Research article

MCA and geospatial analysis-based suitable dumping site selection for urban environmental protection: A case study of Shambu, Oromia Regional State, Ethiopia

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ARTICLE INFO	ABSTRACT
	A lack of suitable dumping sites in a town or city can have an impact on the health of the residents as well as the quality of the urban environment. There are no identified dumping sites in this study area that meet scientific or urban standards. Residents are dumping solid waste into ditches, roads, public water sources, and small streams. The solid and liquid wastes generated by residential areas, state prisons, religious areas, public markets, and business centers have a negative impact on the town. The purpose of this study is to demonstrate the novelty of using Multi-Criteria Analysis (MCA)-based geospatial analysis to select suitable dumping sites in Shambu town. Key factors for dumping site selection, such as LULC, road networks, private well locations, slope, geomorphology, geology, soil texture, drainage density, and lineament density, were confirmed as geospatial analysis criteria. In the Analytical Hierarchy Process (AHP), the importance of the key factors was weighted and prioritized, and thematic maps were created using weighted overlay analysis. The suitable dumping sites were identified using qualitative classifications such as "highly suitable" (13.84%), "moderately suitable" (7.35%), "less suitable" (30.41%), and "not suitable" (48.40%). The consistency of AHP was determined to be CI = 0.012, indicating that the weights assigned to each factor were correct. As a result, the use of geospatial and MCA analysis for dumping site suitability analysis was successful, and the findings of this study will be useful in taking action to reduce the impacts of solid waste by developing dumping plants on the identified sites.

1. Introduction

Solid and liquid wastes emitted by domestic, private business centers, public market centers, prisons, and public institutions are the primary sources of urban pollutants. Pollutants are strong influence all over the world, and the magnitude is most visible in towns in Sub-Saharan African countries. These anthropogenic pollutants have an impact on the urban environment and residents' health. Pollution in the urban environment has risen to the top of the list of critical issues in urban planning (Waleed et al., 2020; Feloni et al., 2020; Girmay et al., 2020). Several strategies and policies are used around the world to reduce solid waste. However, financial affordability has an impact on the effectiveness of these strategies (Asefa et al., 2021; Rezaeisabzevar et al., 2020). Residential areas, industries, institutions, and commercial centers are the primary sources of solid waste in urban areas (Amiri and Karimi, 2018; Ayaim et al., 2019; Pasalari et al., 2019). In many African cities, carelessness to solid waste disposal and poor

urban management are doubling the volume of pollutants in the urban environment (Alkaradaghi et al., 2019; Mallick, 2021).

Solid waste dumped in built-up areas can have a negative impact on both residents' health and the environment. Solid waste is commonly dumped around the town's boundaries in many poor countries, particularly around the river beach and road ditches. The lack of strong urban management policies and structural dumping sites in Ethiopia is increasing the volume of pollutants in the urban environment (Mussa and Suryabhagavan, 2019; Sisay et al., 2021; Weldeyohanis et al., 2020).

Effective disposal sites and strong urban management policies can reduce the magnitude of the problems (Erena and Worku, 2019; Kapilan and Elangovan, 2018; Mohamed and El-Raey, 2020). In principle, the selection of effective suitable dumping sites ensures that the disposal sites are not risky to the residents of the town and urban environment. The solid wastes released from municipal and residential areas are causing the contamination of public sources of water and affecting the health of

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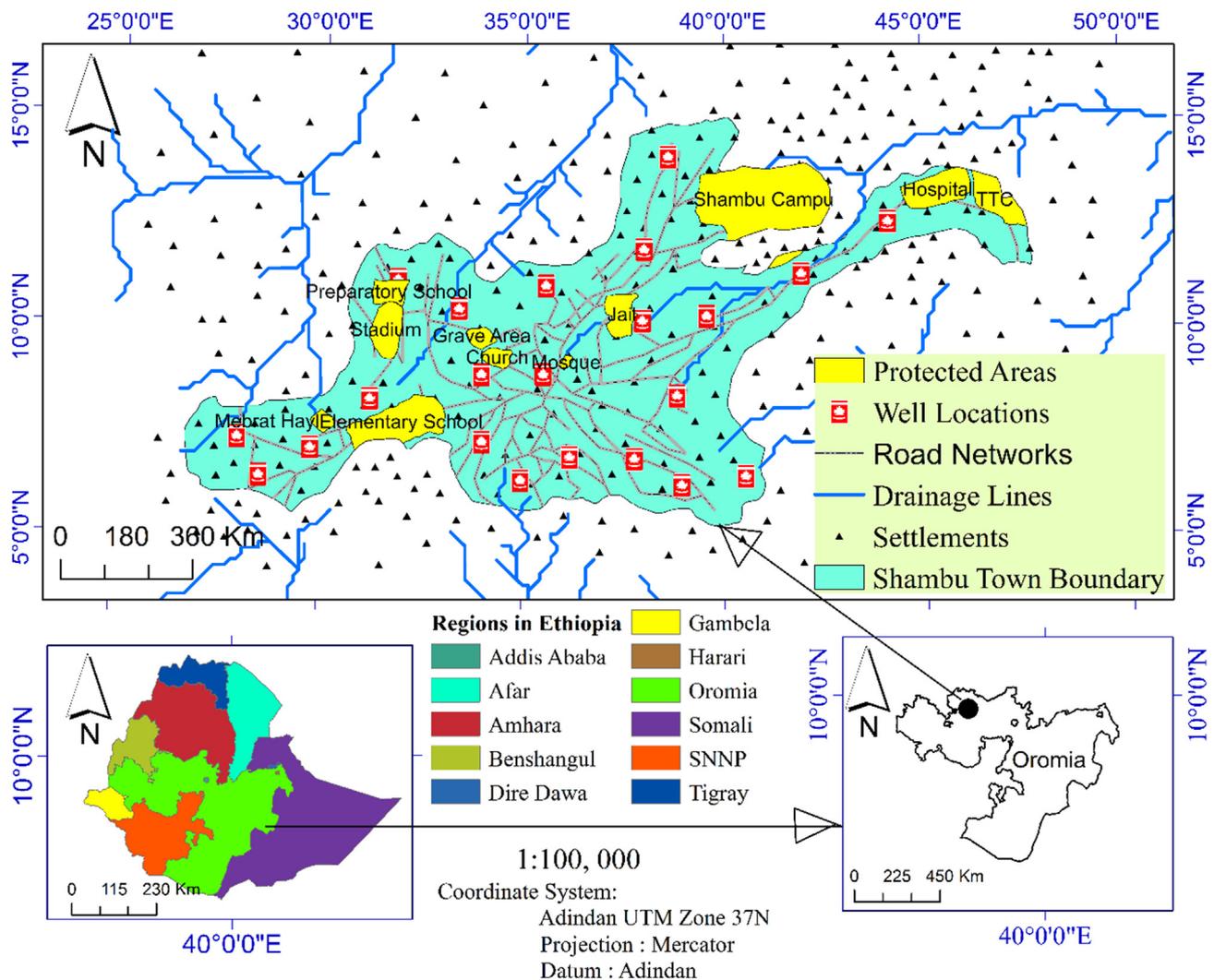
Figure 1. Shambu town boundary, Road networks, well locations and settlement patterns.

community (Shomar et al., 2010; Vijay et al., 2011). Financial affordability and capacity building are the constraints of urban protection. Currently, several modern solid waste dumping plants are available to reduce the impacts of the wastes; however, such practices are expensive and are not feasible for poor countries like Ethiopia. The application of geospatial suitability analysis can give possible solution to the problem (Andualem et al., 2020; Ayaim et al., 2019; Danesh et al., 2019; Mallick, 2021; Sk et al.,

2020; Weldeyohanis et al., 2020). For the final suitable dumping site selection, geospatial analysis supported by a set of guidelines and rules in MCA must be considered, and alternative decisions must be made (Reference). The integration of MCA and geospatial analysis for the selection of suitable dumping sites has been crucial, and it is effective because structural measures are not possible due to financial constraints (Ali and Ahmad, 2020, Alkaradaghi et al., 2019; Mussa and Suryabhagavan, 2019).

Dumping has become an important option for maintaining a healthy environment and public. Unscientific and traditional solid waste disposal methods can increase the level of contaminants in public water sources such as shallow wells, hand-dug wells, and springs, affecting the health of users (Alkaradaghi et al., 2019; Balew et al., 2020; Sisay et al., 2021). The living standards and well-being of the population via industrialization are the major reasons for the solid waste accumulation in a given town

Table 1. Summarized data with the sources and spatial/temporal resolution.

S/N	Data	Sources	Resolution (spatial/temporal)
1	Land Use/land cover	http://geoportal.rcmrd.org	Generated in 2020
2	Road Networks	Digitized from Town map	Shambu town
3	Soil	Ministry of Water, Irrigation and Energy	Generated in 2020
4	River Networks		Shambu town
5	DEM	https://search.asf.alaska.edu/	
6	Well locations	Horo-Guduru Water, Mineral and Energy bureau	
7	Settlement patterns	Shambu town Municipality office	
8	Residential Areas	Digitized from Aerial photo	Shambu town
9	Slope	Generated from DEM (12.5 × 12.5)	
10	Drainage density	Generated from DEM and streams	

Table 2. Analytical hierarchy process scale and judgment.

Scale	Judgment
1	Equal importance
3	Moderate importance one over the over
5	Essential or strong importance
7	Very strong or demonstrated importance
9	Extreme or absolute importance
2,4,6,8	Intermediate values between the two adjacent judgments
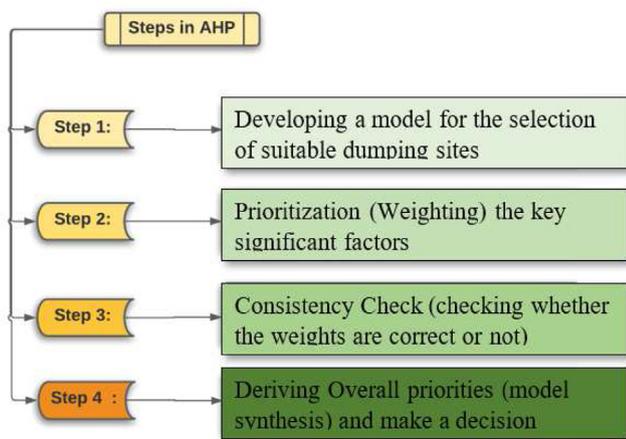
Figure 2. Procedures in AHP for suitability analysis.

Table 3. Dumping sites suitability classifications.

Symbol	Suitability class	Explanation
S1	Highly suitable	Disposal sites without any significant limitations
S2	Moderately suitable	Disposal sites with some limitations
S3	Less suitable	Disposal sites with high limitations
N	Not suitable	Areas where there are no disposal sites

(Mussa and Suryabhagavan, 2019). Studies have been done in different towns (Asefa et al., 2021; Balew et al., 2020; Mussa and Suryabhagavan, 2019) of the country using MCA and GIS that to minimize the impacts of the solid wastes, and still there is in need of research to improve the accuracy of analysis by incorporating multiple geospatial attributes. In Ethiopia, throwing wastes on the road, nearby residential areas, into ditches and river beach are commonly practiced in majority of urban areas (Weldeyohanis et al., 2020), and the same situations are observed in Shambu town. Therefore, this study is aimed to explore the best suitable dumping sites by using Multi-Criterion Analysis (MCA) and geospatial analysis.

The selection of suitable dumping sites necessitates an understanding of the physical features of the town as well as a complex multi-criteria analysis that takes into account financial, topographic, and environmental considerations. Due to time and cost constraints, geospatial analysis for the selection of suitable dumping sites is gaining international attention these days. As a suitable dumping site selection tool, Geographical Information System (GIS) and Multi-criteria Analysis (MCA) have been extensively used. This study aims to investigate suitable dumping in Shambu town, Oromia Regional State, Ethiopia, using the novel integrated MCA approach known as AHP and geospatial analysis.

2. Materials and methods

2.1. Study area

Shambu is a town in Oromia National Regional State (ONRS) located in Horo Guduru Wollega. The town is located 325 km from Addis Ababa,

Table 4. Pair-wise comparison matrix of the key factors.

	LULC	LD	G	So	GM	DD	RN	WL	SL
LULC	**1.00**	3.00	0.25	5.00	2.00	0.33	0.17	3.00	0.20
LD	0.33	**1.00**	0.50	0.33	5.00	4.00	0.13	4.00	3.00
G	4.00	2.00	**1.00**	2.00	0.25	0.33	0.33	0.20	4.00
So	0.20	3.00	0.50	**1.00**	0.33	0.50	2.00	3.00	8.00
GM	0.50	0.20	4.00	3.00	**1.00**	3.00	5.00	0.14	0.33
DD	0.08	0.19	0.07	0.21	0.38	**1.00**	0.19	0.03	0.08
RN	6.00	8.00	3.00	0.50	0.20	0.33	**1.00**	0.25	0.50
WL	0.33	0.25	5.00	0.33	7.00	0.20	4.00	**1.00**	0.17
SL	5.00	0.33	0.25	0.13	3.00	3.00	2.00	6.00	**1.00**
Col. Total	16.89	17.68	14.15	12.29	18.78	15.01	14.63	17.59	17.20
Normalized Pair Wise Comparison Matrix									
LULC	0.06	0.17	0.02	0.41	0.11	0.07	0.01	0.17	0.01
LD	0.02	0.06	0.03	0.03	0.27	0.15	0.01	0.23	0.17
G	0.23	0.11	0.07	0.16	0.01	0.31	0.02	0.01	0.23
So	0.01	0.17	0.03	0.08	0.02	0.47	0.14	0.17	0.47
GM	0.03	0.01	0.28	0.24	0.05	0.35	0.34	0.01	0.02
DD	0.08	0.19	0.07	0.21	0.38	0.23	0.04	0.19	0.03
RN	0.35	0.45	0.21	0.04	0.01	0.01	0.07	0.01	0.03
WL	0.02	0.01	0.34	0.03	0.37	0.14	0.27	0.06	0.01
SL	0.29	0.02	0.02	0.01	0.16	0.06	0.14	0.34	0.06
Normalized Sum of Rows	Normalized average Rows				Eigenvector				
LULC	0.95				0.95/9				0.12
LD	0.81				0.81/9				0.10
G	0.85				0.85/9				0.11
So	1.09				1.09/9				0.13
GM	0.98				0.98/9				0.12
DD	1.07				1.07/9				0.18
RN	1.17				1.17/9				0.14
WL	1.12				1.12/9				0.14
SL	1.03				1.03/9				0.13

$\lambda = 9.21$, n = 9, CI (consistency index) = 0.012, RI (random index) = 1.45, CR = 0.012.

Figure 3. Geospatial and AHP flowchart for dumping sites suitability analysis.

Ethiopia's capital city. Geographically, the town is located between 37° 05 05–37°07 45 East latitude and 9° 33 00–9° 35 25 North longitude (Figure 1). According to National Meteorological Agency (NMA) data, the town's average annual rainfall and temperature are 1,265 mm and 15.7 °C, respectively. The town is divided into two villages, 01 and 02 village, based on political subdivision. According to information obtained from the Census Statistical Agency (CSA), this rural town currently has a total population of 45,000 people, and the rate of population growth is rapidly increasing. The town is expanding, and it is expected to generate a large amount of municipal solid waste. Currently, modern

buildings and commercial centers are being built, which is increasing the town's solid waste.

2.2. Data and selection of the key factors

The key factors are chosen based on topographic conditions, surface dynamic changes, data availability, and settlement patterns in the area. Dumping sites should not be located in cities or agricultural areas as a general rule of urban management and planning strategies, and such data are extracted from land use/land cover maps. A standard distance from

LULC Class	
▧	Fallow Land
▫	Opan Land
▪	Builtup Areas
▪	Forest

1:100, 000

Coordinate System :
Adindan UTM Zone 37N
Projection : Mercator
Datum : Adindan

Suitability Class	
▪	Highly Suitable (S1)
▫	Moderately Suitable (S2)
▪	Less Suitable (S3)
▪	Not Suitable (S4)
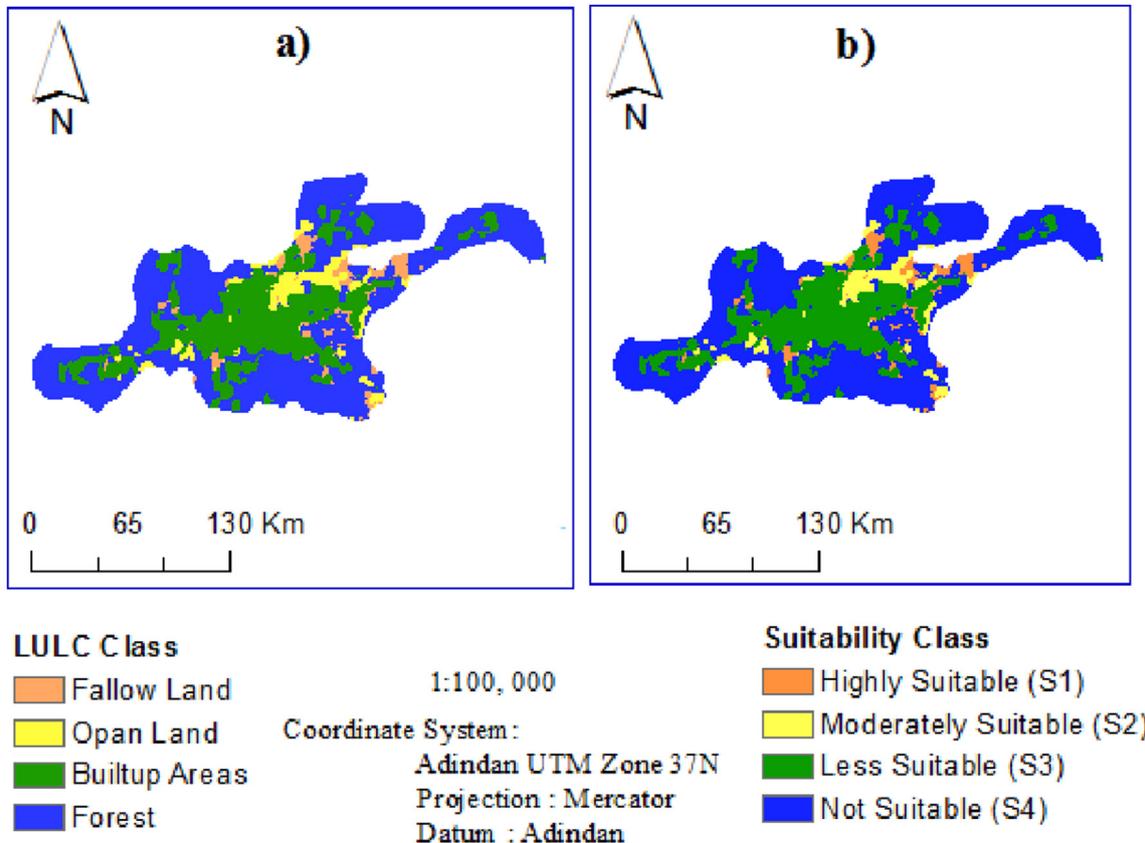
Figure 4. Land use/land cover (LULC) a) Existing LULC, b) Reclassified LULC.
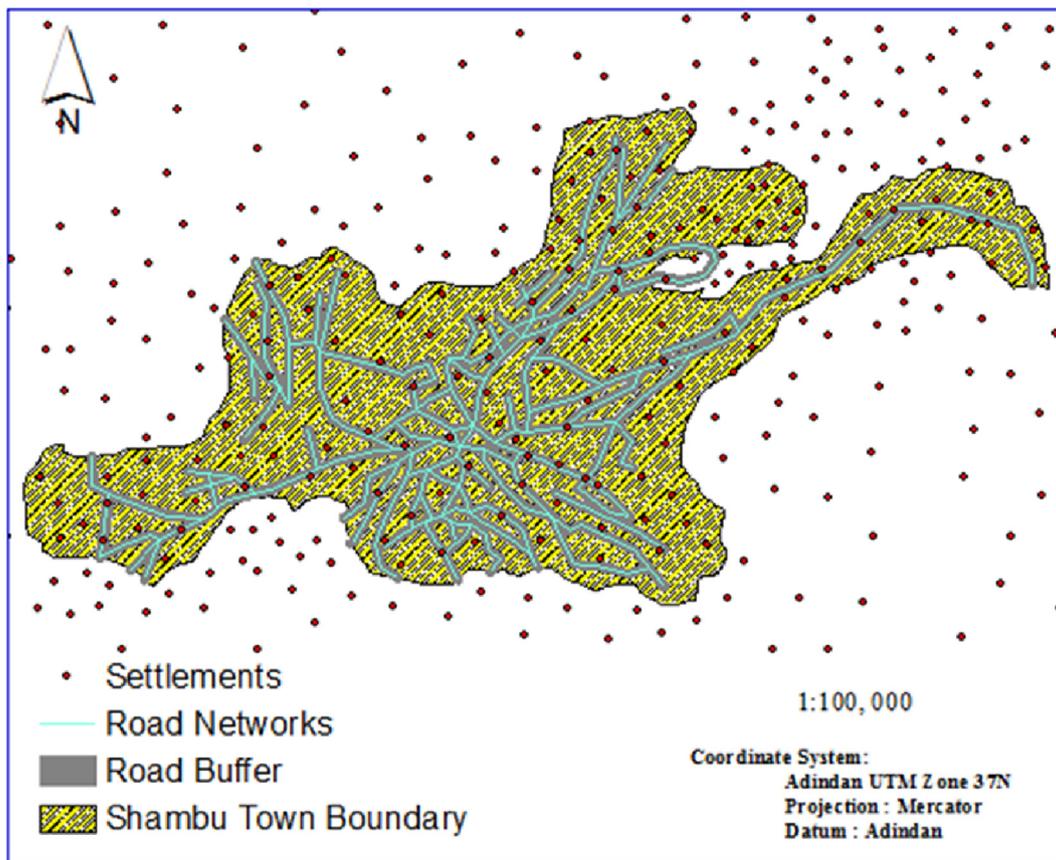
Figure 5. Buffered Road networks in the town.
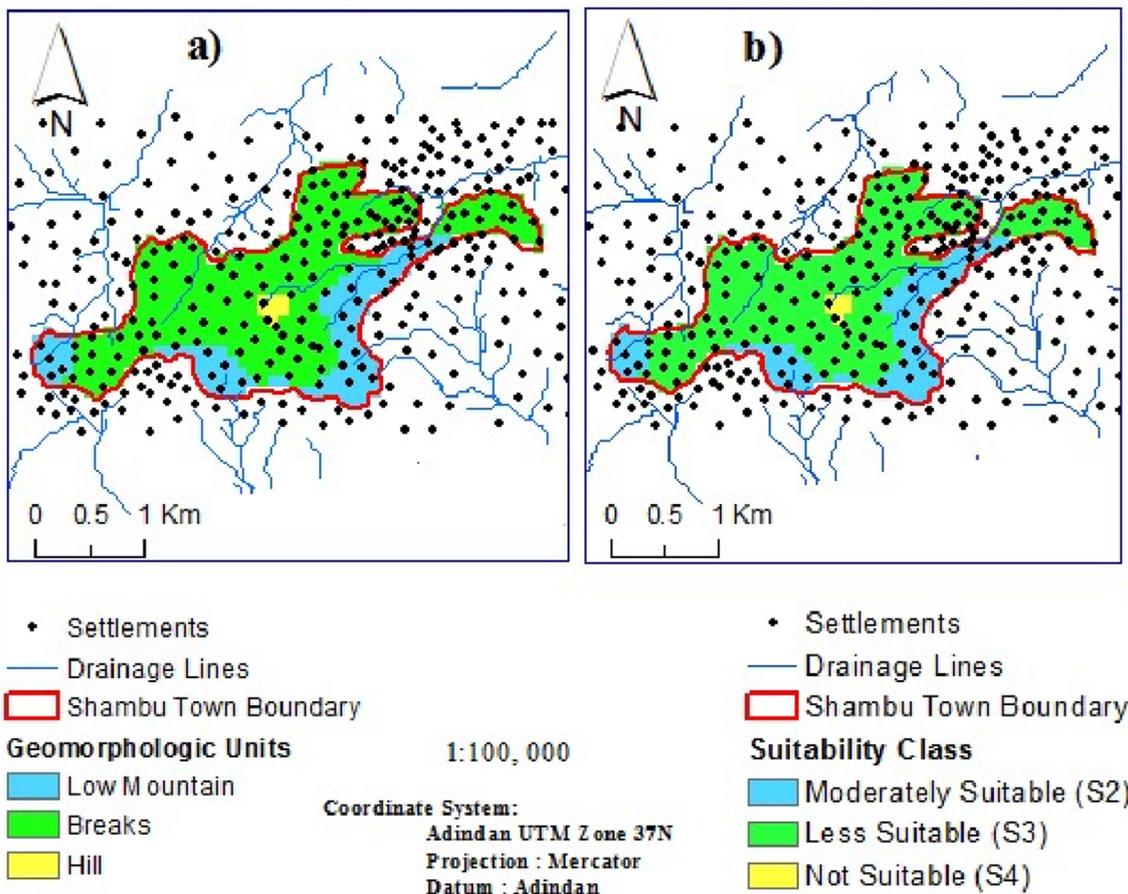
Figure 6. Protected areas in the town.
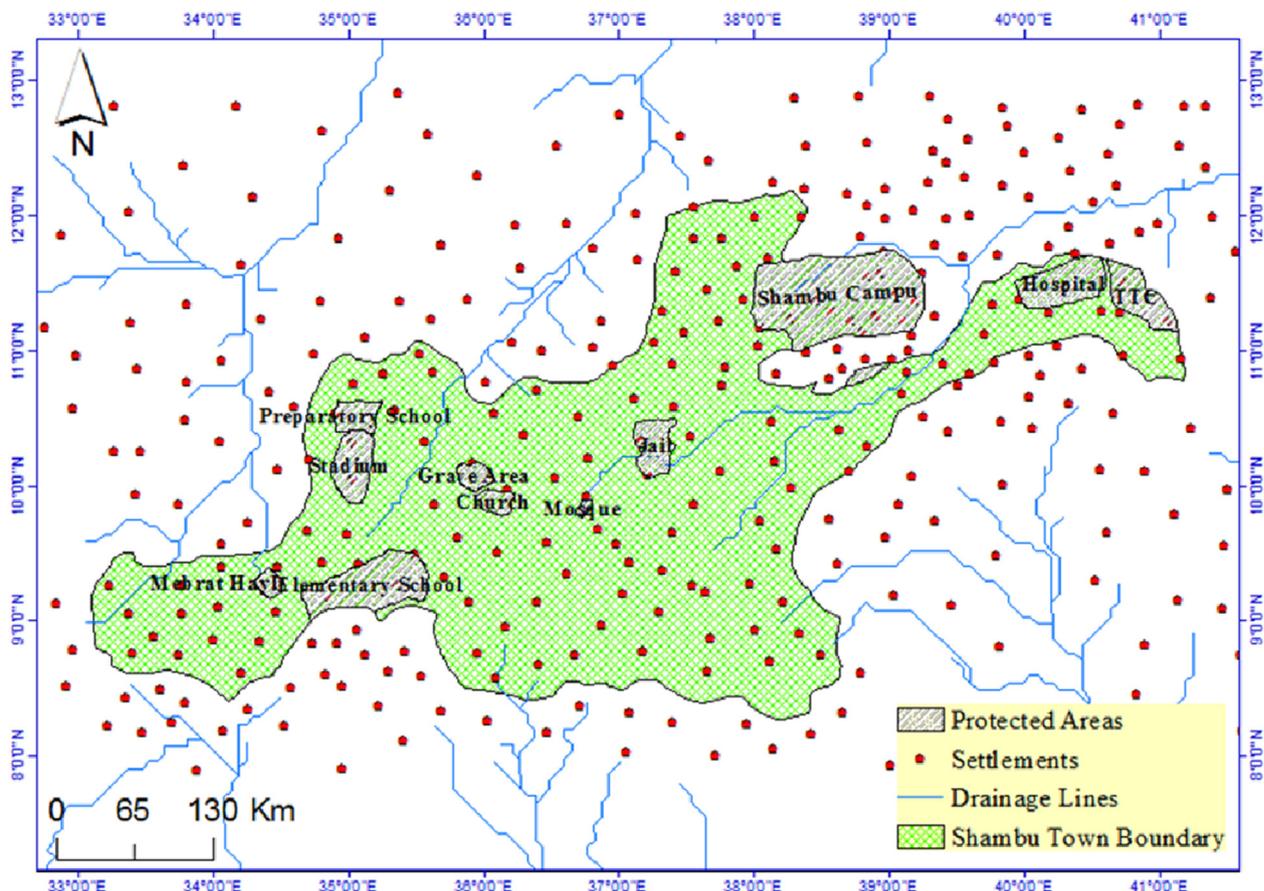
Figure 7. Drainage density a) existing drainage conditions, b) Reclassified drainage.

the dumping sites must be buffered from the road networks. Based on the data available and the purpose of the investigation, the key factors for dumping site selection suitability analysis (Weldeyohanis et al., 2020). The study used a multi-criterion analysis that took into account topographical conditions, terrain, climate, and other surface features to determine the best zones for dumping. Based on the town's tangible conditions, nine (9) key significant factors were identified as criteria for the selection of dumping sites, including LULC, road networks, private well locations, slope, geomorphology, geology, soil texture, drainage density, and lineament density (Alkaradaghi et al., 2019). The significant factors that were chosen were prepared in a GIS environment. The data sources and resolutions (spatial and temporal) were described in detail (Table 1). To generate the pair-wise comparison matrix, the key factors were prioritized and weights were assigned (Waleed et al., 2020). These factors were weighted according to their importance in indicating appropriate dumping sites. The input data was used to generate the individual raster maps (thematic maps). The selected factors were confirmed as input parameters for the geospatial analysis and MCA technique based on physical evidences, the suitability of surface investigation, and the availability of data for the town.

2.3. Method

2.3.1. Analytic hierarchy process (AHP)

Analytical Hierarchy Process (AHP) is a popular multi-criteria decision technique that is widely used in different fields of studies. AHP technique was intensively applied in water resource development, allocation of water resources (Hamdani, 2020; Zzaman et al., 2021; Sisay et al., 2021), flood susceptibility analysis (Rincón et al., 2018; Swain et al., 2020), groundwater exploration (Dar et al., 2020; Berhanu

and Hatiye, 2020; Arulbalaji et al., 2019), water supply distribution systems, and selection of suitable dumping sites (Ayaim et al., 2019; Chabuk et al., 2019; Şener et al., 2011; Sk et al., 2020). AHP technique has a capability of capturing the non-linear relationships among the key factors of suitable dumping sites selection criteria. The application of the AHP technique for the selection of suitable dumping sites requires a combination of different physical land features such as terrain features, alignment of the infrastructures, settlement patterns, locations of public water sources, topographic conditions, geological and soil texture, and identifying socially protected areas (Ahmad et al., 2020). The degree of significance of the individual factor is evaluated in AHP and weighted before the overlay analysis. A pair-wise comparison matrix developed in AHP helps to rate the relative importance of a factor corresponding to the other factors, with a rating scale (Table 2) of 1–9 (Fenta et al., 2014).

2.4. Procedures in AHP

The first stage of AHP is identifying the problem that needs to be solved, the second stage is proposing various alternatives to solve the problem identified in the first stage, and the final stage is evaluating the possible solutions using the criteria (Gedam and Dagalo, 2020; Lange et al., 2019; Pasalari et al., 2019; Russo and Camanho, 2015; Sk et al., 2020). In general, there are four steps in AHP (Figure 2) during making a decision regarding the selection of suitable dumping sites (Aldababseh et al., 2018; Berhanu and Hatiye, 2020). AHP uses the pair-wise comparison matrix to rank the degree of significance of the selected criteria and checks the consistency of the weights assigned for the evaluation. The AHP has the ability to judge and rank the weights of the individual criteria and make a decision based on the possible alternatives.
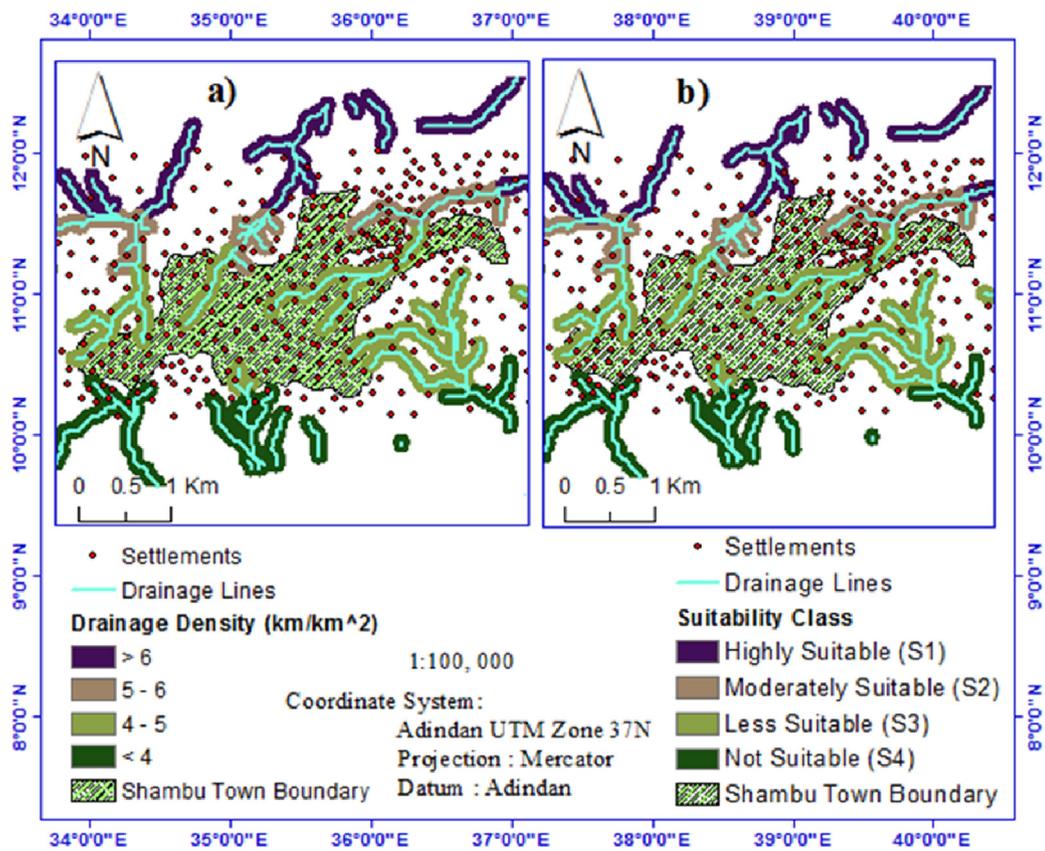
Figure 8. Slope a) slope categories b) Reclassified slope.
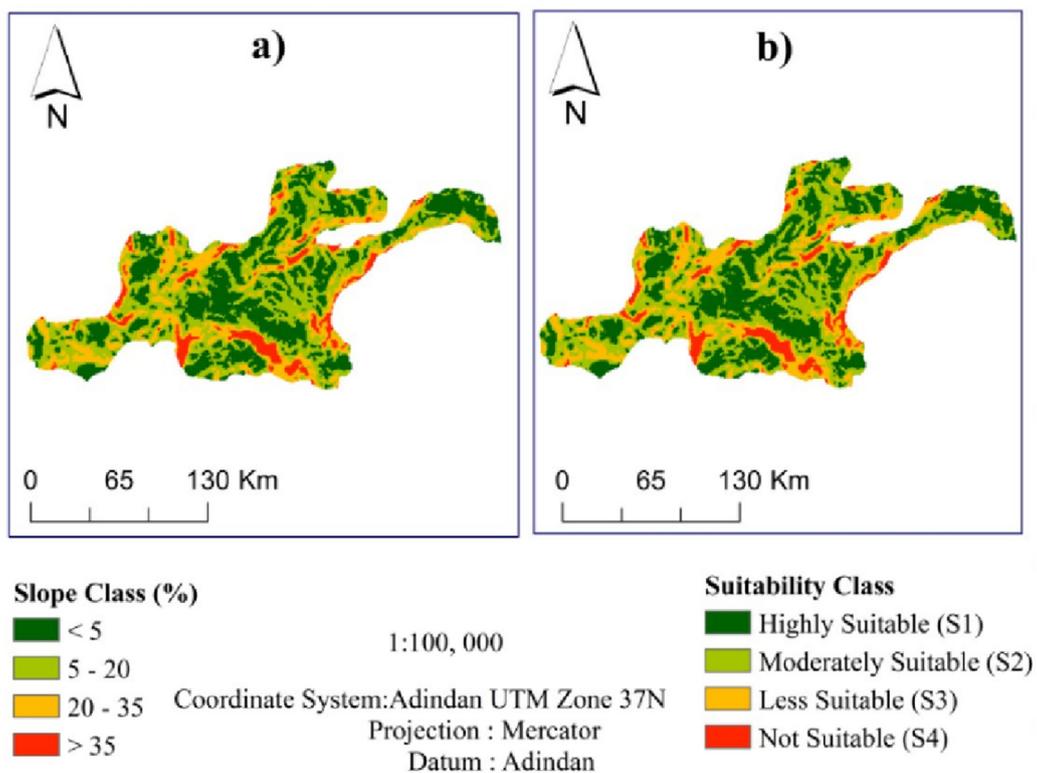
Figure 9. Geomorphologic units a) Geomorphologic categories, b) Reclassified geomorphology.

Table 5. Detailed classifications of the criteria used in this study.

No	Criteria	Sub-criteria	Scale	Suitability	Class
1	Well location (Distance, m)	<10	5	Not Suitable	N
		10–20	6	Less Suitable	S3
		20–30	8	Moderately suitable	S2
		>40	9	Highly suitable	S1
2	LULC	Forest	4	Not Suitable	N
		Built-up areas	5	Less Suitable	S3
		Open land	8	Moderately suitable	S2
		Fallow land	9	Highly suitable	S1
3	Soil (Textures)	Coarse sandy loam	6	Not Suitable	N
		Sandy loam	7	Less Suitable	S3
		Silty loam	8	Moderately suitable	S2
		Clay loam	9	Highly suitable	S1
4	Slope (%)	>35	4	Not Suitable	N
		20–35	6	Less Suitable	S3
		5–20	8	Moderately suitable	S2
		<5	9	Highly suitable	S1
5	Drainage density (km/Km^2)	<4	5	Not Suitable	N
		5	6	Less Suitable	S3
		6	7	Moderately suitable	S2
		>6	8	Highly suitable	S1
6	Road Networks (Buffer, m)	25	3	Not Suitable	N
		20	5	Less Suitable	S3
		15	7	Moderately suitable	S2
		10	8	Highly suitable	S1
7	Geology	Sandstone	7	Not Suitable	N
		Alluvium	8	Less Suitable	S3
		Colluvium	9	Moderately suitable	S2
8	Geomorphology	Breaks	6	Not Suitable	N
		Hills	7	Less Suitable	S3
		Low mountains	9	Moderately suitable	S2
9	Lineament Density (km/Km^2)	0–5.5	7	Moderately suitable	S3
		5.5–11	8	Highly suitable	S2

2.5. Analysis of suitable dumping sites

Prioritization and comparison are the AHP's main procedures before making a decision. Following the preparation of the driving factors for dumping site selection in a GIS environment, the significance of each individual factor was assessed for a better understanding of the selection of suitable dumping sites (Weldeyohanis et al., 2020). The dumping sites' suitability analysis is divided into four qualitative categories: highly suitable (S1), moderately suitable (S2), less suitable (S3), and not suitable (S4), with detailed descriptions provided in Table 3.

Weighting of the key significant factors is used to identify suitable dumping sites in the study area. The main goal of weighting in dumping site suitability analysis is to fix the rank of the individual key factor in relation to the remaining factors (Chandramohan and Siva Vignesh, 2019). The relative importance of the individual key factor is detailed in the pair-wise comparison matrix (PWCM), which rates the significance between the factors regarding the geospatial analysis of dumping sites selection on the basis of scale values ranges 1 to 9 as shown in Table 3. The consistency of the weights derived from the pair-wise matrix should be checked to improve the accuracy of the decision to be made in AHP method. The consistency of the derived values of weights is checked by reducing the error in the estimation and this can be achieved by Consistency Index (CI) and Consistency Ration (CR) as shown in Eqs. (1) and (2) (Kapilan and Elangovan, 2018; Rincón et al., 2018).

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{1}$$

$$CR = \frac{CI}{RI} \tag{2}$$

Where, *λmax* is the maximum Eigen value of the pair-wise matrix, *n* is the number of criteria used in the pairwise comparison, RI is a random Index for a number of an attributes as presented in (Table 4). The driving factors of suitability analysis in AHP were prepared in GIS environment and the final dumping sites suitability map of the study area was generated according to the general framework presented in (Figure 3). The detailed information on the existing data and the derived key factors were briefed in the result section.

To present a suitable dumping site in the town, different attributes of geospatial analysis were processed in ArcGIS pro and the selected dumping site selection criterion were prioritized in AHP. The step by step followed in this study were summarized in the following:-

(a) Suitable dumping site criterion were selected and the GIS database of the spatial information were created and compiled

(b) For the selected criterion, an appropriate buffer was created and the space boundaries for the individual criteria was made

(c) The significance of each individual factors was evaluated and prioritized in AHP based on the importance to dumping site suitability analysis, and the final decision was made in MCA
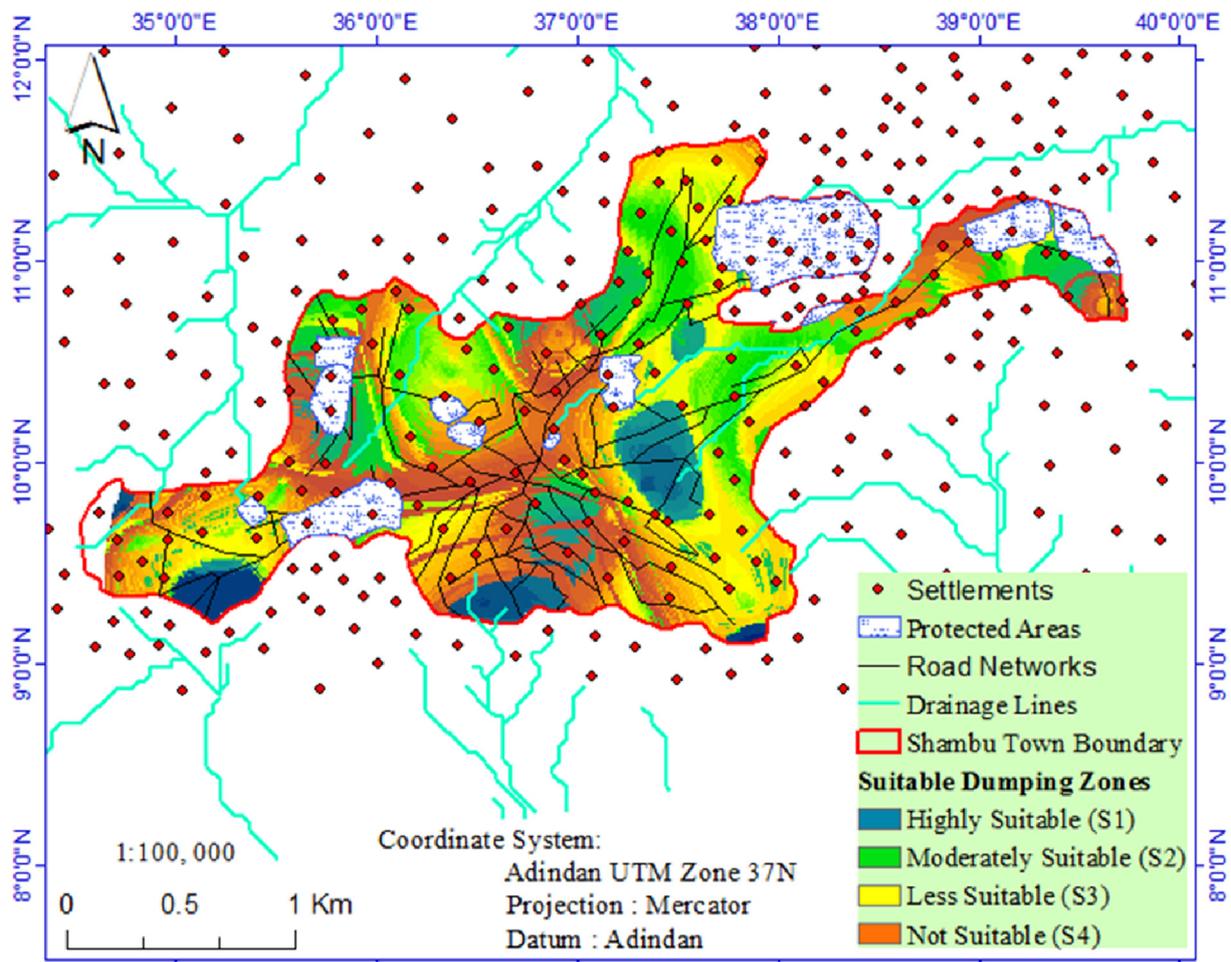
Figure 10. Identified suitable dumping sites in Shambu town.

(d) The selected criteria were weighted and values were assigned to the individual parameters to generate thematic maps and an overlay analysis in ArcGIS pro was done.

2.6. Weighted overlay analysis

The complete procedures in dumping sites suitability analysis are accomplished by the spatial analysis called weighted overlay analysis using an algorithm as shown in Eq. (3). In weighted overlay analysis, dumping sites suitability driving factors such as LULC, Lineament density, geology, soil, geomorphology, drainage density, road networks, well location and slope are integrated and weights are given to them based on their significance (Tolche, 2020; Ahmad et al., 2020).

$$S = \sum (W_i \ X_i) \qquad (3)$$

Where, S is the suitable dumping sites, W_i, is the weight of the individual factor, and X_i is the criteria used in the suitability analysis.

The weighted overlay analysis considers the weights of the individual factor and generates a single suitability map. For this town, nine driving factors were considered and the corresponding reclassified thematic maps were prepared in GIS environment. The reclassified maps and the sub-classification criteria used in this study were presented in the result section.

3. Results

3.1. Significant factors

Multi-criteria Analysis (MCA) and geospatial analysis were successfully used in this study to select dumping sites in Shambu town. Significant factors such as LULC, road networks, private and public well locations, slope, geomorphology, geology, soil texture, drainage density, and lineament density were confirmed as dumping site suitability analysis criteria. In the following sections, the existing data on key significant factors and the corresponding reclassified thematic map classified on the basis of suitable dumping sites were presented. Figures 4, 5, 6, 7, 8, and 9 depicts the existing conditions and the corresponding reclassified dumping suitability analysis key significant factors. The key factors were weighted based on their importance for locating the best suitable dumping sites, and detailed information on the significance of the individual factors is summarized by a pair-wise comparison matrix, as shown in Table 4. Table 4 shows the weight assigned to each individual factor, the detailed pair-wise comparison matrix computation, the normalized pair-wise comparison matrix, and the Eigenvalues. The qualitative result of the overall suitable dumping sites obtained is presented in Table 5, and the corresponding suitability map is shown in Figure 10.

4. Discussions

4.1. Topographic conditions

The steepness and flatness of an area governs the flow of solid wastes during the surface runoff. Slope is one of the significant factors of suitable dumping site selection. Studies (Mallick, 2021; Mussa and Suryabhagavan, 2019; Pasalari et al., 2019) are available regarding the ranges of slope that influence the selection of suitable sites for disposing wastes. The classification of the slope implemented in this study (Figure 8) was based on the classification used in (Das, 2019; Sarkar and Mondal, 2020; TÜdeş & Kumlu, 2017). For this specific study, the slope was classified under four major categories as highly suitable (<5%), moderately suitable (5–20%), less suitable (20–35%), and Not suitable (>35%) as shown in (Figure 5). Similar results were obtained in the studies conducted by (Arulbalaji et al., 2019; Rahmat et al., 2017).

4.2. Land use/land cover (LULC) suitability analysis

The selection of suitable dumping sites primary depends on the evidences regarding the land use and land cover (LULC) of the area (Figure 4). Since the solid wastes disposing areas should not inside the town and agricultural areas, the information about land use/land cover helps in deciding the suitable sites. The LULC generated from Landsat 8 imagery was classified under four (4) dominant land use/land covers namely; fallow land (highly suitable), open land (moderately suitable), built-up areas (less suitable) and forest (not suitable). The reclassification of the LULC implemented in this study was based on the classification made in the studies conducted by (Ogato et al., 2020; Thapa, 2020; Zimba et al., 2018). As general rule, the dumping sites should not close to the town, agricultural areas, public water sources, public market centers and socially respected areas, and the same principle was implemented during the suitability analysis.

4.3. Social and environmental considerations

4.3.1. Protected areas

As a general rule, socially respected areas (grave areas), religious areas (churches and mosques), and public institutions (health centers, schools, jails, colleges, sports centers, and market centers) should be set apart from dumping sites. Educational institutions (elementary and high schools), teacher training colleges, health centers (hospitals), jails, and religious institutions (churches and mosques) were identified in the study area, and a standard distance was considered when selecting suitable dumping sites in the town (Figure 6).

4.3.2. Proximity analysis

A standard distance should be established between dumping sites and other social infrastructures such as main roads, residential areas, and existing water sources. Because solid waste disposal can harm residents' health and the urban environment, dumping sites must be located far from settlement areas and other infrastructure. Proximity analysis is a method for analyzing dumping sites and other social infrastructures based on their distance from one another. As shown in Figure 10, suitable dumping sites with 30.41 % as "highly suitable (S1)", 7.35 % as "moderately suitable (S2)", 13.84 % as "less suitable (S3)", and 48.40 % as "not suitable (N)" were identified in the current study. Because road accessibility is critical during plant implementation, well location should be considered in the analysis of suitable dumping sites (Mussa and Suryabhagavan, 2019). Many studies use LULC as a selection criterion for suitable disposal sites (Mallick, 2021; Sk et al., 2020; Mussa and Suryabhagavan, 2019) and this factor assisted the researchers in determining which land use type is best suited for the selection of dumping sites. The result of current study is almost reached same agreement with

the study conducted by (Sk et al., 2020). According to (Alkaradaghi et al., 2019), the types of soil considered as criteria for landfill suitability analysis in Iraq concluded that considering the soil texture in suitable dumping sites analysis is important.

As a result, the soil textures/types considered in this study, which include clay loam, silty loam, sandy loam, and coarse sandy loam, were chosen based on their significance in dumping site selection. The town's slope was classified into four categories (5%, 5–20 %, 20–35 %, and >35 %), as shown in Figure 5d, and this classification is based on the criteria used in the study (Pasalari et al., 2019). Drainage density, geology, lineament density, and geomorphology were reclassified based on the criteria for suitability analysis used the previous studies (Mandal and Mondal, 2018; Kapilan and Elangovan, 2018; Eisenberg and Muvundja, 2020; Mallick, 2021). The reclassified key factors and the explanation of the sub-criteria generated in this study were summarized in (Table 5).

5. Conclusion

The novelty of geospatial analysis and MCA for dumping site suitability analysis in Shambu town, Oromia regional state, Ethiopia, is presented in this study. As a criterion for dumping site selection, nine key significant factors (LULC, slope, drainage density, lineament density, road networks, geology, soil, well location, and geomorphology) were used. Using the AHP technique, thematic layers for the individual key factors were created in a GIS environment. The importance of the chosen key factors was prioritized and weights were assigned.

Weighted overlay analysis was used to create the suitability map. For this study, four qualitatively based suitability sites were identified, which included highly suitable (30.41 %), moderately suitable (7.35 %), less suitable (13.84 %), and not suitable (48.40 %), with the suitability class as S1, S2, S3, and N, respectively. The detailed pair-wise comparison matrix and the stepwise model performance evaluation computation are presented. As a result, the consistency index (CI = 0.012) evaluates the consistency of the AHP technique in capturing suitable dumping sites, indicating that the weight values assigned to the individual key factors in AHP are correct.

As a result, the use of geospatial and MCA analysis for dumping site suitability analysis was successful, and the findings of this study will be useful in reducing the environmental impact of solid waste by developing dumping plants on the identified sites. Because the current study was limited to the selection of dumping sites, the next study should concentrate on the implementation of other social infrastructures that assist the town's urban designers, decision makers, and other stakeholders.

Declarations

Author contribution statement

Bona Tadese: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Habtamu Tamiru: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Meseret Wagari: Performed the experiments; Wrote the paper.

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Data availability statement

Data will be made available on request.

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