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LANDFILL SITE SELECTION USING SIMPLE ADDITIVE WEIGHTING (SAW) METHOD AND ARTIFICIAL NEURAL NETWORK METHOD; A CASE STUDY FROM LORESTAN PROVINCE, IRAN

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ABSTRACT
The selection of a site for landfill is one of the most difficult steps in landfilling process. Several techniques and methods have been used in a sanitary landfill site selection in the literature. In this paper two methods consist of a method based on the artificial neural network method and simple additive weighting (SAW) method have been used to landfill site selection in Lorestan province, IRAN and the results of two methods compare to each other. The input data of the research consist of 9 digitized data layers including geology, faults, slope, vegetation, residential areas, road and railways, groundwater resources, dams, drainage network maps. The land suitability map prepared by means of SAW method has been grouped in five categories with 0.5 intervals (Ai: 0 to 2.5). Derived map from the neural network modeling exhibit a gradual suitability for a landfill site. With SAW method that was used in the first step of the research, most of the area is considered unsuitable, while by the neural network method, the area with high suitability covers different parts of the study area. One of the most characteristics of the neural network methods is flexibility. The maps that are provided by these methods help the decision makers to select areas with a high suitability value and then proceed to field investigations according to the level of enforcement of the other policies.

Keywords: Landfill site selection, SAW method, Neural network method, Municipal solid waste, Land suitability, Lorestan province.

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Contribution/ Originality

This study contributes in the existing literature about the multi-criteria decision making and the using intelligence tools for site selection. This study uses new methodology for landfill site selection by means of artificial neural networks. This study originates new model for site selection based on the geological and geographical data.

1. INTRODUCTION

The management of MSW consists of a collection of tasks include the collecting, transferring, treatment, recycling, resource, recovery and disposal of solid waste in landfills. Though there are several alternatives to solid waste disposal, including the sanitary landfill method, the incineration method, the composting method and anaerobic digestion but disposing of waste in a landfill is the most traditional method of disposal of solid wastes, and it is a common practice in the most developing countries (Ojha *et al.*, 2007).

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Landfilling has been used for many years as the most common method for the disposal of solid waste generated by different communities (Komilis *et al.*, 1999). So, landfilling as the final destination of MSW has an important role in the waste management process.

The selection of a site for landfill is one of the most difficult steps in landfilling process. The direct involvement of public, environmental impact, political interference, topography, social and legislative issues as well as technical aspects are some of the typical factors that increase the difficulties in selecting suitable sites. The selection of a suitable site may reduce the capital and operational cost of a landfill (Ojha *et al.*, 2007).

A suitable solid waste sanitary landfill site should be characterized by proper hydrological, geological and environmental conditions (Cao *et al.*, 2006). Numerous factors must be evaluated when siting a landfill. An appropriate landfill site should have minimum impact on the environment, society, and economy, comply with regulations, and be generally acceptable to the public (Kao and Lin, 1996).

A scientific selection of feasible sites for a sanitary landfill is fairly important in reducing the cost of landfill work, assuring a stable function of landfill engineering and controlling secondary pollution of leachate (Cao *et al.*, 2006).

Several techniques and methods have been used in sanitary landfill site selection in the literature (Halvadakis, 1993; Bonham-Carter, 1994; Ehler *et al.*, 1995; Balis *et al.*, 1998; Dorhofer and Siebert, 1998; Yagoub and Buyong, 1998; Lukasheh *et al.*, 2001).

Diagramming, gray clustering, expert systems, geographic information systems (GIS) and analytic hierarchy processes (AHP) are some of these methods (Cao *et al.*, 2006). Geographic information system (GIS) is a digital database management system designed to manage large volumes of spatially distributed data from a variety of sources. They are ideal for advanced site-selection studies because they efficiently store, retrieve, analyze, and display information according to user-defined specifications (Wang *et al.*, 2009). GIS has been extensively used to facilitate and lower the cost of the landfill site-selection process (Charnpratheep *et al.*, 1997; Kao *et al.*, 1997; Sener *et al.*, 2006). The use of a multi-criteria decision analysis (MCDA) seems inevitable. Other siting techniques combine multiple criteria analysis with GIS. GIS supplied with information gained by fuzzy logic, simple additive weighting (SAW) and analytic hierarchy process (AHP) has been used in landfill site selection all around the world (Hussey *et al.*, 1996; Kao and Lin, 1996; Siddiqui *et al.*, 1996; Charnpratheep *et al.*, 1997; Kao *et al.*, 1997).

Landfill siting generally requires processing a variety of spatial data such as geological and environmental parameters. Dependency of geological and environmental phenomena on very different and unknown parameters cause to fuzziness and ambiguity of them. This ambiguity of affecting parameters in site selection process and unclear relation and interaction between these parameters make the site selection problem complicated and processing the data by conventional methods is generally time and resources consuming. In this condition the utilization of artificial intelligence technology, such as expert systems, will help in solid waste planning and management, particularly in the landfill sitting process.

Artificial intelligence methods such as fuzzy method as decision-making tools extensively have been used in site selection all around the world. The nature of the fuzzy logic and the ability of the fuzzy systems to handle of the geological and environmental parameters that have no clear boundaries and well defined effect on the landfill sitting process can help to better landfill site selection (Hatzichristos and Giaoutzi, 2006; Ojha *et al.*, 2007; Akbari *et al.*, 2008; Chang *et al.*, 2008; Onut and Soner, 2008).

Artificial Neural Networks (ANN) as an artificial intelligence tool have the ability of modeling the problems with complicated relation between input data and the results. The ability of ANN's in pattern recognition and approximation of system relations is very helpful to solve such a multi-criteria decision making problem like landfill site selection. Also, ANN's are inspired by the biological functioning of human brain and they can learn from prior applications. This learning capability make ANN's as solving problem engine that can solve similar problems and learn more from new data.

In this paper artificial neural network has been used to landfill site selection. To compare the obtained result from this method with the other methods simple additive weighting (SAW) method has been used to landfill site selection. The input data of the models prepared from Lorestan province, IRAN. Lorestan province has an area about 27,422 Km^2 and located in the west of Iran (Fig 1).

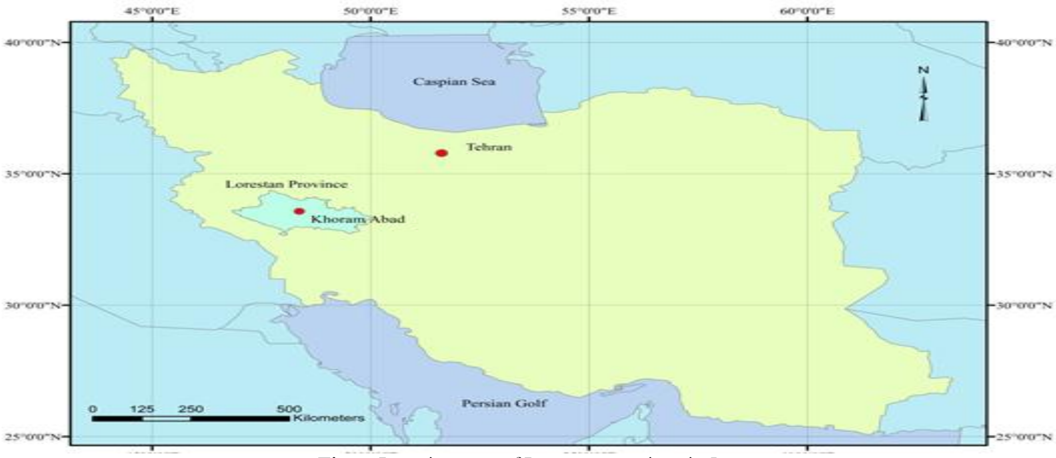

Fig-1. Location map of Lorestan province in Iran

2. MATERIAL AND METHODS

2.1. Input Data

The input data of the research consist of 12 digitized data layers including geology, faults, slope, vegetation, residential areas, road and railways, protected areas, groundwater resources, dams, drainage networks, precipitation and evaporation maps. The preparation of this input data is the most time consuming part of the study and the results of the site selection are very depends on the precision of the input data. This data prepared in the GSI environment and is the raw materials for the two used methods.

Methodology

In this study the landfill site selection carried out by means of two methods, SAW method and ANN method. The first method as a conventional method for landfill site selection has been used for landfill site selection in the study area. This method has some shortcomings in the definition of parameter's boundaries on the map and the weighting of the parameters. The second method is an ANN system that is tested for whether it can solve the problems of the first method.

SAW is the best known and very widely used method of multiple criteria decision making. To each of the criteria in SAW, the decision maker assigns weights which become the coefficients of the criteria. The decision maker can then obtain a total score for each alternative simply by multiplying the scale rating for each criterion value by the weight assigned to the criterion and then summing these products over all criteria (Janssen, 1992; Malczewski, 1997).

In SAW method a two stage process for landfill site selection was utilized. At the first step the forbidden places such as protected, residential areas and dams and water resources eliminated from the maps and in the second stage the remains parts of the map have been evaluated by means of simple weighting method. The methodology evaluated the study area using a grading scale from 0 to 5, where grade 0 shows the fully unsuitable sites for landfill, while grade 5 indicate most suitable sites for landfill.

This method consists of following steps:

a- Preparation of a digital database that includes all spatial information.

b- Determination of selection criteria and their ranking and weighting.

c- Implementation of a SAW method to estimate the suitability index, land suitability mapping for landfill siting.

d- Introducing suitable sites for municipal landfill.

The second stage of research was based on the preparations in the previous step, and also selection criteria. A ANN was used to calculate suitability indices. The methodology of this part of research consists of the following steps:

a) Preparation of input data and training data based on the obtained results from first method.

b) Choosing an ANN and defining its structure and functions.

c) Choosing a learning algorithm and training the network.

d) Testing the trained network with test data.

At the final step of the research the obtained results of two methods will be compared with each other.

3. ANALYSIS AND RESULTS

3.1. Evaluation Criteria

To compare the results obtained from above mentioned methods, the same evaluation criteria have been used in both method. The site selection criteria used in this study are classified into six main categories (Table 1), namely the geological, geomorphological, hydrogeological/hydrological, climatological and ecological criteria. Each of these main groups contains subdivisions that these subcriteria and their ranking (for SAW method) used for landfill site selection have been listed in Table 1.

3.2. Geological Criteria

The geological setting of the landfill site has an important effect of landfill structure and operation. Bearing capacity of soil and rock, permeability, landfill settlement and stability depends on the geological properties of landfill sites.

Geological criteria comprise two subcriteria namely; lithology and faults (Table 1). Lithological properties and fault of the study area (Lorestan province) were evaluated by digital geological maps that prepared by means of the geological survey of Iran (Geological Survey of Iran (GSI), 1962; GSI, 1964; GSI, 1964; National Iranian oil Company (NIOC), 1967; NIOC, 1973; GSI, 1992; GSI, 1992; GSI, 2006). These maps consist of 1:250,000 geological maps were used to prepare a suitability map of the study area for landfill sites considering the lithology and faults. The spatial results of the evaluation are shown in Fig 2.

3.3. Hydrological/Hydrogeological Criteria

Hydrological and hydrogeological parameters that must be considered in the landfill site selection consist of distance from rivers and drainage systems, well and springs and dams (Table 1). The spatial results of hydrogeological criteria are shown in Fig 3.Wells and springs are the most drinking water resources in the study area. In addition, wells have an important role in agricultural purposes. So, the landfill sites must have a safe distance from these water resources to prevent the contamination. International practice states a minimum distance of 500 m is required for landfill site from water sources (Kontos *et al*., 2005). There are totally 2744 groundwater sources in the study area, includes 1355 springs and 1389 wells. The results are presented in Fig. 3A to C.

3.4. Geomorphological Criteria

The geomorphology has a crucial role in the natural hazard prevention and in risk assessment and management programs. Slope gradient was considered as subceriteria of geomorphological criteria in this study.

Slope gradient affects the construction cost of landfill also has a great effect on the instability hazard of landfill. The slope gradients were evaluated by construction of digital elevation model (DEM) of the study area using

1:250000 topographic maps (National Geographic Organization of Iran (NGO), 2004). The results of the geomorphological criteria evaluation are shown in Fig.3D based on the classification and ranking presented in Table 1.

3.5. Climatological Criteria

The climatology criteria considered in this study were the average annual precipitation and average annual evaporation. Climatological analysis was done by using the data from 22 climatological stations in the study area. These criteria are based on this fact that the landfill site should have lower precipitation and more evaporation. Therefore, the categorization of climatic criteria was done based on the minimum and maximum value of precipitation and evaporation in the study area. (Fig. 4A and B)

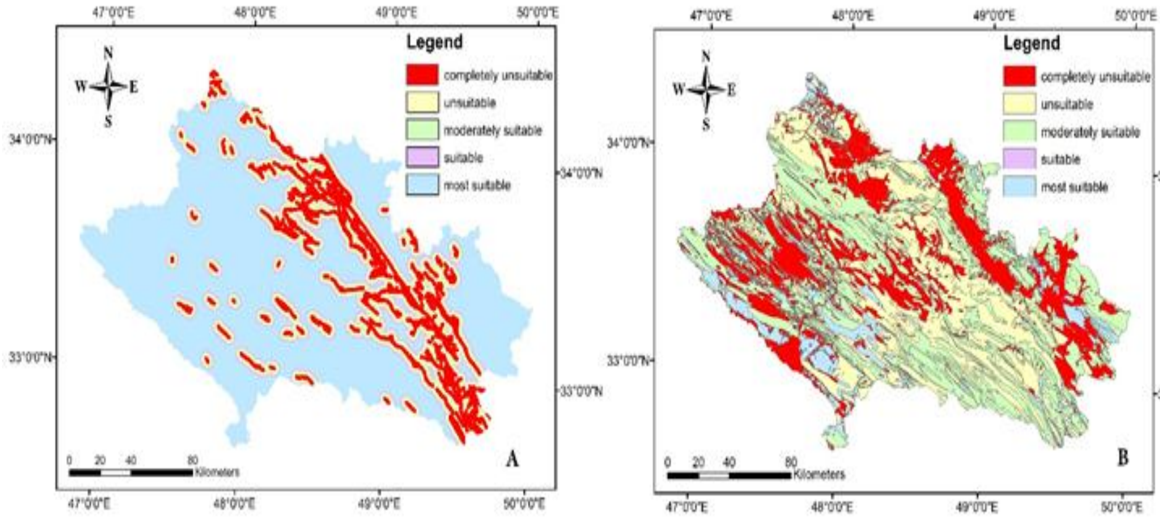

Fig-2. Spatial presentation of geology, prepared using GSI from the input data. A. Faults. B. Lithology.

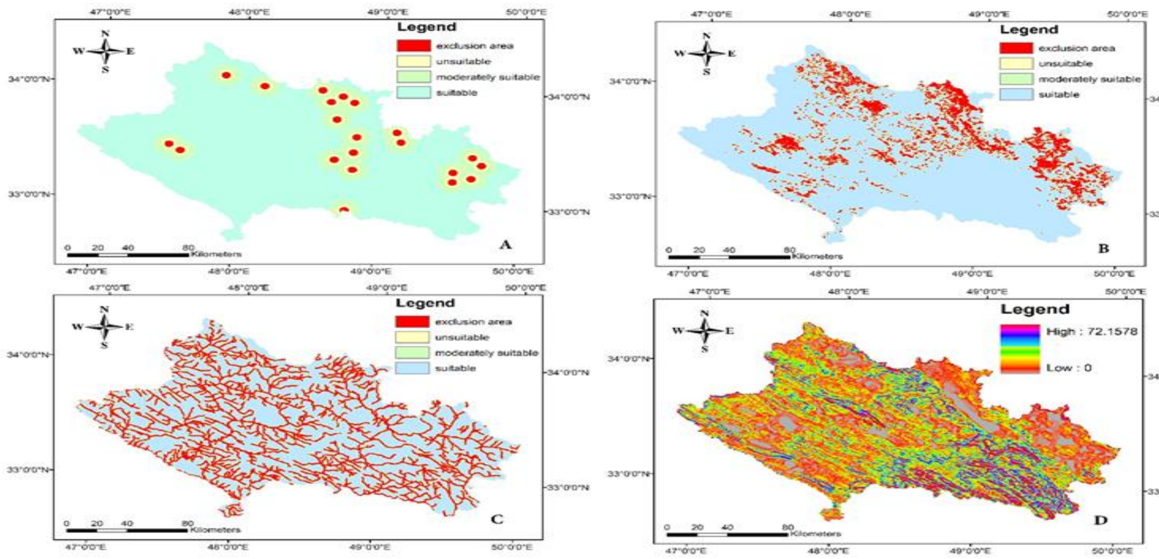

Fig-3. Spatial presentation of hydrology/hydrogeological and geomorphological criteria, prepared using GSI from the input data. A. Dams. B. Wells and springs. C. Drainage system. D. Slope.

Table-1. Grading and normalized relative importance weights of criteria used in the analysis, obtained from the input data.

Criteria	Subcriteria	Grading (xij)						Relative importance weight	Normalized relative importance weight (w_j)
		Most suitable (5)	Suitable (4)	Moderately suitable (3)	Unsuitable (2)	Completely unsuitable (1)	Exclusion area (0)		
Geology	Lithology *	Sh,Mn,Cl	Sc,Tf,Ev,Ls	Ig, Mm,Sl	Ss,Ls	Do,Cg,Af,Qt,Qs		6	0.098
	Distance from Faults	> 4 km	3-4 km	2-3 km	1-2 km	0.5-1 km	< 0.5 km	5	0.080
Geomorphology	Slope (^{0})	0-5	5-10	10-15	15-20	>20	-	10	0.152
Hydrology/ Hydrogeology	Distance from rivers and drainage system (m)		> 2000	1000-2000	500-1000		<500	8	0.128
	Distance from Wells and springs (m)		>1000	750-1000	500-750		<500	9	0.135
	Distance from Dams (m)		>3000	2000-3000	1000-2000		<1000	5	0.080
Pedology	Vegetation **	BL	R3,R2	SH,R1,DF	IF,F3,F2, F1, RB,L,URB			7	0.120
Social/ Economical	Distance from residential area (km)	1-10	10-20	20-30	>30		<1	7	0.120
	Distance from roads (km)	0.5 -2	2-4	4-6	6-8	>8	< 0.5	5	0.080

* Description of Lithology- Sh:shale, Mn: marl, Cl: clay, Sc: schist, Ev: evaporation rocks, Ls: loess, Ig: igneous rocks, Mm: metamorphic rocks, Ss: sandstone, Ls: limestone, Do: dolomite, Cg: conglomerate, Af: alluvial fans, Qt: quaternary sediments, Qs: landslides.

** Description of vegetation- BL: bared lands, R3: rangelands with 5 -25 % canopy cover, R2: rangelands with 25- 50 % canopy cover, R1: rangelands with more than 50 % canopy cover, SH: shrub lands with more than 10% canopy cover, IF: irrigation farming and orchards, DF: dry farming, F3: forest with 5-25% canopy cover, F2: forest with 25- 50% canopy cover, F1: forest with more than 50 % canopy cover, L: water bodies, RB: river beds, URB: residential area.

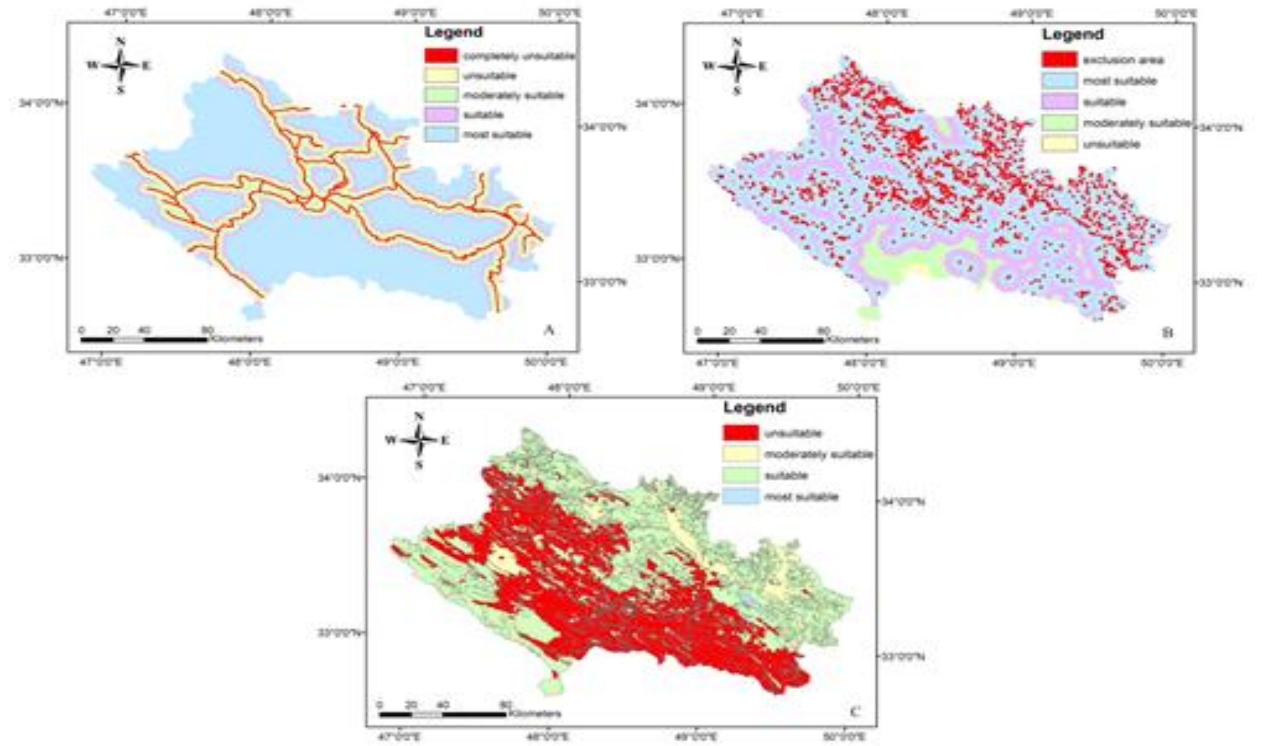

Fig-4. Spatial presentation of pedology and social/environmental criteria, prepared using GSI from the input data. A. Roads. B. Residential area. C. Vegetation.

3.6. Social/Economic Criteria

These criteria include the three main subcriteria consist of distance from residential areas, distance from roads and distance from environmentally protected area. The distance from the residential area depends on the population of the city or village but a distance at least 5 to 10 kilometers recommended in regulations. The selected landfill sites should not be very far from the source of the wastes (Fig. 4D).

Because of the importance of transportation problem in waste management the landfill location must be close to the road network in order to facilitate the transportation. But a buffer of 500 m to 1 kilometer from the roads must be considered in the landfill site selection (Fig. 4C).

Environmentally protected areas are some parts of the country that any kind of construction in these areas is not permitted. There are two protected areas in the study area (Fig. 4E). These areas with a buffer of 500 m were considered as an exclusion area for landfill siting.

3.7. Pedological Criteria

In this research the vegetation was considered as the pedological criterion. The 1:250000 scale land cover maps were used to prepare the land use layer of the study area and 12 different vegetation cover type were recognized (Ministry of Agriculture of Iran (MGI), 2002). The evaluation of the importance of vegetation type was based on the ecological uniqueness of deforested vegetation and spatial spread of natural vegetation. The effectiveness of vegetation on landfill sitting depends on the height and the continuity of the canopy and density of vegetation cover (Khamechian *et al.*, 2011). Fig 4E and F shows the spatial results of this criterion.

Evaluation of land suitability

3.8. The SAW Approach

The next step of the study is to combine the evaluation criteria to evaluate the land suitability for municipal waste landfill sites. The SAW method that is based on the Boolean logic, was used for calculation of suitability indexes. Eq. 1 describes the formula of the method (Malczewski, 1997):

$$A_i = \sum_{i=1}^{n} x_{ij}\, w_j \qquad \text{(Eq.1)}$$

Where A_i is the suitability index of area i, w_j is the normalized relative importance weight of criterion j, x_{ij} is the grading value of the area i under criterion j, and n is the total number of criteria. In order to calculate the suitability indexes (A_i), the grading values (xij) and the normalized importance weight (wj) of criteria are required. The relative importance weight of criterion is defined from 0 to 10 (Table 1) based on expert decision. The relative importance of each criterion was normalized by dividing each weight to the sum of the weights. The evaluation criteria with their corresponding normalized relative importance weights were used to calculate the suitability indexes (Table 1). The land suitability map for municipal waste landfilling in Lorestan province prepared by means of SAW method has been shown in Fig. 5. Land suitability (A_i: 0 to 2.5) in this map has been grouped in five categories with 0.5 intervals.

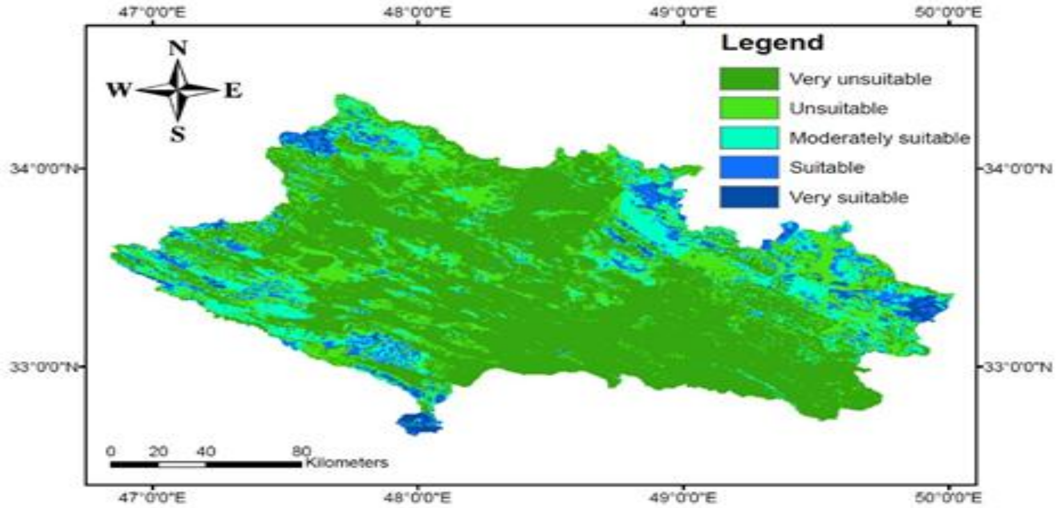

Fig-5. Suitability map for landfill in Lorestan province based on the SAW method, prepared from the outputs of the model.

3.9. The Artificial Neural Network Approach

The abilities of artificial neural networks as computational tools are as follow: -Determination of a definite function. -Approximation of an indefinite function. -Pattern recognition. -Signal processing. -Learning.

As for the nature of landfill site selection process which consist of uncertain affecting parameters and unclear reaction between these parameters for site selection, it seems that artificial neural networks can be helpful in this regard.

Also the ground zonation and classification on map for landfill construction is adaptable with the ANN's abilities. Akyürek and Yanar (2012) trained a simple MLP network by means of obtained result from a neural network model and used this network to solve the landfill site selection problem in Turkey.

Figure 6 shows the different steps of the modeling process. The means of artificial neural network affecting parameters of the landfill site selection intended same as the SAW method to compare the results of two method. At the next step the type of the suitable network type for this problem should be specified. The most common type of neural networks that has been used for this type of engineering problems is multi-layer perceptron network. The structure of this type of networks consists of an input layer, one or more hidden layer and an output layer. The designation of the network structure is a heuristic process and depends on the problem at hand. A multi-layer perceptron with a feed forward back propagation structure that have an input layer, two hidden layers and an output layer considered as suitable network. The input layer of the network has nine inputs. The neural network consists of two hidden layer with six and three neurons respectively and finally the output layer of network have one neuron. Figure 7 shows the structure of the designed network.

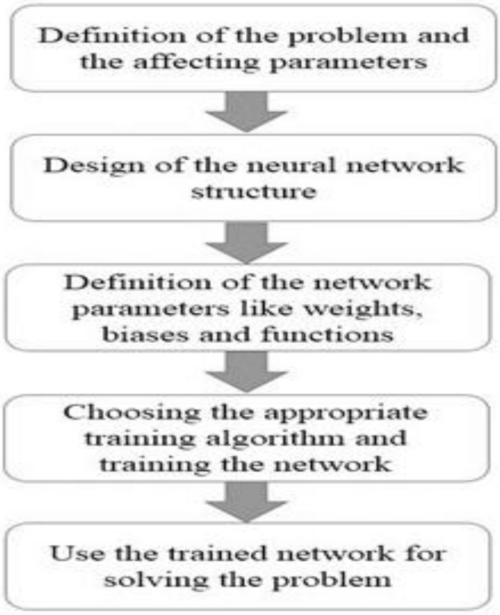

Fig-6. Steps of solving the problem by means of the neural network method in this study.

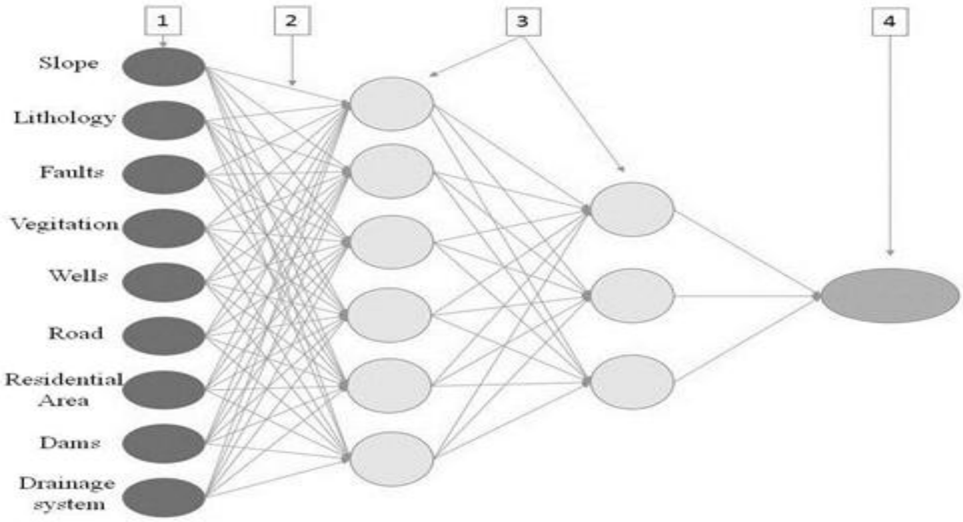

Fig-7. schematic figure of the designed network that was used for landfill site selection in this study: 1- Input layer. 2- Connection between neurons. 3- Hidden layers. 4- Output layer.

The weights of connections between neurons will be determined in the training step and no bias intended for neurons. The learning algorithm that was used to train the network was Levenberg- Marquardt algorithm. The training data was selected from obtained results from SAW method. To prepare this data the obtained map from SAW method divided to cubic cells with 500 meters dimension that the center of each cell indicates the value of cell. The prepared land suitability map at the previous step consists of 120000 cells that from these amounts 20000 point considered for training of network, 10000 point as the training data and the others as the testing data. Figure 8 shows the result of obtained data from the training step and the testing data. The relation between obtained data from network and testing data shows that the training of network has been successful and this network can be used to solve the landfill site selection problem.

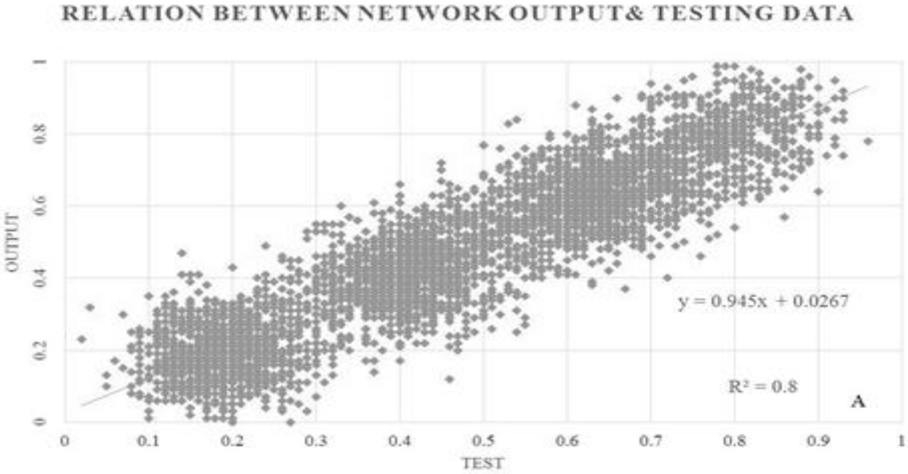

Fig-8. Relation between obtained data from the trained network and testing data.

At the last step of modeling the trained network was used to prepare a land suitability map of sanitary landfill in Lorestan. For this purpose the total 120000 points considered as the input data of network. The output of network considered as the input data of land suitability map and by means of interpolation method these data converted to a map that has been shown in figure 9.

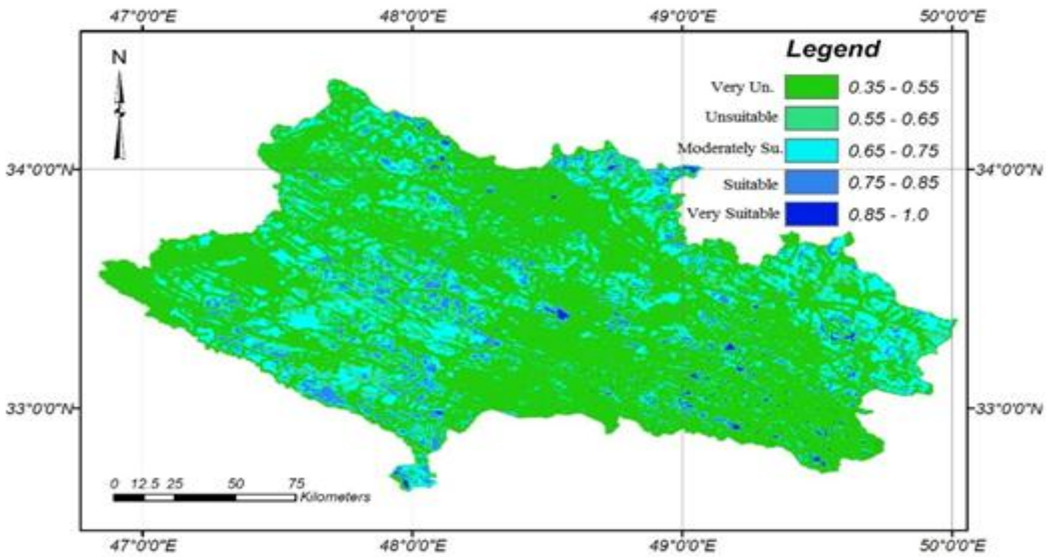

Fig-9. Suitability map for landfill in Lorestan province based on the ANN method, prepared using the outputs of the model.

4. RESULT

Derived map from the neural network modeling exhibit a gradual suitability for a landfill site. With the simple additive weighting method that was used in the first step of the research, most of the area is considered unsuitable, while by the neural network method, the area with high suitability covers many parts of the study area. Table 2 shows the area of different classes on prepared maps by SAW and neural network method and the percent of these classes from the total area of the Lorestan province.

Table-2. The area of different classes on prepared maps by SAW and Neural network method, obtained from the outputs of models.

SAW map			**Neural network map**	
Class	Area on map (Km^2)	Percent of total area	Area on map (Km^2)	Percent of total area
Very unsuitable	9274.51	32.8	7299.85	25.8
Unsuitable	12821.10	45.3	9393.61	33.2
Moderately suitable	3640.83	12.9	5092.92	18
Suitable	691.02	2.4	3027.46	10.7
Very suitable	1866.53	6.6	3480.16	12.3
	Total area: 28294		Total area: 28294	

To verify the accuracy of the maps provided by SAW and ANN methods, field visits were carried out in the study area. During these visits forty one situations were discussed for landfill suitability. These sites selected near the major populated towns of Lorestan province. Table 3 and the figure 10 show the coordination and the position of these sites. In each sites the above mentioned site selection criteria were checked and the sites classified based on the classification that was used in the neural network and SAW methods. This classification consists of A that shows very suitable sites, B as the suitable sites, C as the moderately suitable sites, D as the unsuitable sites and E that shows the very unsuitable sites.

Table 4 shows that the validations of the map provide by means of neural network method is about 62 percent whereas the validation of the SAW map is about 43 percent.

Table-3. The coordination and classification of the visited sites and comparison of them with neural network and SAW method results.

ID	**Name**	**X**	**Y**	**TRUE**	**Neural network**	**SAW**
1	L1	48° 27' 0.000" E	33° 30' 0.000" N	A	D	C
2	L8	48° 29' 24.000" E	33° 27' 36.000" N	A	D	E
3	L12	48° 31' 23.270" E	33° 52' 59.466" N	A	A	D
4	L22	48° 17' 38.399" E	33° 54' 32.479" N	A	A	C
5	L27	49° 10' 6.103" E	33° 27' 0.120" N	A	B	C
6	L32	49° 35' 57.097" E	33° 21' 54.944" N	A	A	A
7	L40	49° 11' 32.102" E	32° 55' 29.320" N	A	A	D
8	L42	48° 5' 13.152" E	32° 50' 27.553" N	A	B	A
9	L2	48° 25' 48.000" E	33° 28' 48.000" N	B	D	D
10	L3	48° 14' 24.000" E	33° 24' 36.000" N	B	B	E
11	L4	48° 17' 24.000" E	33° 29' 24.000" N	B	C	B
12	L10	48° 27' 6.000" E	33° 22' 13.000" N	B	D	D
13	L13	48° 56' 51.902" E	33° 43' 0.512" N	B	B	C
14	L17	47° 36' 18.978" E	33° 35' 31.010" N	B	B	B
15	L18	47° 40' 55.910" E	33° 37' 32.286" N	B	B	D
16	L23	48° 10' 10.413" E	33° 49' 34.253" N	B	B	D
17	L29	49° 5' 40.053" E	33° 28' 52.097" N	B	C	D
18	L33	49° 45' 16.789" E	33° 26' 17.826" N	B	C	D
19	L34	49° 47' 40.154" E	33° 19' 25.365" N	B	B	B
20	L41	49° 7' 59.807" E	32° 57' 10.849" N	B	B	D
21	L5	48° 22' 48.000" E	33° 29' 24.000" N	C	D	C
22	L14	48° 46' 43.693" E	33° 33' 0.980" N	C	C	E
23	L19	47° 41' 39.283" E	33° 26' 1.851" N	C	C	B
24	L11	48° 42' 52.000" E	33° 52' 45.000" N	C	C	D
25	L24	48° 19' 32.259" E	33° 47' 33.977" N	C	E	C
26	L30	49° 4' 57.861" E	33° 31' 2.157" N	C	C	D
27	L35	49° 37' 39.667" E	33° 27' 5.450" N	C	C	C
28	L36	49° 42' 2.605" E	33° 18' 17.485" N	C	C	C
29	L6	48° 16' 48.000" E	33° 29' 24.000" N	D	D	D
30	L7	48° 25' 12.000" E	33° 24' 0.000" N	D	E	E

31	L15	48° 43' 8.648" E	33° 41' 19.955" N	D	D	B
32	L20	47° 39' 56.853" E	33° 30' 7.377" N	D	E	D
33	L25	48° 9' 31.654" E	33° 53' 4.296" N	D	D	D
34	L28	49° 4' 9.768" E	33° 24' 14.795" N	D	C	D
35	L37	49° 35' 51.449" E	33° 16' 26.459" N	D	D	D
36	L38	49° 31' 2.499" E	33° 24' 40.180" N	D	C	D
37	L9	48° 15' 0.000" E	33° 21' 36.000" N	E	E	E
38	L16	48° 47' 51.747" E	33° 54' 24.405" N	E	E	C
39	L21	47° 28' 42.402" E	33° 25' 0.098" N	E	E	C
40	L26	48° 20' 2.842" E	33° 50' 27.140" N	E	C	E
41	L31	49° 0' 10.386" E	33° 29' 26.428" N	E	E	E
42	L39	49° 44' 53.435" E	33° 22' 34.221" N	E	E	D

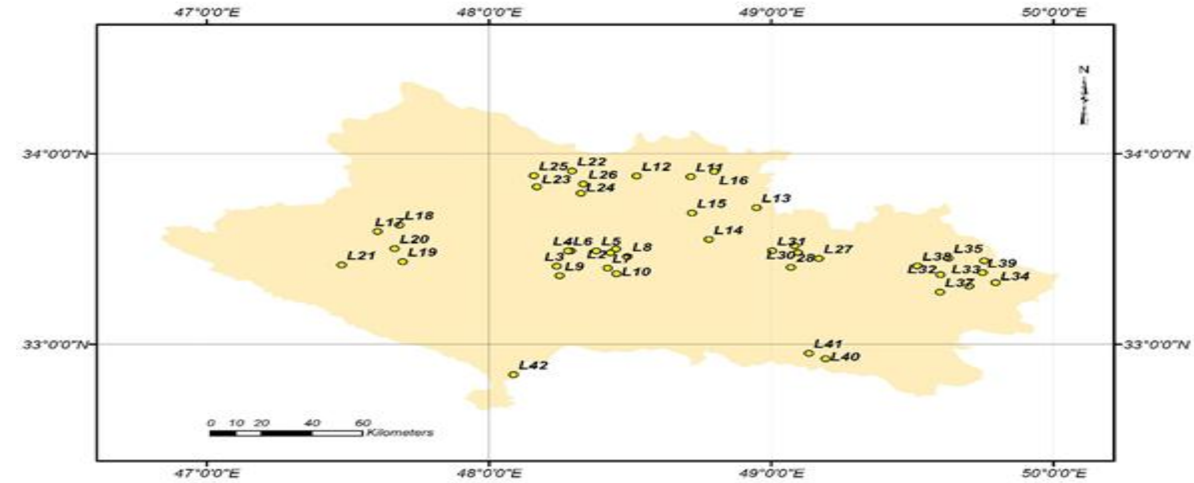

Fig-10. The position of the visited sites on Lorestan province map during the field study.

Table-4. The validation of the maps provided by means of the neural network and SAW methods, based on the field study results.

	Percent of validation	
	SAW method	**Neural network method**
Very Unsuitable	50	84
Unsuitable	75	50
Moderately suitable	50	75
Suitable	25	59
Very suitable	25	50
Total	43	62

5. CONCLUSION

Landfill site selection is a part of the waste management process that is a regional planning problem where the characteristics of the problem cannot be treated irrespective of each other. The use of the conventional methods like SAW method is inadequate because these methods are incapable of coping with problems where complication is involved in the phenomena and the relations of parameters.

The artificial neural networks can deal with environmental problems that are usually have many complexities and characterized by complication of affecting parameters interaction. These methods provide the opportunity of combining parameters and allowing the criteria to be processed simultaneously. One of the most characteristics of the neural network methods is flexibility. The maps that are provided by these methods help the decision makers to select areas with a high suitability value and then proceed to field investigations according to the level of enforcement of the other policies. Based on the field studies, the validation of the map provide by means of neural network method is about 62 percent whereas the validation of the SAW map is about 43 percent.

One of the most important problems of the neural network approaches is that the accuracy of model reduces and the amount of calculations increases dramatically with increase of affecting parameters.

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