regulation, government and municipal funding, urbanisation, rising population densities, growing environmental awareness, public health, decreasing land availability for landfills, and rising political and social opposition to the creation of landfill sites.

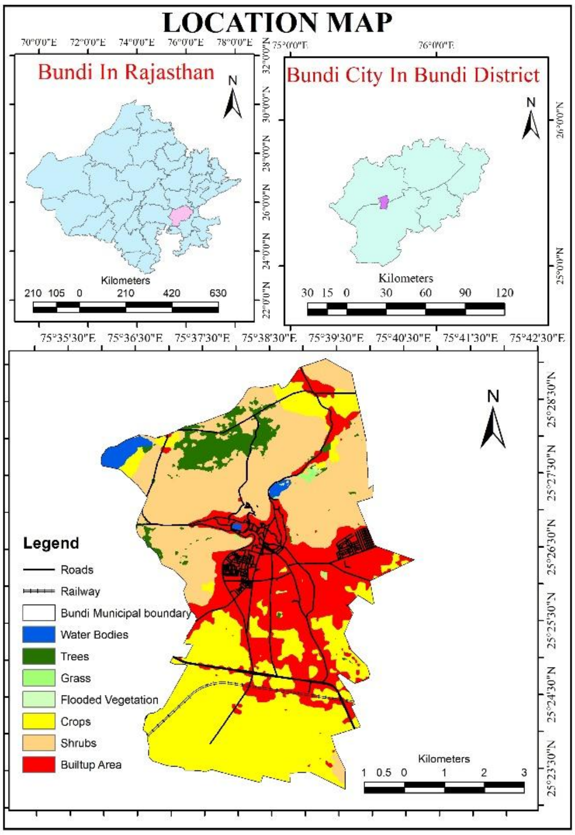
Appropriate landfill site selection is important because the opposite would have several negative consequences, unsuitable landfills can lead to water,soil and air pollution which inturn can lead to public health hazards, so this process requires a thorough review best process taking environmental ecological economic and legislative aspects into consideration. GIS is a powerful tool due to its ability to manage and analyse a large volume of spatially distributed data from a variety of sources, thus it is an influential tool to solve the landfill site selection problem. Large volumes of spatial data from many sources can be managed with GIS (Siddiqui et al. 1996). Multi criteria decision analysis is a technique designed to assist decision-makers who must weigh various and contradictory judgments. Rating, ranking, and the analytical hierarchy process are some of the different ways weights are assessed in multi-criteria analyses. The pairwise comparison method in Analytical hierarchy process (AHP) can be used to calculate the weights of the criteria. A method for integrating criteria into a single composite index is weighted linear combination (WLC). After conducting field inspections at the shortlisted sites and confirming their suitability for building, the final site may be chosen. The study attempts to use GIS and multi criteria decision analysis for landfill site selection in Bundi town of Rajasthan.

II. LITERATURE REVIEW

Volkan Yildirim (2015) in his paper application of raster-based GIS techniques in the siting of landfills in Trabzon Province, Turkey utilized GIS-based LSS method for the evaluation of two landfill sites in Trabzon province. Ahmed Barakat and others (2017) used GIS-based multi-criteria evaluation technique in landfill site selection in Beni Mellal-Khouribga region of Morocco. Amit P Multaniya and others (2021) used geospatial techniques to assess the suitable landfill sites of Raipur urban region of Chhattisgarh. Researchers have used a variety of methods for choosing landfill sites, including the weighted linear combination (WLC) method and spatial cluster analysis (SCA) (Al-Hanbali et al., 2011; Moeinaddini et al., 2010; Saeed et al., 2003; Salmon Mahini and Gholamalifard, 2006), merging fuzzy procedure and GIS (Akbari et al., 2008; Ali et al.,2014)A combination of MCDA and GIS has been used (Abdulhasan et al., 2019; Ajibade et al., 2019; Alanbari et al., 2014; Alkaradaghi et al., 2019; Chabuk et al., 2014; Demesouka et al., 2014; Fides K. Kirimi, 2014; Gautam et al., 2020; Ibrahim Mohammed et al.,2018) and GIS digital map overlay techniques (Balaguru, 2015; Mussa and Suryabhagavan, 2019; Nallusamy et al., 2017; Nishant.T, Prakash M.N, 2010). Azem Kuru and et al,(2021)used GIS and Multicriteria Decision Analysis for landfill site selection in Edrine province, Turkey.Monika Sharma used geospatial techniques in 2015 to suggest waste disposal management sites in Gwalior urban area of Madhya Pradesh. Similar study was done by Muheeb Majid and B A Mir in 2021 to select suitable landfill site selection in Srinagar city of India. Sagar Pathak (2022) applied GIS-based multi criteria decision making for landfill site selection in Surkhet in Nepal.

STUDY AREA

Bundi city is situated in the southeast of Rajasthan between the $25^0 23^l$N and $25^0 29^l$ N latitudes $75^0 35^l$ E and $75^0 40^l$ E longitude. It is located 210 kms. southeast of Jaipur, the state capital. The city is growing at a slow rate as it had 26478 population in 1961 which increased to 103286 in 2011. The temperature during summer ranges between 42-45 Degree Celsius in Bundi. In monsoon average rainfall is 650-750 mm. The temperature during winter ranges between 03-08 Degree Celsius. This city is surrounded by hills on the 3 sides, making it a picturesque location. Its location combined with the historical architectures, make the city an important part of the state's tourism map. To identify the most appropriate locations for garbage disposal, field surveys have been combined with geospatial technology in the form of remote sensing and GIS. The city has an area of 48.198 sq.kms divided into 60 wards. Collection and proper disposal of urban waste is a major concern for the municipal authorities and majority of waste collection is done by waste collection vehicles. At present waste is dumped in nearby village Astoli which has barren land and is adjacent to the city.



Map 1: Study Area

III. METHODOLOGY

Using GIS for analysis in this investigation, Esri ArcGIS 10.4 software is employed. The software's basic operations involve the usage of tools including buffer, clip, intersect, union, merge, dissolve, identify, weighted overlay, and erase. The analysis's data can be roughly divided into two categories. primary data, which comprises unprocessed data acquired from many organisations like the Bundi Municipal Board and USGS Earth Explorer.

Table1Suitability Classificationbasedondistance &Slope

Criteria	**Distance**	**Suitability**	**Rank**
RoadNetwork	<300m	Not Suitable	1
	300-500m	Least Suitable	2
	500m-750m	Most Suitable	5
	750m-1000m	Moderatelysuitable	4
	Above 3000m	Lesssuitable	3
WaterNetwork	<500m	Restricted	1
	500-1000m	Least Suitable	2
	1000m-1500m	LessSuitable	3
	1500m-2000m	Moderatelysuitable	4
	Above 2000m	Mostsuitable	5
Slope	< 5.060	Most suitable	5
	5.060-12.80	ModeratelySuitable	3
	12.90-21.70	Least Suitable	2
	Above 21.70	Restricted	1
SettlementArea	<300m	Restricted	1
	300-500m	LeastSuitable	2
	500m-1000m	LessSuitable	3
	1000m-1500m	Moderatelysuitable	4
	Above 1500m	Most Suitable	5
Land Use	Crops/Water body	Restricted	1
	Built-up	LeastSuitable	2
	Forest	Lesssuitable	3
	ShrubLand	ModeratelySuitable	4
	Grassland	Most suitable	5

After applying cartographic procedures, processed data from primary data is referred to as secondary data. The extraction of the slope of the study area was carried out from SRTM 1 Arc-Second Global satellite imagery-based DEM data, in raster format with a 30m resolution, which was downloaded from US GS Earth explorer.

The first step in this process was to establish criteria for selecting possible landfills. As a result, the criteria were derived from a review of existing studies on landfill selection criteria. The criteria for selecting a suitable site were slope, land use, water bodies, road and settlement, as well as the data layers required for interpretation. The following considerations were made to derive criteria for the five different layers selected for suitability analysis.

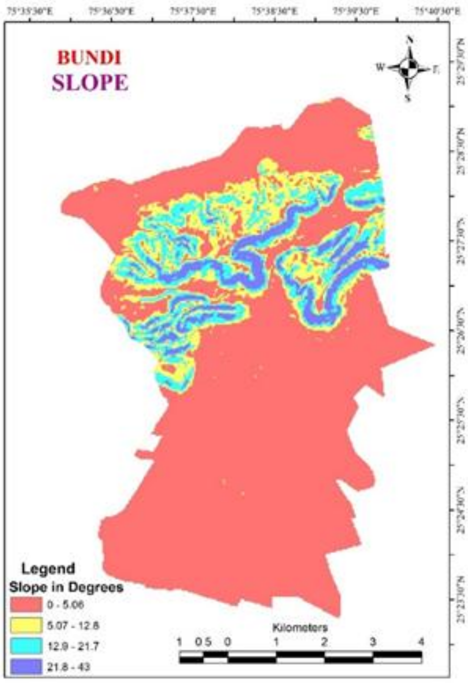
Table2Planningparametersusedanditsdescriptions.

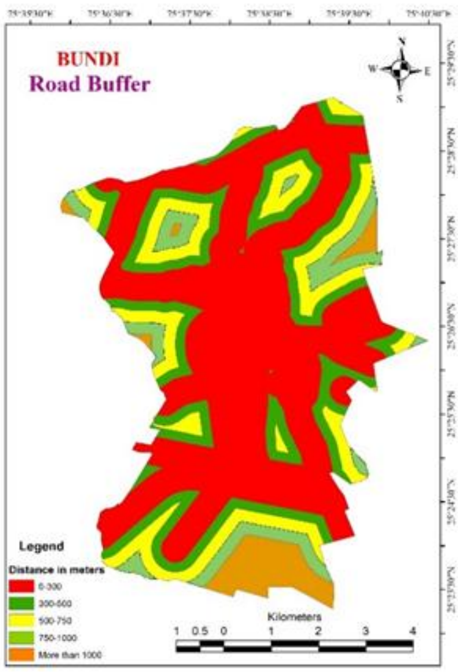
Sr.No	PlanningParameters	Description
1	SiteTopography	Slopeshouldbesuchthatitdoes not encourageleaching.
2	Settlement	Landusespecificationsshould allowthedevelopmentoflandfill.
3	Accesstoroads	Itallowssmoothfunctioningof transferringwastetothelandfill sites.
4	Distancefromwaterbodies	Itkeepschecksforwaterpollution whenitisa sourceofdrinkingwater.
5	Futureexpansion	In futurethe waste generationquantitiesandthe populationbothwillincrease.

Slopes: It plays an important role before construction of infrastructure, especially landfills. Paul & Ghosh, (2022) assigned values from 1 to 5 to the gradients based on worst-to-best designs. In this paper 5 is best, 1 is worst. They also suggested that for landfills, slopes up to 0-8° are suitable, and slopes above 25° may be rejected.

Road: This is also considered an important segment of the landfill for health and aesthetic reasons. The distance from the road to the landfill site is assumed to be at least 700m. Also, landfill sites that are very far from roads are not considered suitable due to high transportation expenses. Sites that are very far from main roads may not have easy access to landfills.

Settlement Area: This location was chosen away from residential areas to avoid public health complications from biohazards from landfills. A buffer of over 700 m was used for the appropriate distance from the landfill to residential areas. To avoid any controversy landfill sites should not be selected near densely populated areas.

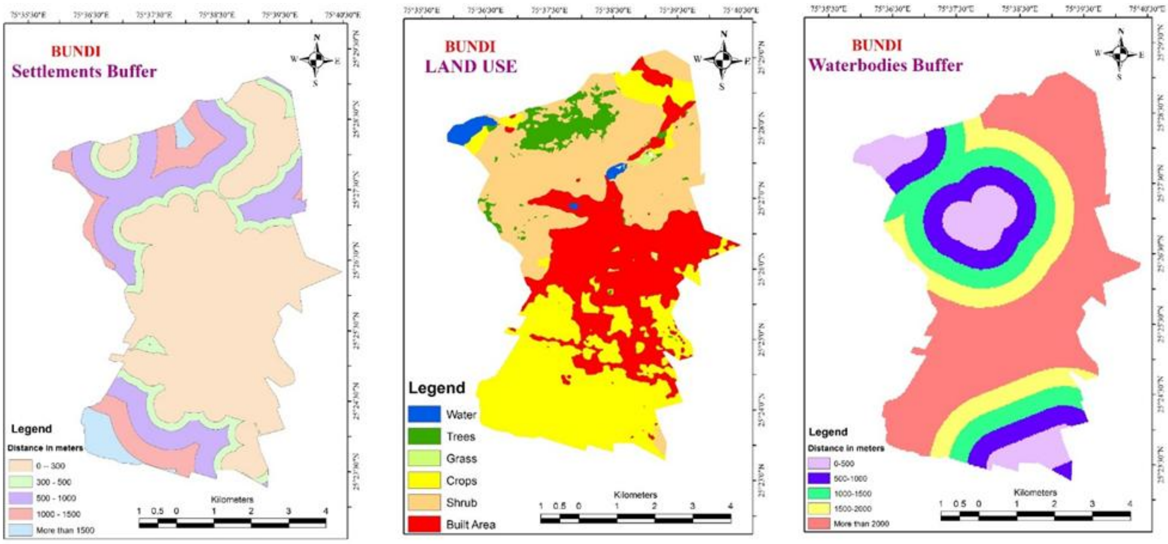




Land use: This category includes grasslands, forests, crops, etc. The agricultural sector received a value of 1, followed by 3 for forest,5for grassland. 2 was assigned to build area and 1 for waterbodies.
Water Body: A buffering environment of 500m and above was created in a raster environment of ArcGIS 10.4 and reclassified providing rating 1 for unsuitable buffer and providing 5 to the most suitable buffer.
Multi-criteria decision-making is used in the study and Analytical Hierarchical Process (AHP) is one
such method. The AHP is a mathematical technique created by Saaty in 1977 for the analysis of difficult decisions comprising numerous criteria. In the context of the AHP technique, pairwise comparison compares the criteria that are employed in decision analysis and establishes values for each of these criteria.The comparison matrix indicates the comparative importance of the assigned criteria in a column to the criteria in a row as shown in the below table. A scale from 1 to 9, with 1 indicating that both column and row elements are equally important.

Table3Rating Scale

Rating	Definition
9	Row extremely more important
8	Row very strongly to extremely more important
7	Row very strongly more important
6	Row strongly to very strongly more important
5	Row strongly more important
4	Row moderately to strongly more important
3	Row moderately more important
2	Row equally important to moderately more important
1	Row and column equally important
1/2	Column equally important to moderately more important
1/3	Column moderately more important
1/4	Column moderately to strongly more important
1/5	Column strongly more important
1/6	Column strongly to very strongly more important
1/7	Column very strongly more important
1/8	Column very strongly to extremely more important
1/9	Column extremely more important



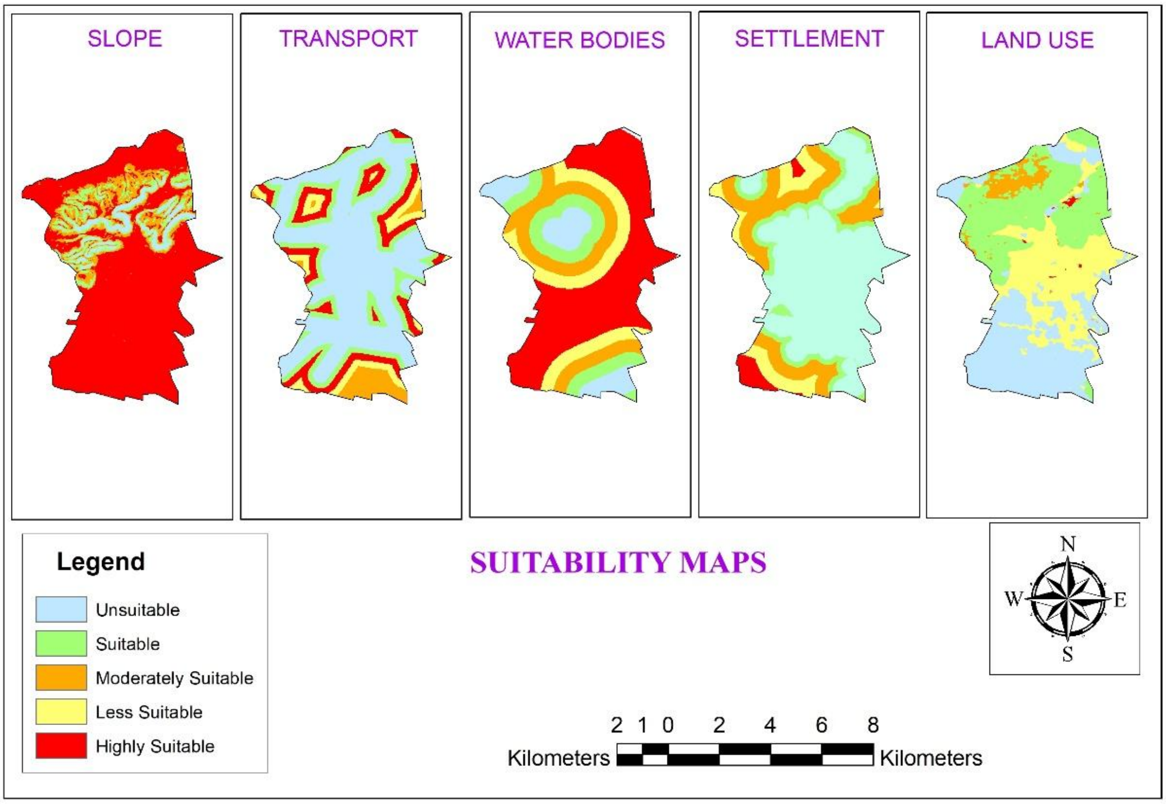
Map 2: SettlementBuffer, Land Use and Waterbodies Buffer

Table4Comparison Matrix

Item Description	Land use	Waterbodies	Settlement	Slope	Road
Land use	1.00	0.50	0.25	7.00	3.00
Waterbodies	2.00	1.00	0.50	7.00	7.00
Settlement	4.00	2.00	1.00	9.00	9.00
Slope	0.14	0.14	0.11	1.00	0.50
Road	0.33	0.14	0.11	2.00	1.00

Consistency ratio – 0.03 Reasonable consistency

In AHP, pairwise comparisons produce a matrix, and these calculations lead to the determination of the criteria weights. In pairwise comparison, it is also feasible to calculate the consistency ratio (CR) of decisions. In a pairwise comparison matrix, CR displays the random probability of values being obtained.Pairwise comparisons are examined after each relative criterion has been given a score to obtain a weighted aggregate of



Map 3: Suitability Maps

1 (100%). The settlement area was given the highest priority, whilst the slope factor was given the lowest priority, as can be seen in the Priority table that was generated using the online AHP calculator.

Table5 Weightage to different parameters

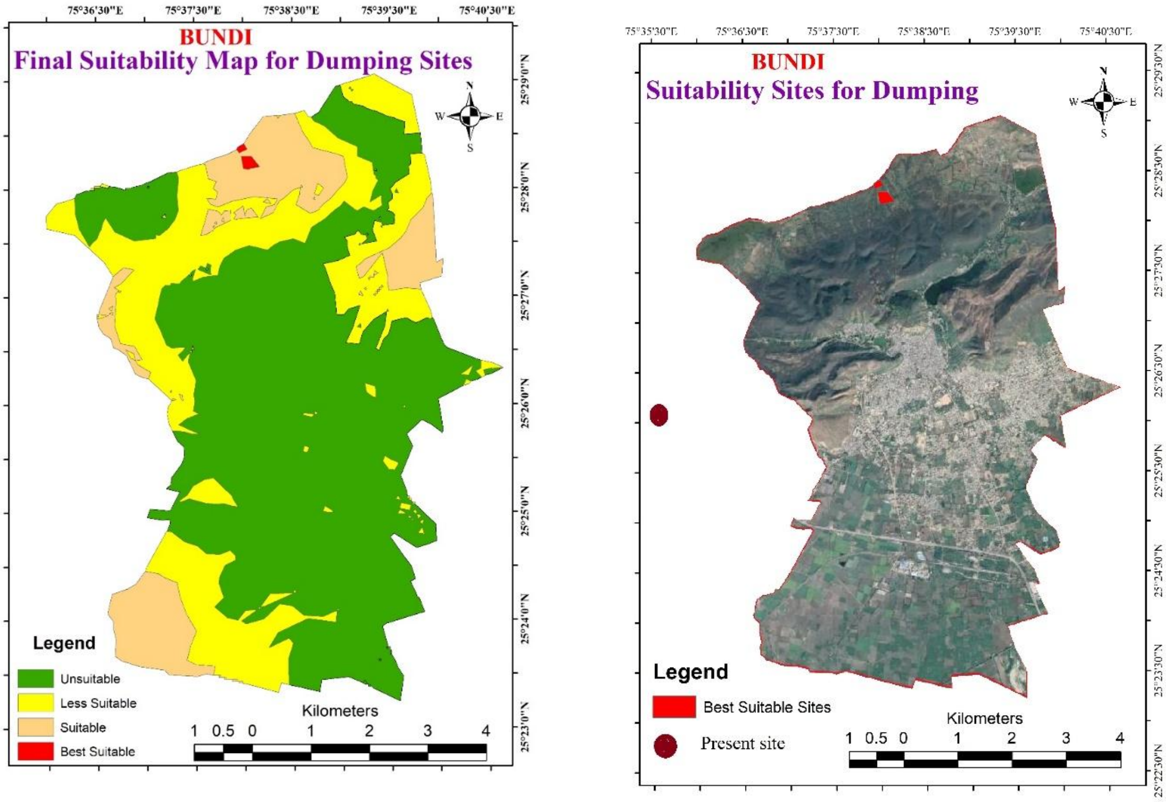
Parameters	Weight
Land use	16.2%
Waterbodies	27.9%
Settlement	47.1%
Slope	3.5%
Road	5.3%

After giving each criterion weight using the AHP method and sub-criteria weighting, the final suitability map was produced. Each criterion map, which had been transformed from vector to raster format, was then reclassified using ArcGIS. The analysis was further carried out using the ArcMap weighted overlay tool by multiplying each criterion by its weight plus an additional criterion for the most appropriate landfill locations. Four categories—unsuitable, less-suitable, suitable, and best-suitable—were used to categorise the results (see Table 6).

Only 0.13% of the area was determined to be extremely suitable and 12.51% to be highly acceptable for the solid waste disposal sites, meaning that only 12.64% of the area is suitable under the current circumstances, according to the weighted overlay analysis of the present study. The waste disposal sites currently in use, fall outside the municipal limits in an adjacent village Astoli (as shown in the map).

Table 6 Selection site Area coverage

Site	Area (In Sq. Kms.)	Percentage of Total Area
Unsuitable	29.324	60.84
Less Suitable	12.78	26.52
Suitable	6.03	12.51
Best Suitable	0.064	0.13



Map 4: Final Suitability Maps

However, it is important to note that the numerous variables considered here are case-specific and could differ from region to region depending on the population.

IV. CONCLUSIONS

Over the past few decades, urbanisation in Bundi has increased rapidly. Future waste generation will undoubtedly exceed the capacity of the current disposal procedure and places, which will also make them outmoded. Finding potential landfill locations in the research area is crucial because of this. To find suitable sites for the disposal of solid waste in the city of Bundi, which included a few parameters that affect the choice of suitable waste disposal sites, GIS was utilised in combination with AHP-MCDA in this study. All the factors, including land use, distance from the road system, water bodies, and settlement, were given weights using the AHP. The strategy made it easier to rank and weigh the several aspects that were considered during the research.Only five parameters are used in this study. In the future, more parameters can be used to get better results. The geology, the wind direction and soil type of the area are examples of these parameters that can be used in the future. Knowing the soil properties of potential sites, mainly hydraulic conductivity, and permeability, can even enrich the suitability analysis for the best landfill.

Thus, geospatial technology can be used to manage municipal solid garbage in an efficient manner, which will undoubtedly be a huge relief for city officials.

DECLARATION

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

REFERENCES

[1]. Ahire, Vishal & Behera, Dhiroj& Saxena, Manoj & Patil, Swati &Endait, Mahesh &Poduri, Harshitha. (2022). Potential landfill site suitability study for environmental sustainability using GIS-based multi-criteria techniques for Nashik and environs. Environmental Earth Sciences. 81. 10.1007/s12665-022-10295-y.

[2]. Barakat, Ahmed &Hilali, Abdessamad& El Baghdadi, Mohamed &Touhami, Fatima. (2017). Landfill site selection with GIS-based multi-criteria evaluation technique. A case study in BéniMellal-Khouribga Region, Morocco. Environmental Earth Sciences. 76. 413. 10.1007/s12665-017-6757-8.

[3]. Christian, H. &MacWan, J.E.M.. (2017). Landfill site selection through gis approach for fast growing Urban area. International Journal of Civil Engineering and Technology. 8. 10-23.

[4]. Dave, Deeksha &Gul,S.M. (2022). Impact of Socio-economic Profile on Municipal Solid waste Generation: A Study of Baramulla district of Jammu & Kashmir, India.International Journal of Environmental Sciences 11(1), 10.13140/RG.2.2.19904.20489.

[5]. Ghose, M.K., Dikshit, A.K. & Sharma, S.K., (2006), A GIS based transportation model for solid waste disposal--a case study on Asansol municipality. Waste management (New York, N.Y.), 26(11), pp 1287–1293.

[6]. Ibrahim Mohammed, Habiba & Majid, Zulkepli& Bello Yamusa, Yamusa. (2019). GIS based sanitary landfill suitability analysis for sustainable solid waste disposal. IOP Conference Series: Earth and Environmental Science. 220. 012056. 10.1088/1755-1315/220/1/012056.

[7]. Kuru, Azem& Tok, Ezgi&Ağdaş, Merve& DEMİR, Hacer& ÖZCAN, Hüseyin& DEMİR, Göksel. (2021). GIS and Multicriteria Decision Analysis for Landfill Site Selection in Edirne Province, Turkey. Journal of the Institute of Science and Technology. 969-981. 10.21597/jist.792249.

[8]. Majid, Muheeb& Mir, Bashir. (2021). Landfill site selection using GIS based Multi Criteria Evaluation technique. A case study of Srinagar city, India. Environmental Challenges. 3. 100031. 10.1016/j.envc.2021.100031.

[9]. Multaniya, Amit & Verma, Sanju & Beg, M.. (2021). Assessment of suitable landfill site using geospatial techniques: a case study of Raipur urban region, Chhattisgarh, India. International Journal of Research - Granthaalayah. 9. 132-148. 10.29121/Granthaalayah. v9.i3.2021.3778.

[10]. Pandey D. & Jain L.P., (2012), Selection of prospective waste disposal sites for Gondia Municipal Council of Maharashtra, India. International Journal of Earth Sciences and Engineering, 5(4), pp 825–830.

[11]. Pathak, Sagar. (2022). GIS based multi-criteria decision making for waste disposal site selection a case study in Surkhet.Report submitted to Kathmandu University.

[12]. Pokharel, Jeshan& Acharya, Nischal& Chaudhary, Dinesh. (2022). Disposal site selection in Sunsaridistrict (Nepal) using GIS-based multi-criteria analysis. Report submitted to Kathmandu University.

[13]. Sekulovic, Dragoljub &Jakovljević, Gordana. (2016). Landfill site selection using GIS technology and the analytic hierarchy process. Vojnotehnickiglasnik. 64. 769-783. 10.5937/vojtehg64-9578.

[14]. Sharma, Monika &Pani, Padmini & Mohapatra, Surya. (2015). Urban solid waste disposal site suitability analysis using geospatial technology: a case study of Gwalior city, Madhya Pradesh, India. International Journal of Environmental Sciences. 6. 352- 367. 10.6088/ijes.6040.

[15]. Yadav S. (2011). Atlas of Bundi District.

[16]. Yadav, Sandeep & Khan, Zuber & Sharma, Dinesh Kumar. (2022). Morphometric Analysis to Infer Hydrological Behaviour of ERU Watershed, Western India. IOSR Journal of Humanities and Social Science. 27. 46-54. 10.9790/0837-2703084654.

[17]. Yildirim, Volkan &Uzun, Bayram &Memisoglu Baykal, Tugba& Terzi, Fatih&Atasoy, Bura. (2022). Odor-aided analysis for landfill site selection: study of DOKAP Region, Turkey. Environmental Science and Pollution Research. 29. 1-17. 10.1007/s11356-021-16474-x.

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