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Identification of Potential Landfill Sites for Municipal Solid Waste Disposal Using Integrated Remote Sensing and GIS Techniques

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Abstract

One of the main environmental challenges in non-industrialized countries is MSWM.In both urban and rural settings, managing MSW is essential for maintaining public health and high living standards.The most well-known method of solid waste disposal is still on land, despite several attempts to reduce and recycle waste.This study is aimed to locate suitable landfill sites utilizing GIS, remote sensing, and methods like AHP. A GIS, which has a large capacity for managing input data, was used to determine the best landfill sites in Lonikot and Mullah Kathiyar based on a variety of factors, including soil types, geology, elevation, slope, surface water, road map, lineament density, and wind direction. The pairwise comparison technique of the AHP method is used to establish the relative weightings for each criterion. Even though the relative importance of each criterion varies, they were all regarded as essential and required for choosing appropriate locations for the disposal of solid waste. For AHP method applications Expert Choice 11.5 Software have been used by deriving the relative weightings for each criterion using pairwise comparison, AHP allows inconsistency, but provides a measure of the inconsistency in each set of judgments. Considering the inconsistency ratio of Environmental, Socio-economical and Geological Factors the inconsistency ratio is 0.042 which is a clerical error and we can say that it is perfectly consistent (as measured with an AHP inconsistency ratio of zero) along with the overall inconsistency of two landfill sites which includes site1: Lonikot has 0.826 and Site 2: MullahKathiyar has 1.00 and by comparing them the overall inconsistency ratio was found to be 0.02 and its low inconsistency ratio. While considering the overall impacts using AHP, Lonikot comprising of 0.41 and on the basis of the results it was observed that Lonikot is an appropriate landfill site.

Keywords: Remote sensing, Municipal Solid Waste Management, Analytical Hierarchy Process, Geographical Information System, Sindh Solid Waste Management Board

1. Introduction

Solid waste generation is currently increasing in volume and complexity around the world, primarily as a result of urbanization, increased economic development, and urban populations' growing expectations for daily comforts at the cost of the environment. The pace of municipal solid waste generation was greatly increased in emerging countries due to uncontrolled population expansion, a growing economy, and a high rate of urbanization (Minghua et al., 2009). Because of financial difficulties and a lack of structure, regions are currently unable to address the problems with solid waste and its management, which has left residents feeling really disappointed (Sujauddin et al., 2008). In general, economic resources, complexity, and framework multidimensionality have been highlighted by (Burnley, 2007) as the main factors influencing both effective and ineffective waste management systems in various municipalities in developing countries. For the best disposal site this demands for an effective management and planning. One of the most important management actions that should be meticulously planned is having a well-planned waste disposal facility (Regassa et al., 2018). Like many towns and cities in the Hyderabad district,(Sindh, Pakistan) the study region is not exempt from these issues. Therefore, in order to handle the issue and create an efficient management system, GIS and remote sensing applications have been taken to play a crucial role.

Solid waste is a broad phrase that refers to any undesirable or ineffective solid waste created in a given area by commercial, residential, and industrial activity. as well as it is divided into many categories depending on where it comes from, including institutional, commercial, residential, and industrial trash, as well as waste that is expected to pose a threat (such as radioactive, infectious, non-toxic, toxic, flammable, and so on) (M. Faleh&Azzawi, 2018).

The main drivers of an enormous rise in waste production include rising prosperity, changing lifestyles, increasing rates of population growth, and rising levels of industrial and commercial activity in urban centre’s around the world.

The main cause of poor solid waste management, which pollutes the air, land, and water, is usually a lack of funds. 80% of the people in developing nations live in poverty, which is frequently related to a lack of financial resources, making solid waste management a significant problem (Al-ansari, 2000).

Today's global production of municipal solid waste (MSW) is estimated by the United Nations (2010) to be over 277 million US tons of waste. Around 12.2% and 57.1% of rubbish is produced in middle-income and low-income countries, respectively. High-income nations produce about 30.7% of the global output. It is anticipated that this amount will increase by 677 million tons in 2025.High-income nations will generate 12.7% of the world's solid waste, compared to middle- and low-income nations, which will produce 16.4% and 70.9 percent of the world's solid waste, respectively. Processes involved in MSW management include waste reduction, energy recovery, recycling, and reuse in addition to garbage burning and landfill disposal (Moeinaddini et al., 2010).

Regardless of the size of the municipality, solid waste is not currently managed in Pakistan in a proper and adequate manner for collection, transportation, disposal, or dumping; as a result, people living in such conditions and the natural environment as a whole become more real over time. The scope of the problem is very broad when it comes to solid waste, taking into account a wide range of perspectives on how to handle it either directly or indirectly.

The viewpoints often include the rate of growth, the layout and organization of municipal regions, development, growth management, the physical makeup of solid waste, the compactness of waste, temperature and precipitation, the scavenger movement targeted at biodegradable division, and the suitability and restrictions of particular cities to deal with the solid waste, such as storage, collecting, transportation, and dumping eventually (ADB, 2008).

According to the 1998 census, there are currently 130.579 million people living in Pakistan, with 67% of them living in rural regions and 33% in urban ones. Relocation from rural to urban areas occurred in the urban areas over the past few years. The slow development of agriculture, low crop yields caused by water logging or salinity, deforestation and desertification, a lack of new economic possibilities, and environmental deterioration are all significant factors in this immigration. As a result, the vast rural-urban convergence will cause metropolitan facilities and infrastructure to become congested (Buckley, 1999).

Landfilling is the process of disposing of the remaining bits of material that could no longer be repurposed, from which all useful components have been removed, and from which there is no longer any energy or other use. Despite widespread criticism, landfills are vital since no waste management strategy can work without them. The process of putting trash in landfills includes identifying trash rivulets, getting ready for waste compaction, and putting environmental controls and monitoring in place.Using landfill facilities, solid wastes have been removed from the soils at the surface of the ground. Municipal solid waste has been built and operated to minimize effects on the environment and general well-being. Sanitary landfills are connected to an engineering facility for this purpose. Making ensuring that the facility for disposal is situated in a location that has the fewest negative impact on the population or the environment is the primary objective of picking a landfill site. A detailed evaluation strategy is planned in order to locate the optimum legal and accessible disposal location for a landfill placement that minimize negative effects on the economy, the environment, human health, and society.

Population growth and development activities result in the production of large amounts of solid waste from homes and cities. When an enormous amount of waste is produced by a disposal facility, there is also a danger that the environment could be significantly harmed. The most significant problems associated with improper solid waste management include disease transmission, fire risks, odor, air and water pollution, and economic losses (Id & Halim, 2021).

Leachate from the dumping of waste in landfills or dumpsites can contaminate water sources and groundwater, and the exposure that results from that exposure is represented in the drinking of contaminated water that contains harmful or cancer-causing compounds.

For the selection of the solid waste disposal site in this study, GIS techniques and AHP approaches were utilized. Landfill placement decisions clearly require consideration of a wide range of parameters, and geographic information systems (GIS) are the best tool for these preliminary studies given their capacity to handle substantial volumes of spatial data from many sources. According to user-defined criteria, it efficiently stores, retrieves, analyses, and presents information (Muhammad Siddiqui et al., n.d.).The effective manipulation and presentation of data provided by GIS and the consistent ranking of potential landfill regions based on a number of criteria provided by MCDA (Multi-criteria Decision Analysis) make the integration of GIS and MCDA a potent tool for solving the landfill site selection problem.A complex decision problem is decomposed into simpler decision problems to form a decision hierarchy in the analytic hierarchy process (AHP) developed by Saaty (1980). The top level of a hierarchy is the ultimate goal, which in this case is landfill site selection.

Firstly, investigating and survey the current situation of solid waste management in Hyderabad, Sindh Pakistan, was the area to which the technique was implemented. In addition to this, the selection of suitable landfill site that is environmentally feasible and socially acceptable for the Hyderabad Sindh, Pakistan that includes Lonikot and Mullahkathiyar site. The scope of the study was to use GIS-based AHP to identify appropriate MSWD locations in Hyderabad, Sindh Pakistan. After taking into account the recommendations of local experts and pertinent research from the literature, 6 evaluation criteria were chosen. These parameters included surface water, slope, elevation, roads, geology/soil and lineament density. These factors were weighted in order to determine the most optimal locations for solid waste dumping facilities. In order to corroborate the findings after the studies, selected areas were verified on-site.

1.1 Materials and Methods

Hyderabad is the largest city in Sindh and ranks second in terms of population in Pakistan. On a sphere between 25° 22' 45' North and 68° 22' 6' East, there are about two million people living there. At a height of roughly thirteen meters above sea level, it is about 150 kilometers from Karachi.

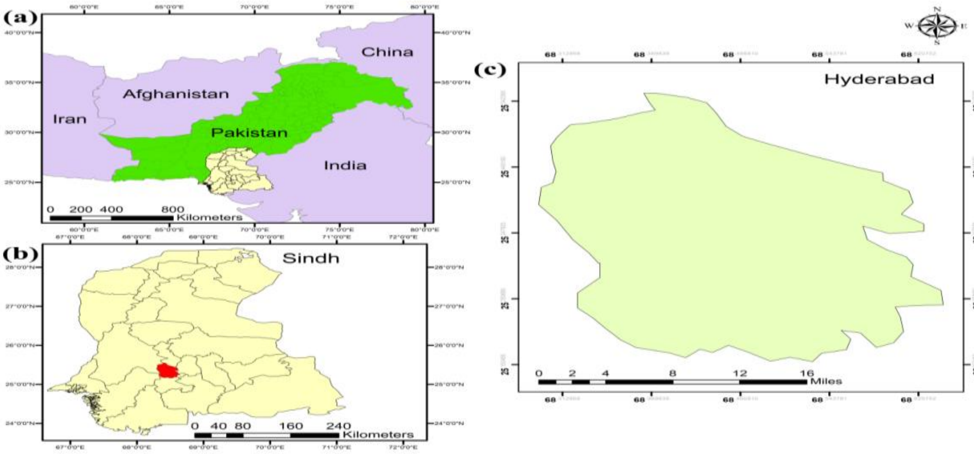


Figure 1: Study Area Hyderabad

1.1.1 Site 1 Lonikot Landfill Site Location

The proposed Lonikot Landfill Site is located in the Jamshoro District's TalukaKotri (DehSonwalhar, TappoBolhari). The planned site has GPS coordinates of 25°22'7.49"N 68° 8'38.71"E and is situated 3.5 kilometers from Nawab Khan Khoso village and the Karachi Hyderabad Motorway (M9). Furthermore, Hyderabad City is 22.5 kilometers away from the site. SSWMB purchased the 100-acre piece of property designated as the sanitary landfill for that use.Table 1 below lists the closest landmarks and their respective distances.

Table 1: Nearest Landmarks with Distances

S.No	Nearest Landmark	Distance from Site (Km)
1.	BaranNadi	1.0
2.	Master Green Energy Wind Farm	1.5
3.	Nooral/Nawab Khan Khoso Village	3.5
4.	Karachi Hyderabad Motorway (M9)	3.5
5.	PAF Base Bholari	17
6.	Surjan, Sumbak, Eri and Hothiano Game Reserve	20
7.	Darawat Dam	23
8.	Khirthar National Park	25

1.1.2 Site 2 MullaKathiyar Landfill Site Location

In the Hyderabad district's DehGanjoTakkar, TappoKhathar, and LatifabadTaluka is where the MullaKatiyar Landfill Site is expected to be built. GPS coordinates for the proposed site are 25°13'45.55"N 68°25'4.41"E. Hyderabad and Badin Road are separated by 2.5 km and 3.5 km, respectively, from Rahim BuxBrohi Village. The distance between the site and Hyderabad City is 17 kilometers. SSWMB purchased 500 acres of the authorized sanitary landfill area for that purpose.Table 2 below lists the closest landmarks and their respective distances.

Table 2: Nearest Landmarks with Distances

S.No	Nearest Landmark	Distance from Site (Km)
1.	Rahim BuxBrohai village	2.5
2.	Hyderabad to Badin Road	3.5
3.	Pinyari Feeder Lower Canal	3.5
4.	Khathar Town	3.5
5.	Proposed Housing Scheme	4.0
6.	KetiMehran Reserved Forest	6.0
7.	River Indus	8.5

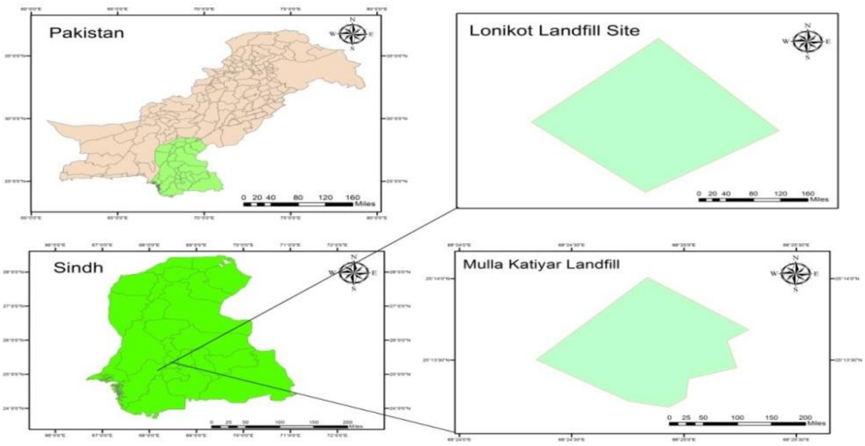


Figure 2: Insert Maps of Lonikot and MullaKathiyar Landfill Site

1.2 Data Acquired and Source

This research integrates spatial data analysis in a GIS environment with a multi-criteria decision-making process. In the GIS environment, a map of the area was first georeferenced and then digitized to show criteria features considered for selecting municipal solid waste landfill site.For the purpose of excluding locations where a municipal solid waste landfill cannot be located, buffer analysis was done on the digitized features. Then, maps with criteria feature and buffer analysis were created. In order to identify prospective landfill locations in the research area, the buffered maps were analyzed. Potential landfill sites were narrowed down based on geography and distinguishing characteristics, and the AHP model and GIS-based MCE software was used as part of the MCDA decision-making process to choose the optimum landfill site in the study area.

1.3 Analytical Hierarchical Process

AHP is a method of decision-making that supports and takes into account options with a variety of objectives, frequently even conflicting ones. A geographical information system (GIS) was used in conjunction with AHP to determine if a piece of land would be suitable for use as a dump site (Kharat et al., 2016). AHP has thought of using a multi-level hierarchical structure to obtain the weighted percentage of the several criteria. Out of a variety of possibilities, AHP is also utilized to choose the optimal landfill location (Ali JalilChabuk et al., 2016). It is a method inwhich how to assign weights to a set of activities in accordance with relevance is a key topic in decision theory. Generally speaking, importance is assessed using a number of factors. Each requirement might be shared by some or all of the activities.

The criteria could, for instance, be goals that the activities were designed to achieve. These layers were all brought together into a GIS after the criteria map layers were represented in raster data format and the values between 0 and 1 were scaled. The weights related to criteria map layers were obtained using AHP. AHP is based on pairwise comparisons for each data layer using a numerical grade on an absolute scale of numbers(Koc-San et al., 2013), and it offers a straightforward hierarchy for dealing with complicated problems(Cheng et al., n.d.).

AHP assigned a single numerical value between 1 and 9 to indicate the relative relevance of two criteria. Decision-makers who are professionals in astronomical observations, geosciences, meteorology, and urban planning awarded these numbers to each pairing. Pairwise comparison is carried out in order to create an AHP matrix that comprises the grade of relevance between pairwise data. The intensity of importance scale ranges from 1 to 9. If the significance of the compared data is the same, then the matrix's value is one. When the reference data is vastly more significant than the compared data, the value of the comparison is provided as nine, the highest number in the AHP matrix.

The pairwise comparison matrix lists each comparison grade (AHP matrix). The matrix element of a pairwise comparison matrix is constructed as aij = (1/aji). The diagonal values on this matrix are equal to one (aii = 1, ajj = 1, ann = 1, etc.) because the column and row data layers are equal to one another. The largest absolute eigenvalue is used to standardize the grade values of all couples to one. Eq 1:

$$\sum_{i=1}^{n} w_i S_{i\,k}$$

The matching eigenvector of kmax and the ranking weight value are denoted by wi I = 1, 2,..., n).

The AHP is used in GIS-dependent, raster-driven suitability evaluations as a method for eliciting criteria weights and as a superb illustration of WLC. In vector-driven investigations with a constrained number of alternatives, the AHP has undoubtedly worked superbly in its default configuration. The AHP is acknowledged as the best tactic since it breaks down the problem into smaller decision sets and focuses on them one at a time. According to (ZelenovićVasiljević et al., 2012), experts frequently evaluated factor groupings that were related to the element at the top of the hierarchy.

However, on the basis of the suitability map's findings, several studies and research on landfill site selection using the AHP approach have been conducted in a number of countries (Dolui&Sarkar, 2021).

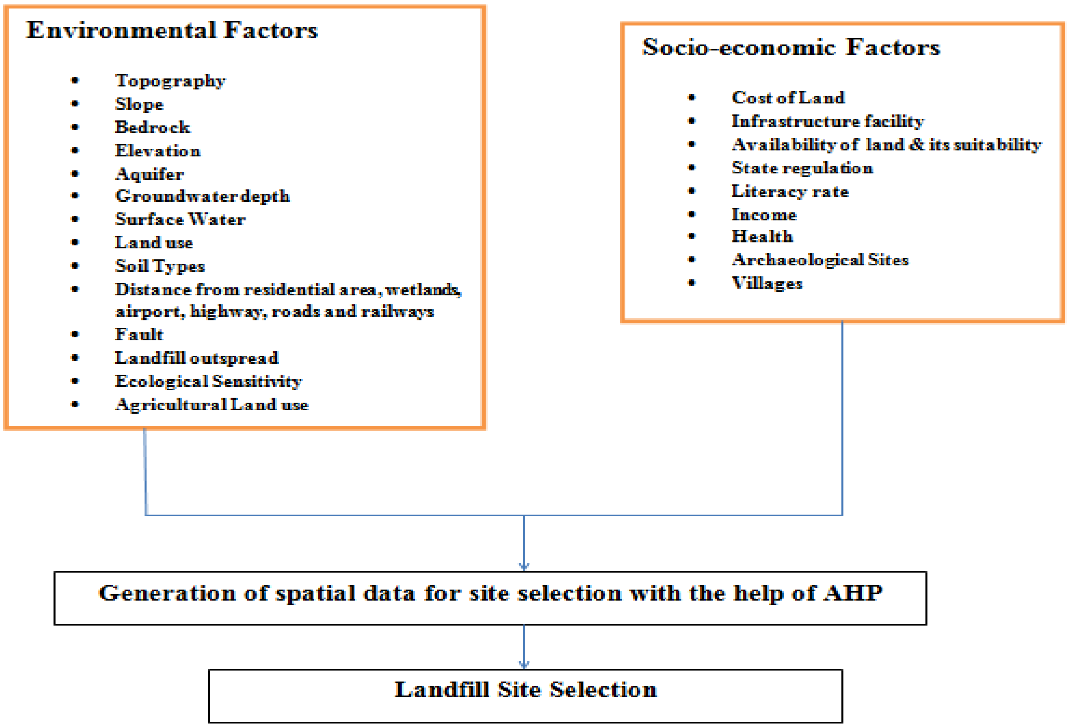


Figure 3: AHP Method for Landfill Site Selection Process

In order to study the research region and choose the optimal dump site, the analytical hierarchy process (AHP) and GIS, together with its specialized analysis tools/devices, were used to generate maps that rendered to environmental and social criteria. The process involves the following procedures, which are determined by current landfill siting standards. Figure 5 provides more illustration:

The suitable criteria will be chosen for the ongoing study.

- Around key places to meet each criterion map, making an appropriate specific constraints.
- As the database is being built up, digital maps of the study area will be produced within GIS.
- The appraisal of specialists, literature, the environment, and scientific requirements will be taken into consideration when choosing the weights for the sub-criteria.
- The AHP model will be used to calculate the criteria's weights.
- A suitability index will be computed to create a map.
- To create a map for the landfill site, a suitability index will be created.

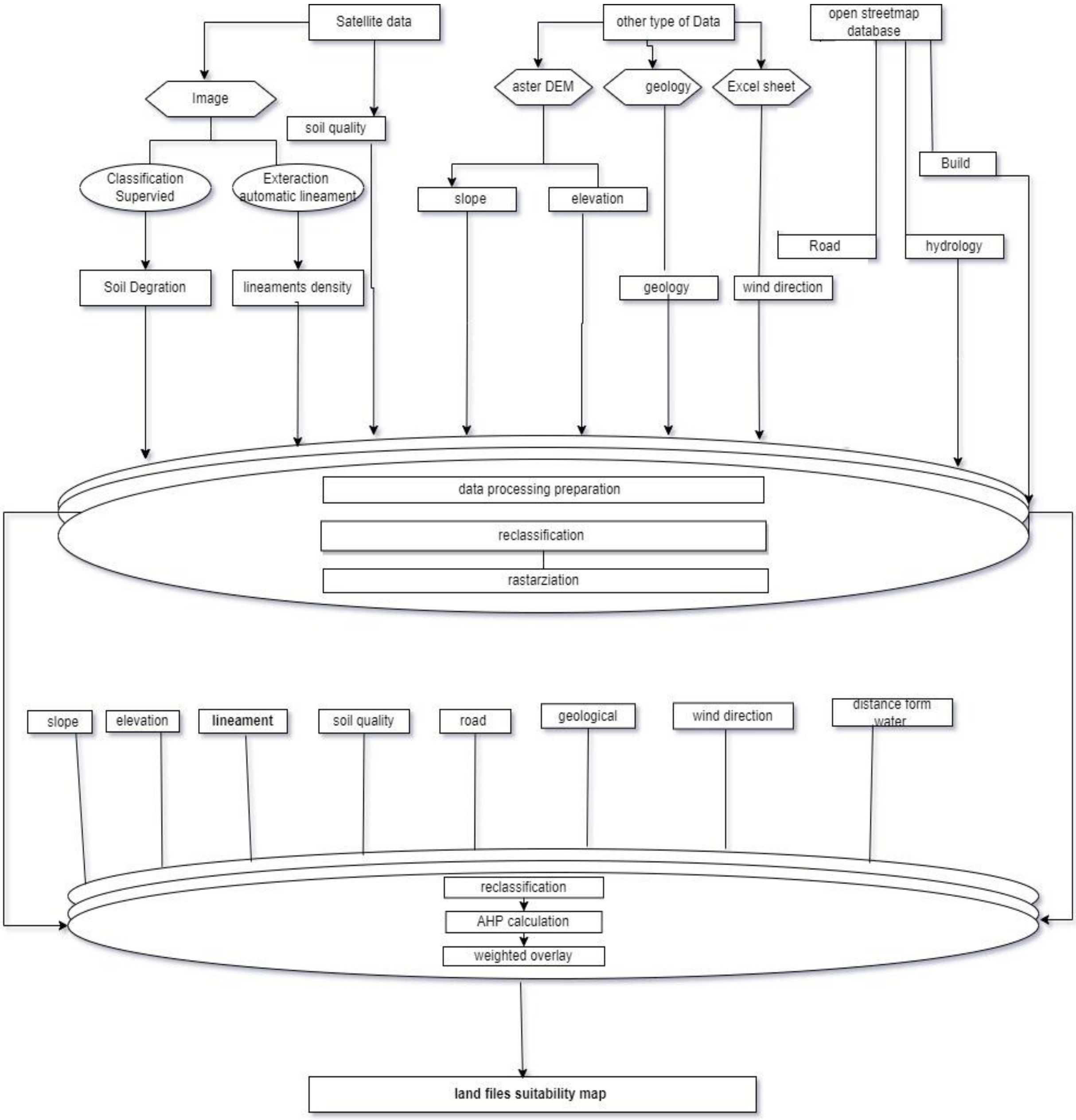


Figure 4: Flow chart of Model for Landfill Siting

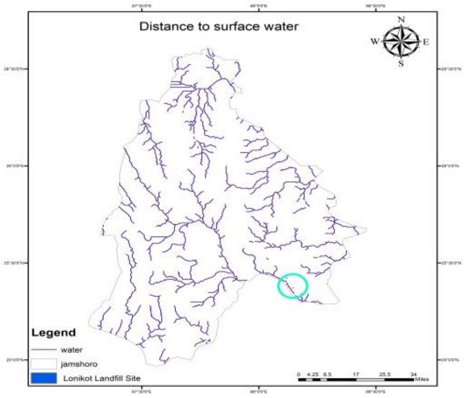
2. Results and Discussion

GIS has been used to create digital maps, therefore a significant criterion that is pertinent to the current study has been selected. The remaining maps will be converted, first explicitly into a shape file (vector), then into digital maps. Shape files served as the foundation for creating individual maps that detailed landscape, slope, rivers, roads, and lineament density. Additionally, each map's shape file and pertinent data were used to create raster maps with the aid of a GIS mapping application. The data was then projected onto the World Geodetic System using the UTM projection coordinate system (WGS 1984). To determine the best dump site, a lengthy assessment process is needed. The landfill locations that have been selected must adhere to legislative requirements while also lowering expenses on the social, economic, and environmental aspects (Mundy & Verger, 2015).The phrase "landfill site to be positioned within the limited sites" refers to areas that do not include a landfill site within them due to anticipated risks to the environment, human health, or excessive expense (Meeting et al., 2011).Taking into account GIS software that has added particular geographic elements while utilizing the special tool "buffer" buffer zones, or special limitations.

2.1.1 Surface Water/ Rivers

It has been suggested that an acceptable distance of 800 m from a river boundary be established, and that a buffer zone of more than 1000 m be constructed between a river border and a landfill, which also gives pollution protection.A 500-meter buffer zone from rivers and other bodies of surface water has been suggested in order to lessen the likelihood of river pollution.

(a) Mullah Kathiyar Distance to Surface Water Map (b) Lonikot Distance to Surface Water Map



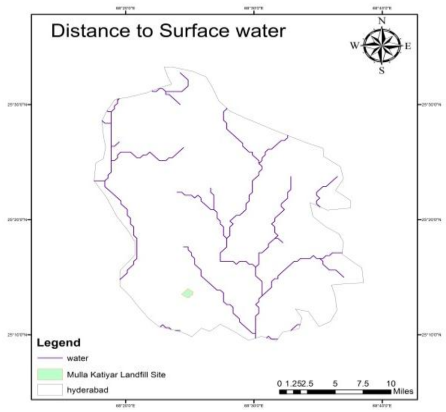
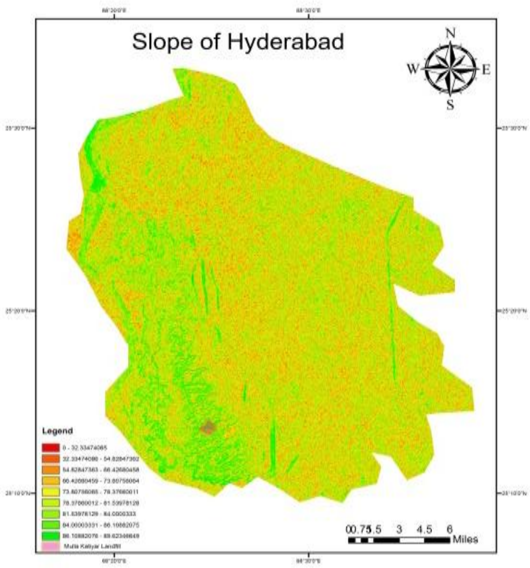


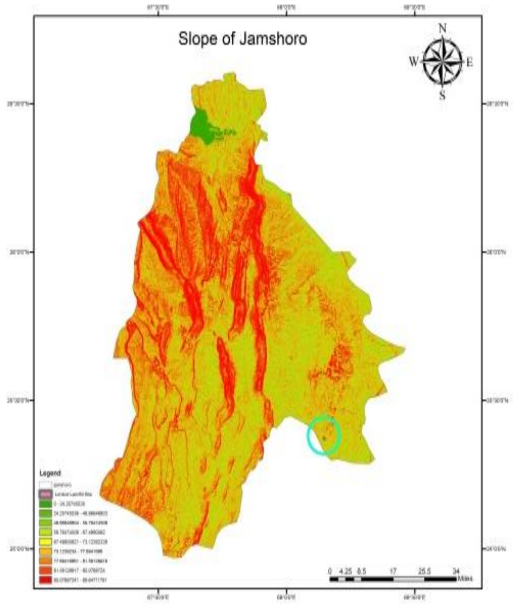
Figure 5: Suitability index maps of surface water (a) Mullah Kathiyar Landfill Site (b)LoniKot Landfill Site

2.1.2 Slope

When selecting a landfill location, land slope is an important consideration. A landfill must have an adequate slope of 8–12% in order to be built on, as slopes that are excessively steep or flat may hinder construction and increase the risk of leachate drainage into flat areas and water body contamination in cases of high slopes. A slope of less than 15° is required to stop pollutants from reaching nearby areas, and drainage ranges between 0 and 5° are reasonable to avoid contaminants. A slope layer has been developed using the digital elevation model (DEM) of the research area. The slope of the dump site near Mullah Kathiyar and Lonikot is seen in Figure 7.



(a) Mullah Kathiyar Slope Map



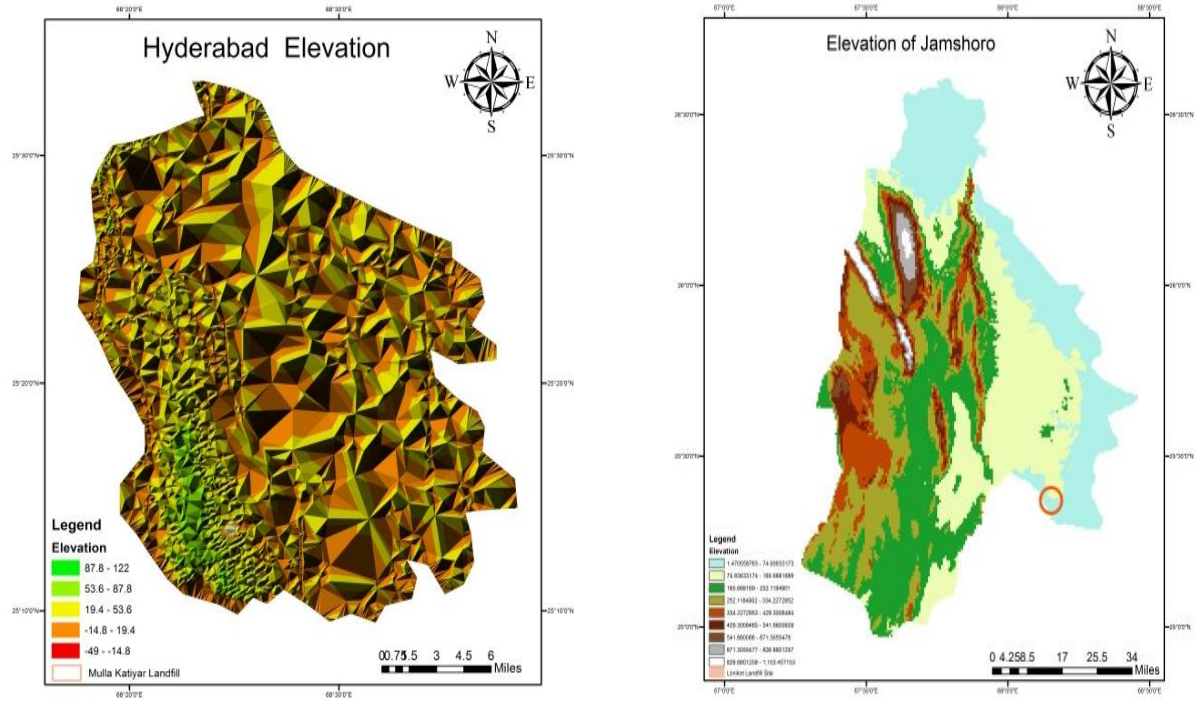
(b) Lonikot Slope Map

Figure 6: Suitability index maps of Slope (a): Mullah Kathiyar Landfill Site (b): Lonikot Landfill Site.

2.1.3 Elevation

In this work, a digital elevation model (DEM) has been used. Based on the results, the environmental elements that are significant to the majority of the affected factors, such as elevation: Lonikot and MullaKatiyar dump sites, are chosen. The DehSonwalhar, TappoBolhari, TalukaKotri, and District Jamshoro all contain the Lonikot dump site. The area contains rough topography and an arid landscape. The Lonikot Site has higher elevation in the northeast while lower elevation is found in the south.

The only raised landforms in the Eastern Valley of the River Indus are limestone hills, which make up the majority of the topography of the MullaKathiyar site. The estimated average elevation of the land above sea level is 66 metres. In the MullaKatiyar Site, the higher elevation was located to the west and south-west, while the lower elevation was located to the north of the map.



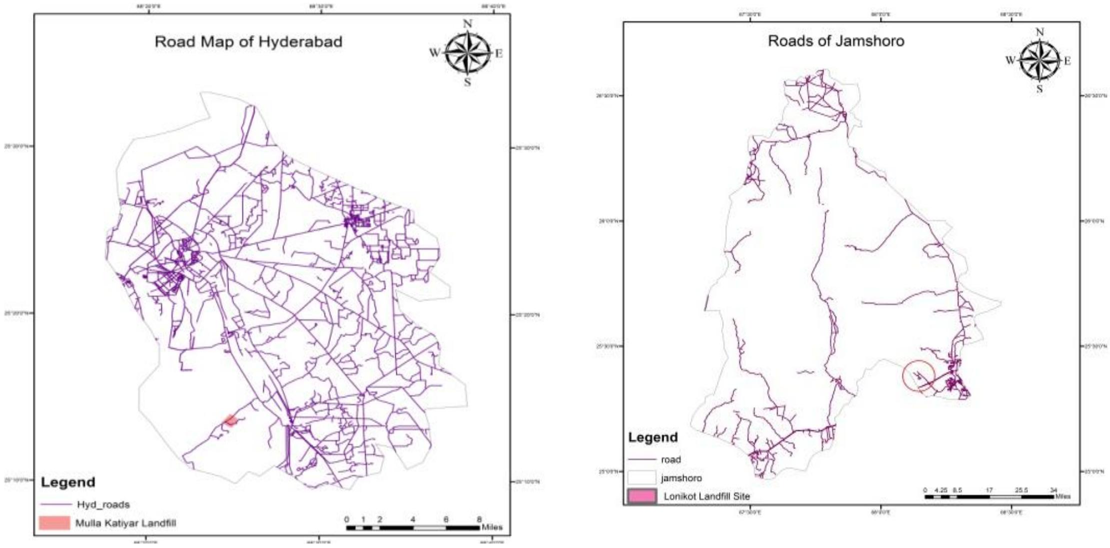
(a) Mullah Katiyar Elevation Map (b) Lonikot Elevation Map

Figure 7: Suitability index map of Elevation of (a) Hyderabad and (b) Jamshoro

2.1.4 Roads

There should be sufficient space between roads and dump sites in order to avoid unpleasant aesthetic effects and to safeguard motorists from errors or accidents that may occur as a result of the material being blown onto roadways by strong winds.Avoid placing the waste disposal sites too close to the road systems; therefore, these networks must be given a 100 m buffer zone.

Generally, a landfill site must be located close towards current roadways, as well as other economic variables, to lower the cost of future road extension. Layers of key roads and highways have been depicted on the following road maps (Figure 7).



(a) Mullah Kathiyar Road Map

(b) LoniKot Road Map

Figure 8: Suitability index maps of Roads (a): Mullah kathiyar Landfill Site (b): Loni Kot Landfill Site

2.1.5 Geology and Soil

The best locations for garbage disposal are created using reliant geological units. When deciding where to put a landfill, one should consider karst formation, earthquakes, erosion, volcanoes, erosion, and erosion. It is frequently preferred to create a substantial vertical barrier between the landfill base and the higher aquifer using homogenous, enormous, and nearly impermeable clay and shale strata.

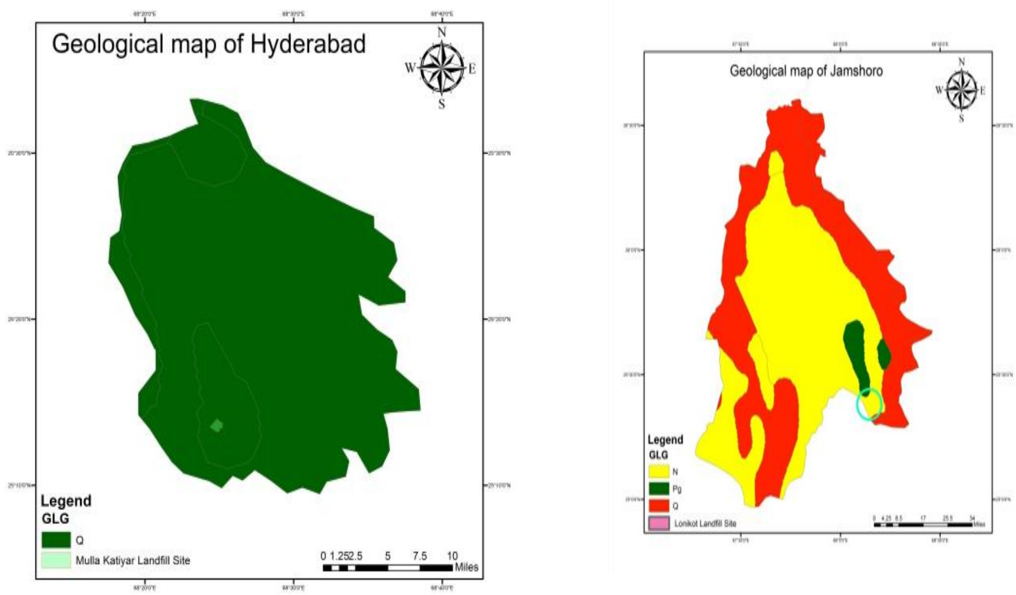
On the southern side of the Khirthar range, a hill range that spans over 400 kilometers from north to south along the border between Sindh and Baluchistan provinces, lies where the landfill site, Lonikot in District Jamshoro. Limestone from the Laki Formation predominates in the district's sedimentary lithology, which also contains shale and sandstone. The Laki Formation is dominated by Eocene fossils (56-34 million years ago).

Deposits from flood plains make up the majority of the district. Two of the most active faults in the region are the Jhimpir Fault, which is located about 25 kilometers to the southwest, and the Surjam Fault, which is located about 30 kilometers to the west. The largest earthquakes on the Jhimpir and Surjam Faults were measured at 6.1 and 5.6 on the Richter scale, respectively.

The majority of the soil, which is composed of silt, sand, and gravel-sized bits, was left behind as the shale and limestone from the Lakhra and Laki formations were eroded. The soil is exceptionally productive and has a brownish yellow to dark brown hue in areas where small-scale agriculture is practiced with rainwater.

The majority of the landscape is arid and dotted with plants and shrubs, notwithstanding some minor agricultural activity. The target region has grass and plants that are used as food by both domestic and wild animals. Land in the area is mostly used for agriculture, grazing grounds for cattle, and dimension stone quarrying.

The geological map for the Mullah Kathiyar dump site (in the district of Hyderabad) and the Lonikot landfill site (in the district of Jamshoro) is shown in figure 8 below.



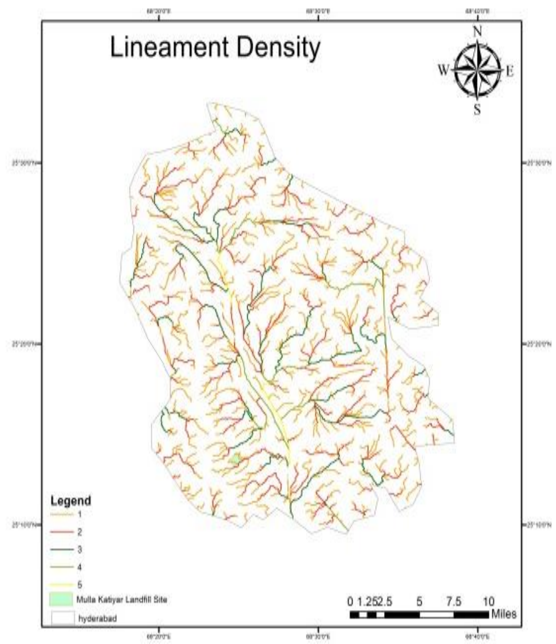
(a) Geology Map of Hyderabad

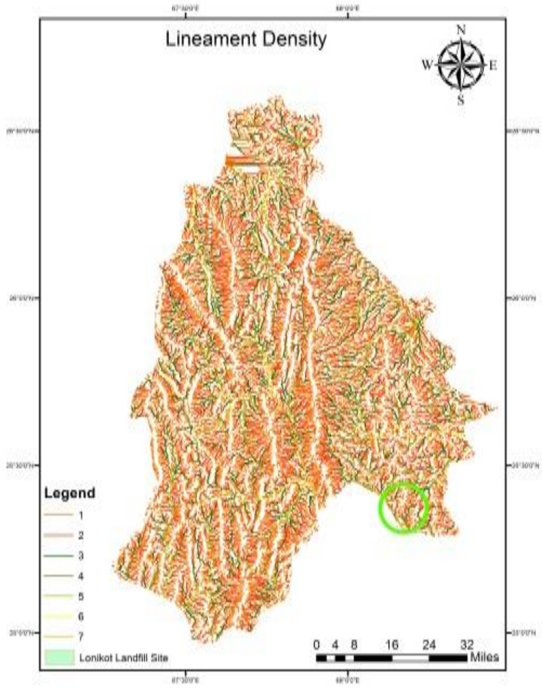
(b) Geology Map of Jamshoro

Figure 9: Suitability index maps of Geology of (a) Hyderabad and (b)

2.1.6 Lineament Density

Particularly, lineaments are important groundwater controls in any subsurface water. The majority of the time, underdeveloped areas operates as natural conduits for subsurface flow or groundwater ponding. Using satellite data and a geological map to extract a lineaments map, the visual interpretation methods are applied for this study. It has been proposed that landfill sites shouldn't be located near high lineament density areas because they tend to support abundant groundwater supplies and there is a chance that leaching could seriously contaminate those supplies. Instead, areas with low lineament density will be suitable for landfills.





(a)Lineament Density Map of Hyderabad (b) Lineament Density Map of Jamshoro

Figure 10: Suitability index maps of Lineament Density of (a)Hyderabad and (b) Jamshoro

2.1.7 Wind Direction

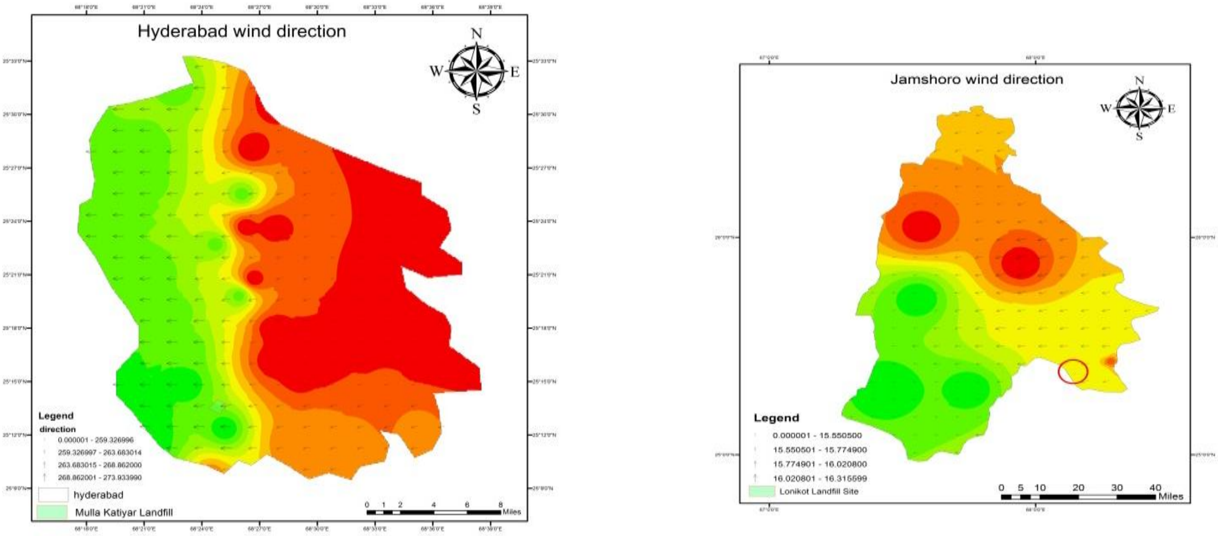
The residential areas close to landfills are typically affected by the smell of the landfills. Additionally, landfills must to be constructed away from residential areas where the wind is blowing directly at them.

(A) Wind Direction of Lonikot Landfill site (District Jamshoro):

The low population density areas receive wind from the south-west in the summer and the north-east in the winter. Additionally, landfill-produced air toxins will be carried downstream by the wind to regions with dense populations.

(B) Wind Direction of MullaKatiyar Site (District Hyderabad):

The high population density in downwind locations will be impacted by air pollution created by landfills that are carried away by the wind. In the summer, the wind blows from the South West toward the low-density areas, while in the winter, it blows from the North East.



(a) Wind Direction Map of Hyderabad (b) Wind Direction Map of Jamshoro

Figure 11: Suitability index maps of Wind Direction of (a) Hyderabad and (b) Jamshoro

2.1.8 Normalized Difference Vegetation Index (NDVI)

Through a variety of enhancing methods, a lot of valuable information may be gleaned from satellite images(Nagler et al., 2009). NDVI is the most often used vegetation indicator because of its close connection to the plant canopy (Tucker, 1979).

As per (Xue& Su, 2017) the NIR and RED bands of Landsat images are used in NDVI because they quantify how much visible and infrared light is absorbed. When represented numerically, the equation looks like this:

$$\boldsymbol{NDVI} = \frac{(\boldsymbol{NIR} - \boldsymbol{RED})}{(\boldsymbol{NIR} + \boldsymbol{RED})}$$

The NDVI and LST maps of Hyderabad were produced using remotely sensed satellite data beginning in 2021 using ArcGIS software. The NDVI clearly demonstrated a trend toward decline, whereas temperature dramatically increased. The extracted NDVI values for Jamshoro in 2021 range from -0.15 to 0.3727 and for Hyderabad, Sindh, from -0.3 to 0.525 and -0.065 to 0.4.

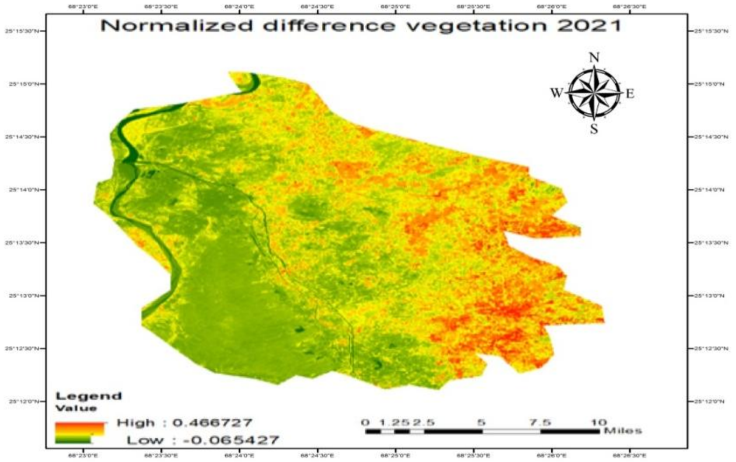


Figure 12: Normalized Difference Vegetation Index of Hyderabad 2021

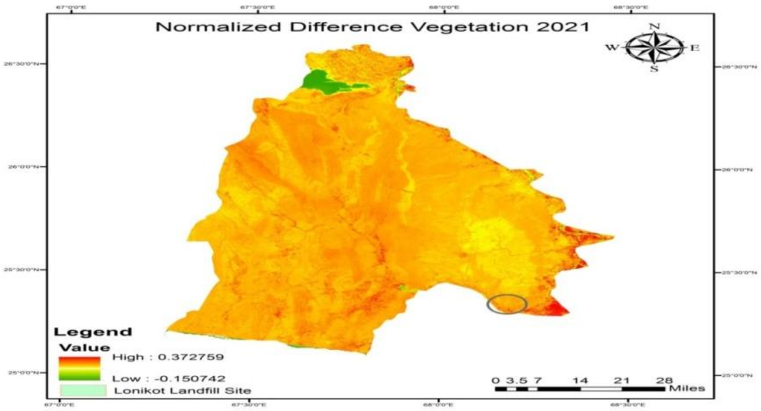


Figure 13: Normalized Difference Vegetation Index of Jamshoro 2021.

2.1.9 Land Surface Temperature (LST)

The thermal band of the satellite image is used to extract data for LST calculations. It is widely utilized for change detection research in areas including climate change modeling, the hydrological cycle, agricultural operations, urbanization, and vegetation evaluation. It also helps us comprehend environmental changes. The following steps will be used to retrieve LST for this research:

$$\left(\frac{K_2}{\left(ln\left(\frac{K_1}{TOA}\right)+1\right)}\right)-273.15$$

The LST maps of Jamshoro and Hyderabad were produced to show temperature variations while you were waiting. Results for the temperature in 2021 range from 23.73 to 48.78 in Jamshoro and from 33.09 to 36.37 in Hyderabad.

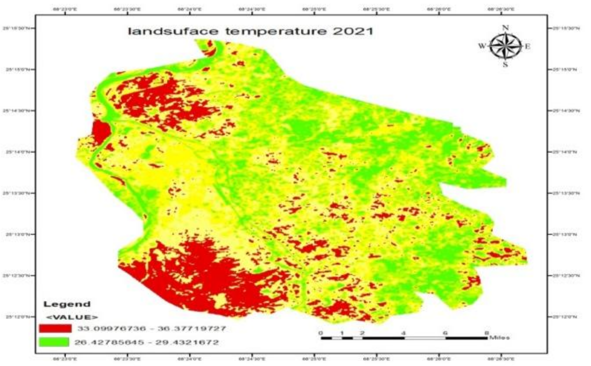


Figure 14: Land Surface Temperature of Hyderabad 2021

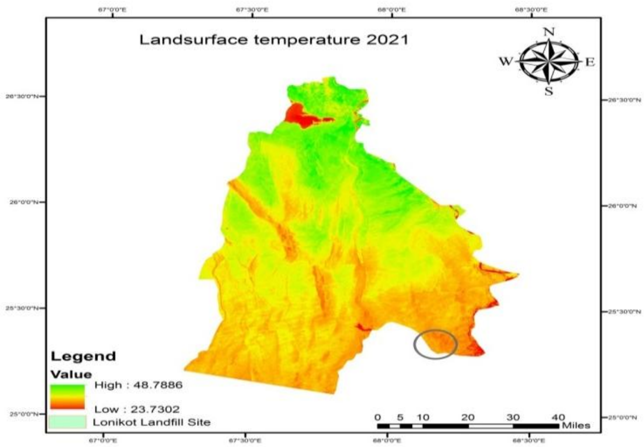


Figure 15: Land Surface Temperature of Jamshoro (Lonikot Site 2021)

2.2 AHP Results

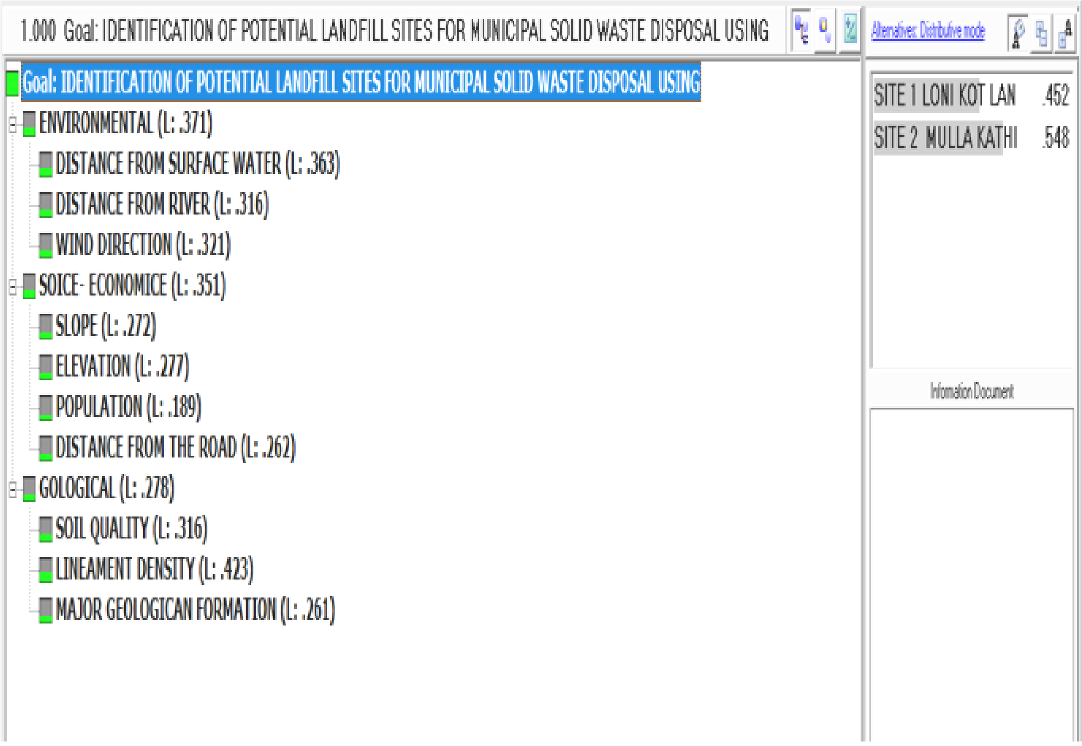


Figure 16: AHP Pairwise Comparison Matrix Results

Distributive mode		PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE
Alternative	Total	DISTANCE FROM SURFACE WATER (L: .363)	DISTANCE FROM RIVER (L: .316)	WIND DIRECTION (L: .321)	SLOPE (L: .272)	ELEVATION (L: .277)	POPULATION (L: .189)	DISTANCE FROM THE ROAD (L: .262)	SOIL QUALITY (L: .316)	LINEAMENT DENSITY (L: .423)	MAJOR GEOLOGICAN FORMATION (L: .261)
SITE 1 LONI KOT	.283	1.000	1.000	.575	.714	1.000	.763	.333	.734	.645	.671
SITE 2 MULLA	.340	.645	.709	1.000	1.000	.840	1.000	1.000	1.000	1.000	1.000

Figure 17: AHP Model/ Weighting Criteria

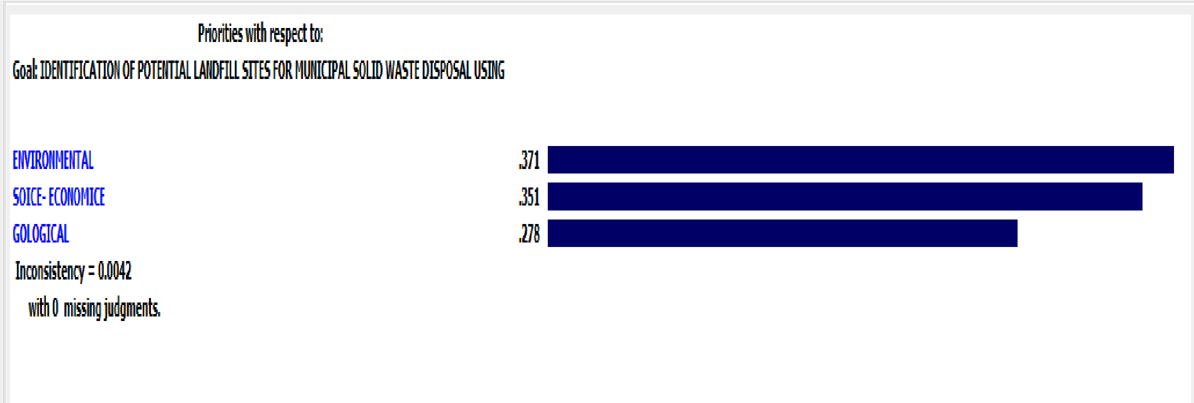


Figure 18: Inconsistency Ratio

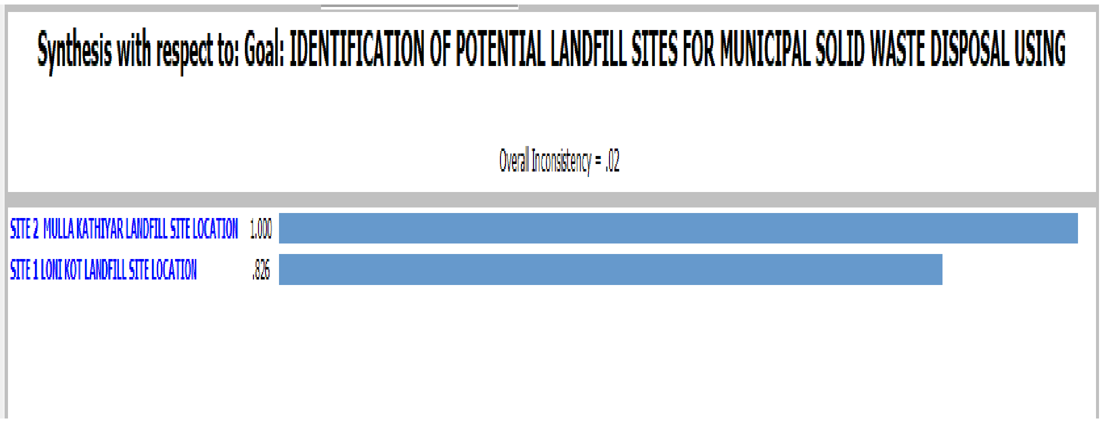


Figure 19: Overall Inconsistency Ratio

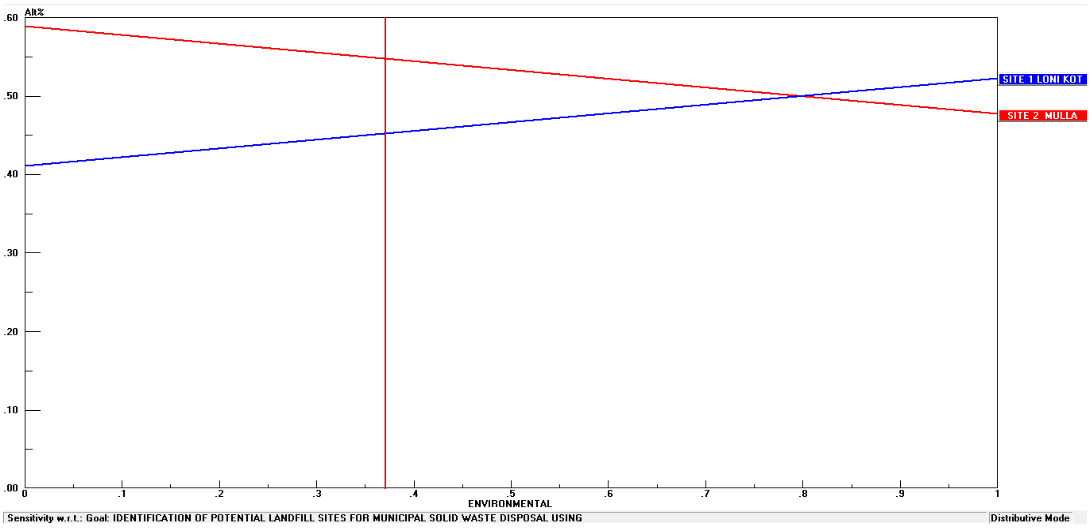


Figure 20: Over all Impacts Using AHP

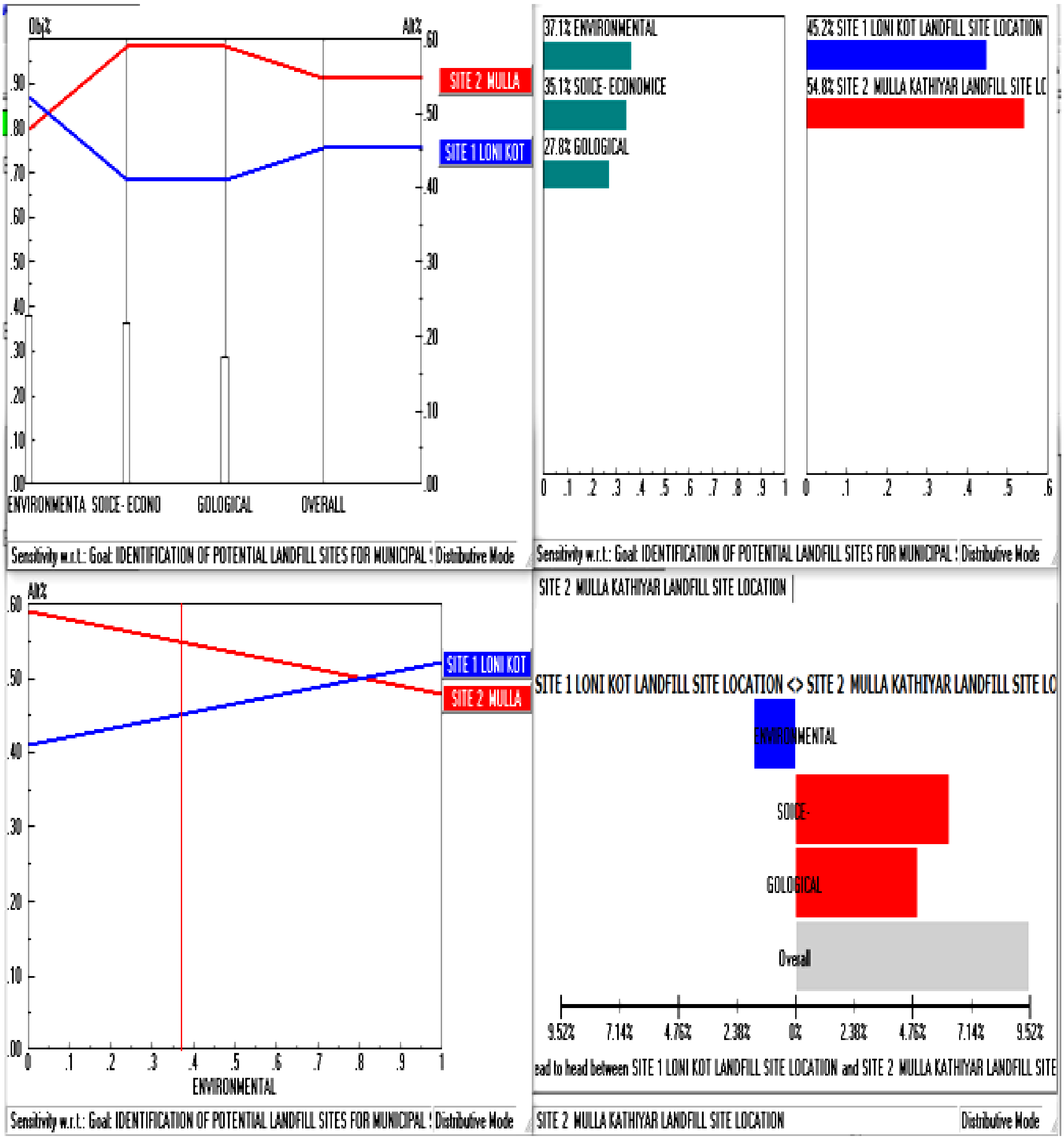


Figure 21: Overall Results of AHP

Level 1	Level 2	Alts	Prty
ENVIRONMENTAL (L: .371)	DISTANCE FROM RIVER (L: .316)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.071
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.050
	DISTANCE FROM SURFACE WATER (L: .363)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.081
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.052
	WIND DIRECTION (L: .321)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.041
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.072
GOLOGICAL (L: .278)	LINEAMENT DENSITY (L: .423)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.046
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.071
	MAJOR GEOLOGICAN FORMATION (L: .261)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.029
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.044
	SOIL QUALITY (L: .316)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.042
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.053
SOICE - ECONOMICE (L: .351)	DISTANCE FROM THE ROAD (L: .262)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.018
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.055
	ELEVATION (L: .277)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.058
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.049
	POPULATION (L: .189)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.030
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.040
	SLOPE (L: .272)	SITE 1 LONI KOT LANDFILL SITE LOCATION	.041
		SITE 2 MULLA KATHIYAR LANDFILL SITE LOCATION	.057

Figure 22: Summary of AHP Weighting Criteria

The calculated relative weights of each of the criteria as well as the relative weights of each landfill site against each criterion will be used to rank the two dump sites. The weights awarded to each of the three criteria and the weights given to each of the dump sites are added together to determine the overall rating of the sites.

3. Conclusion

AHP allows for inconsistency but gives a way to quantify it for each set of judgements. This is especially useful for the applications where Expert choice 11.5 software has been used to derive the relative weightings for each criterion via pairwise comparison. . The overall inconsistency of two landfill sites, which include site 1: Lonikot with 0.826 and Site 2: Mullah Kathiyar with 1.00,was found to be 0.02 and its low when taking into account the inconsistency ratio of Environmental, Socio-economical and Geological factors. We can say it is perfectly consistent(as measured by AHP inconsistency ratio of Zero) and that the inconsistency ratio of 0.042 which is a clerical error. Lonikot is an appropriate landfill site that satisfies scientific and environmental requirements, such as preventing groundwater pollution by leachate from the site because the groundwater depths in Lonikot site and its surrounding areas are shallow. Based on the results, it was determined that Lonikot comprises of 0.41 when considering the overall impacts using AHP. From the findings it was justified that the relative influence of various influencing factors on the potential outcomes can be evaluated using AHP, which can be used to anticipate (derive the distribution of relative likelihoods of outcomes. In order to make decision-making easier, the Analytical Hierarchy Process breaks down complicated choice problems into simpler ones. This study takes into account both natural and artificial environmental factors, as well as an adequate method for choosing a landfill location within the study area. Because it can handle a lot of data from many sources, GIS is a useful tool for assisting in the selection of a waste disposal site. Any complex problem can be successfully solved with AHP in a variety of fields and real-world contexts.

When using pairwise comparison to build a comparison matrix and determine weights for criteria, the AHP technique will be helpful. Therefore, combining the GIS and AHP may help decision-makers examine any issue and find a speedy solution, such selecting a suitable garbage location. In Hyderabad, Sindh, Pakistan study layers were entered to determine the ideal site for a solid waste dump. The layers that make up this structure include distance from roadways, soil types, height, and slope. After the study was complete, the final map's most appropriate category contained two spots that were the best places to dump waste. The Lonikot site has also been examined on satellite pictures to ensure that it is suitable for landfilling. In order to preserve groundwater from contamination and to protect it from leachate infiltration, additional research is required, including geotechnical and hydro-geological evaluations.

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