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Prioritizing Suitable Lands for Flood Spreading for Artificial Discharge using Integrated Model AHP / Fuzzy (Case Study: Shourdasht Basin)

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Abstract
During recent years, increasing exploitation of groundwater aquifers has caused a substantial and sharp drop in groundwater table in the plains of Iran. Artificial discharge of aquifer using flood spreading in plains is an approach that has been implemented in many parts of the country so far. In this method, by flowing flood into the aquifer, will control flooding and soil conservation. In addition, increasing the volume of the reservoir and preventing a sharp decline in groundwater level do the same work. This research has been used to integrate the AHP / Fuzzy model in order to evaluate suitable land for flood spreading in the Shourdasht watershed in the Ghahavand, Hamadan province. To this end, after the selection of effective indicators in the location of these areas such as slope, permeability, alluvial thickness, transmission capacity, flooding, and hydraulic conductivity, using the analytical hierarchy process (AHP) were weighted and their importance was identified. The fuzzy method was used to normalize the effective measures in the zoning of flood spreading areas. Then, based on the integration of fuzzy layers, a final map of the land suitability for locating the flood spreading areas was determined. The results showed that in the relevant classification it was found that 42.46% accounted for completely unsuitable, 19.27% in the classes with a moderately suitable, and finally 37.78% were in a suitable and completely suitable class.

Keywords: Groundwater Artificial Discharge, AHP, Fuzzy logic, Shourdash.

1. Introduction
During last two decades, artificial discharge is an idea that has been recognized over the past 20 years as a major water management tool for solving the water challenge issue (Eden et al., 2007). The artificial discharge program aims to maintain the groundwater table balance, in different parts of the world (Das, 2003). Groundwater artificial discharge is carried out by placing surface water in basins, wells, ponds or other facilities where soil penetration and downward flow to the aquifer (Bouwer, 2002). in the selection of sites for artificial discharge, it is a very important task in discharge studies, and since there are many parameters that should be taken into account when determining a particular site of artificial discharge, so it should be performed with great care. (Saravi et al., 2006). There are numerous methods to assess the status of groundwater. The traditional method of exploring underground water using hydrological, geological and geophysical methods is usually uneconomic due to the high cost of drilling and long research (Israil et al., 2006; Jha et al. 2010). In recent years, with advances in spatial technology, efficient techniques for groundwater exploitation have been developed using remote sensing software (RS) and GIS (GIS) software. These techniques essentially changed our thoughts and ways of

managing. Many studies have been carried out to find suitable artificial discharge locations using Gis, including (Chowdhury et al, 2010, Dar et al., 2010, Gaur et al., 2011, Magesh, 2012, Manap et al., 2013). There are several factors for choosing an artificial discharge site that can be considered. The use of traditional data processing methods in selecting groundwater artificial discharge locations is time consuming due to the fact that the data is large and usually needs to be integrated. The correct analysis and evaluation of multivariate decision making in recent decades has become the strongest programming method with a complete framework for complex decision making. One of the multi-criteria decision-making methods of the Hierarchy Process Analysis (AHP) developed by Saaty (1980) is a method that determines the relative importance of a set of activities in a multi-criteria decision-making problem. In this method, many alternatives or weight estimation methods are used to make decisions (Vaidya, 2006). In fact, AHP addresses the rational analysis of the problem and helps decision makers to understand the impact of the elements in the hierarchical structure with several comparisons (Saaty and Vargas, 1990). Fuzzy multi-criteria decision making in decision-making science has been considered special, and the use of fuzzy logic has led to the creation of various methods in multi-criteria decision making (Amiri, 2010; Cavallaro, 2010). Fuzzy logic can be used as a technique the overlapping analysis is appropriate for solving problems such as choosing a site and model. Fuzzy set theory was first introduced by Zadeh (Zadeh, 1965) and then on the decision problem by Bellman & Zadeh (1970) the use of a fuzzy set of decisions to deal with the hesitation of human thoughts and the complexity and uncertainty in decision making. This is very useful in the real world (Chen and Pham, 2001). Based on the theory of fuzzy sets, the membership in the collection may not be entirely complete, and any member with a degree of membership from zero to one will be considered based on the membership whose members, units of each of the base maps and membership criteria The collection is suitable for flood spreading and degree membership, between zero and one (AleSheikh et al., 2008). In the field of location and better location for artificial discharge, we can mention a lot of research work using fuzzy multi-criteria decision-making methods and hierarchical analysis process. Moghaddam et al. (2017) in Sarbisheh basin in Khorasan based on the land surface, penetration, water depth in the aquifer, alluvial quality, land use, water congestion, the geology of quality and quantity of water using hierarchical analysis method and The fuzzy logic was to determine the most suitable place. The results show that the process of analytical hierarchy and logical fuzzy logic is appropriate, but for practical purposes, AHP is superior to fuzzy (Moghaddam et al., 2017). Ibrahim et al. (2011) selected the best location for wastewater to combine the analytical hierarchy process with the weighting of GIS indexes and software to provide a zoning map in northern Egypt. (Ibrahim et al, 2011). Aryafar et al., (2013) evaluated the impact of the environment and mining activity on groundwater using a hierarchical and fuzzy analysis process. After evaluating Indicators affecting groundwater contamination in the mining area concluded that the development of vegetation had the least effect (Aryafar al, 2013). Gdoura et al. (2015) to identify and rank suitable locations for groundwater discharge in Tunisia used multi-criteria AHP methods. Their research results showed that the northern city in the Keshava region Razi is located far from urbanization and is an ideal place for artificial discharge. (Gdoura et al, 2015). Imran et al. (2014) identified an appropriate location for underground dams in northern Pakistan using multi-criteria AHP decision-making analyze And FIM. The proposed method provides significant results and can be used in the initial planning to determine the proper location for the construction of underground dams. The sensitivity analysis showed that AHP was a weighing technique stronger than FIM and the user Lands are the most sensitive species (Imran et al, 2014). Sargaonkar et al. (2011) to identify potential sites for groundwater discharge in the sub-basin of the Kahan River, India using the AHP method to compare five selected locations based on geological indicators, geomorphological characteristics and fluctuations in surface water content. The results showed that the P5 site is located at the maximum aggregate of the sandstone flow and land (Sargaonkar et al., 2011). Aydi et al. (2016) evaluated and selected suitable locations for olive mill waste by fusion logic, AHP, and WLC integration. The results of this study indicate that at least the appropriate drainage location is 2.5% for environmental and economic purposes, while when the economic target is higher, it is a good and desirable disposal area of 1% (Aydi et al, 2016). Bhowmick et al. (2015) assessed the desirable areas for groundwater in India using fuzzy logic and GIS software and remote sensing and concluded that proper location requires the systematic study of hydrology and geology on a scale Local has (Bhowmick et al, 2015). Razandi et al. (2015) prepared a groundwater potential map in Varamin plain of Tehran using AHP method and a reliable factor and frequency ratio. The results of the mapping of water availability potential will be useful for planning and managing future water resources (Razandi et al, 2015). Dabral et al. (2013) to determine the most important factors affecting groundwater resources, as well as determine the potential areas of Gujarat groundwater in western India, applied effective parameters such as geology, geomorphology, soil, slope, drainage density, and to weighting AHP method was used (Dabral et al, 2013). The results of this study indicate that about 28% of the area has groundwater discharge capability. Pourmand et al. (2018) proposed A fuzzy multi-stakeholder multi-criteria methodology for water allocation and reuse in metropolitan areas.The results show that using a fuzzy multi-criteria decision-making method considering equal and different negotiation powers can lead to different outcomes.(Pourmand et al, 2018). Chakrabortty et al. (2018) Modeled and mapped the groundwater potentiality zones using AHP and GIS technique in West Bengal. Groundwater potential zone is categorized as good and excellent (21.41%) (Chakrabortty et al, 2018). Shailaja et al. (2019) have been developed A novel framework for delineating groundwater potential zones using fuzzy datasets and the analytical hierarchical process (AHP) integrated with hydrogeological, geophysical and geospatial data for a hard-rock trap-covered terrain in Maharashtra, India. The findings reveal that the areas of very high groundwater potential are located in the plateau region and plains of the basin that occupy about 11.5% of the total study area (Shailaja et al, 2019).In the present study, we try to combine the process of hierarchy analysis and fuzzy logic into Location of favorable areas for discharge water in the Shourdasht basin in the Ghahavand, Hamadan province.

2. Materials and Methods

2-1 study area

Shourdasht basin has 33649.7 h with coordinates 34° 40´ to 48° 34 N and 48° 48 to 04° 49 E in Hamedan province. (Fig.1).The basin is divided into 5 independent hydrological units based on factors such as streams density, the status of the adjoining of secondary streams to the Main River and needs of the study groups. The Shourdasht basin has an average annual rainfall of 286.22 mm with an arid and cold climate. The average elevation of the basin is 1912.3 m.

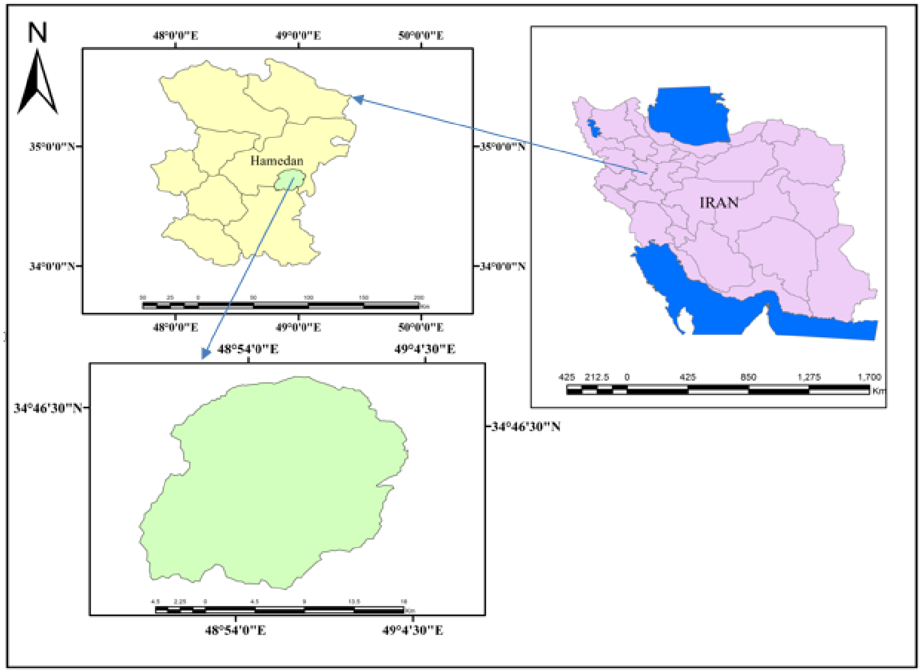


Fig.1. The geographical position of the study area

2.2. Methodology

In this study, documentary and library studies related to flood spreading were used, and various maps and Google Earth images were used to prepare the basic maps for performing the fuzzy model. In order to investigate and evaluate the land suitability for optimal zonation of flood spreading using environmental parameters influencing flood spreading and their effect on the rate of water penetration into the earth, suitable parameters were chosen which included 8 parameters including slope, alluvial thickness, electrical conductivity, Geology, land use, drainage density, transmission capability and elevation. Then, using the information of the reports, the conversion of data and maps and the use of the GIS, each factor map was prepared and analyzed. In this research, the integration of the AHP / Fuzzy model in order to evaluate the land for flood spreading has been used. Analytical hierarchy process is one of the most popular multi-purpose decision-making tools for complex situations with multiple and conflicting measures, flexible decision-making tools, and at the same time, it is based on a two-way comparison that facilitates judgment and indicates the degree of compatibility and incompatibility of the decision (Ghodsipour, 2005). In order to weigh the factors that influence the process of hierarchical analysis, the highest weight is assigned to the layer that has the greatest impact in determining the target. In other words, the most effective factor in flood spreading is the highest. To determine the priority of factors and weight, the factors were compared to each other. The fuzzy method is used to normalize the effective criteria for zoning flood spreading areas. The main purpose of fuzzy logic is to provide concepts that make it possible to make approximate reasoning. In order to perform a fuzzy model, the layers must have a raster format. The slope and elevation maps prepared according to the DEM map of the area are Raster. Linear drainage density was determined using draining density. To convert the electrical conductivity point, the thickness of alluvium and the water transfer capability, the Kriging interpolation instruction was used. Also, polygonal layers (geology, land use) are coded according to a bachelor's point of view in proportion to the purpose of the research, which was converted into Raster layers by giving 1 up to code. After lamination and re-categorization, based on the research objectives, each of the layers was fuzzy using fuzzy membership functions in Arc GIS10.2. The research method is presented in the form of the following conceptual model (Fig.2).

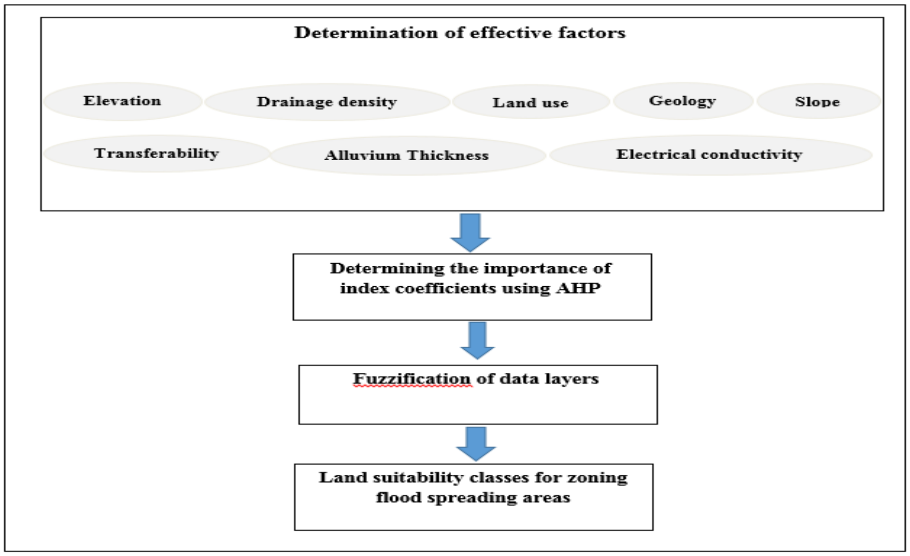


Fig. 2. A conceptual model for research methodology

3. Discussion and Results

3.1. Determination of effective factors

In order to evaluate the land suitability for optimal zonation of flood spreading using environmental parameters influencing flood spreading and their effect on the rate of penetration of water into the earth according to points such as the scale of work and the desired accuracy, purpose, conditions of the area and Effect of each of the indices (weight of the layers) was chosen to select the appropriate indices, 8 factors including slope, thickness of alluvium, electrical conductivity, geology, land use, drainage density, transmissibility, and elevation were identified.

3.1.1. Slope

The slope is one of the effective factors in locating areas that are prone to spreading and feeding groundwater slopes, which plays a very important role in controlling factors such as flood and permeability. According to the experiences of domestic and foreign researchers, the locations suitable for flood spreading have a slope of less than 5 percent. The slope has a very important role in water permeability and the location of flood spreading, and a map of the slope of the DEM map of the study area was used.

3.1.2. Alluvium Thickness

One of the important factors in flood spreading and discharge of groundwater is the thickness of alluvium. The theoretically, the larger the thickness of the alluvium, the more groundwater storage will be. Available studies show that, so far, the role of the thickness of alluvium in groundwater discharge has not been studied quantitatively, but the residues were created in alluvial soils where the depth of the rocky floor is not high and the environmental problems that result from it, the importance of this Reminds the agent. Due to the strength of the layers and logs of the wells, the thickness of the alluvial layer was obtained in the region. After obtaining the thickness of alluvium in parts of the region, the data obtained in the GIS environment were interpolated and a digital model of alluvial thickness was prepared in the range.

3.1.3. Transferability

Another important factor in determining areas susceptible to flood discharges and discharge of groundwater is the ability to transfer water in alluvium. The ability to transfer water in the alluvium is one of the hydrodynamic effects that indicate the movement of water in the porous medium. The ability to transfer in juicy layers has very different amounts but typically ranges from 10 to 1000 square meters per day. The water transfer capability map of Shourdasht basin was prepared according to the results of the piezometer pumping experiments in Plain (regional water of Hamedan) and interpolated by the Kriging method in ARC GIS 10.

3.1.4. Drainage density

The ratio of the length of all streams in a basin to its area is called drainage density. The drainage density has a direct relation with maximum discharge in the basin. The drainage system is evolving and dense, showing low permeability and an irresponsible drainage system indicating high permeability. Therefore, drainage can indirectly indicate the suitability of an area for flood spreading. In order to provide the above-surface DEM layer, the flow layer was extracted and then the drainage density was obtained.

3.1.5. Water quality (electrical conductivity)

If alluvium is characterized by a lot of solutes, it will be affected by various ions due to the movement of water in this porous medium, and water quality will decrease. Therefore, it is necessary to study the electrical conductivity of the alluvial water (Asgharpour et al., 2011). The electric conductivity layer is based on the regional linear water level of Hamedan province and using the well-known observation wells and converted with linear interpolation instruction.

3.1.6. Geology

The areas with Quaternary alluvium are areas suitable for flood spreading because of their high permeability. Geological map of 1: 100000 scales were used to extract the geological layers of the study area.

3.1.7. Land use

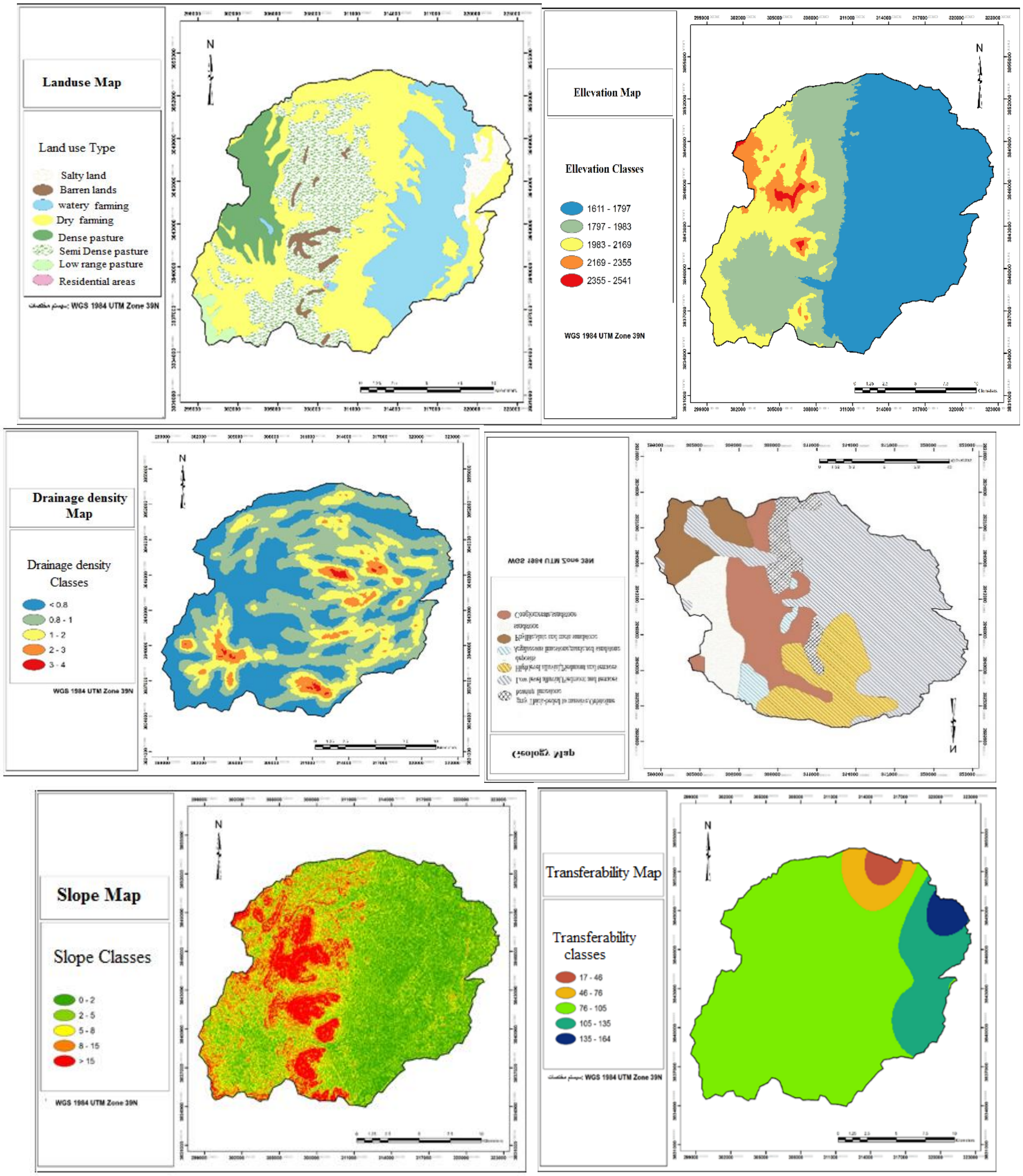
The type of land use in the possibility of flood control and development is very important. Inappropriate lands include agricultural land and gardens, urban and residential areas, roads, highways and lands that lack the potential for flood spreading operations or those that contain flood spreading factors. Among the various uses, rangelands are suitable for artificial discharge and flood spreading. In this study, residential lands, river bed, and agricultural land were considered as lands with no potential for flood spreading operations. The above layer was obtained by processing satellite imagery.

3.1.8. Elevation

The elevation is one of the most important factors in hydrological phenomena. The topographic map of 1: 25000 was used to provide elevation. Weighting table and map of each of the effective indicators are presented in Table (1) and Fig (3).

Table1. The weighting of the effective indexes

Prioritizing Number	**electrical conductivity (µmho/cm)**	**Drainage density (km/km^2)**	**Transferability (m^2/day)**	**Alluvium Thickness (m)**	**Slope (%)**	**Elevation (m)**	**Land use**	**Geology**
1	1373-1720	<0.8	17-46	<98	>15	1611-1797	Dense forest and garden	Phyllite,Slate and meta Sandstone
2	1720-2067	0.8-1	46-76	98-113	8-15	1797-1983	Residential Area	Conglomerate, Sandstone
3	2067-2414	1-2	76-105	113-129	5-8	1983-2169	Watery and Dry farming	Grey Thick bedded Limestone
4	2414-2761	2-3	105-135	129-144	2-5	2169-2355	Low range Pasture	Pediment and High level Terraces deposits
5	2761-3107	3-4	135-164	>144	0-2	2355-2541	Barren land	Pediment and low-level Terraces deposits


Landuse Map
Land use Type
Salty land
Barren lands
watery farming
Dry farming
Dense pasture
Semi Dense pasture
Low range pasture
Residential areas
WGS 1984 UTM Zone 39N
Ellevation Map
Elevation Classes
1611 - 1797
1797 - 1983
1983 - 2169
2169 - 2355
2355 - 2541
WGS 1984 UTM Zone 39N
Drainage density Map
Drainage density Classes
< 0.8
0.8 - 1
1 - 2
2 - 3
3 - 4
WGS 1984 UTM Zone 39N
Slope Map
Slope Classes
0 - 2
2 - 5
5 - 8
8 - 15
> 15
WGS 1984 UTM Zone 39N
Transferability Map
Transferability classes
17 - 46
46 - 76
76 - 105
105 - 135
135 - 164
WGS 1984 UTM Zone 39N

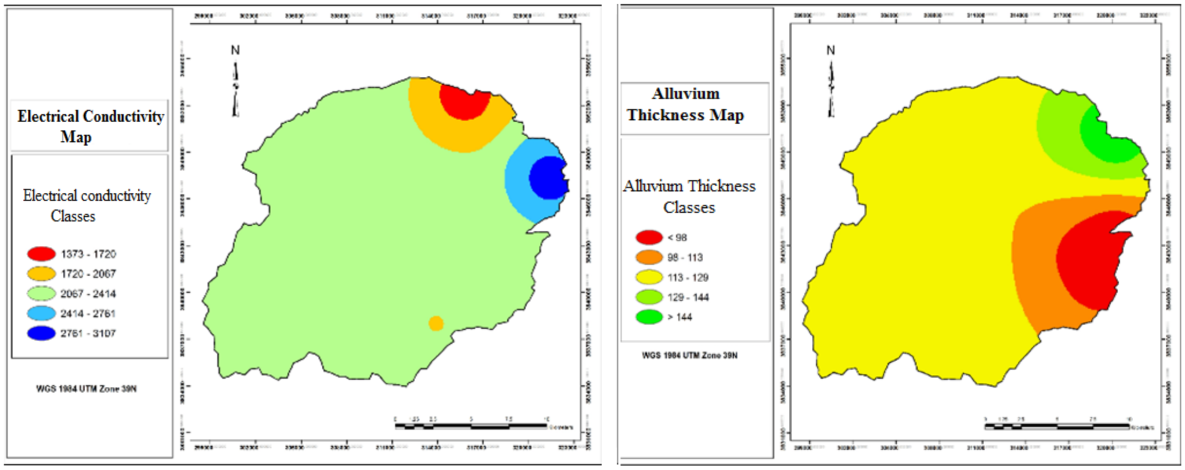


Fig. 3. Map of the effective indexes in zoning

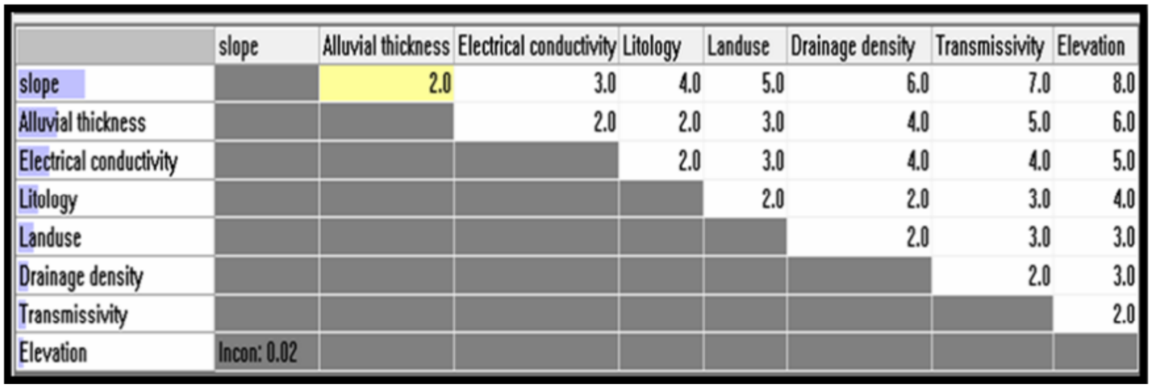
3.2. Determining the importance of index coefficients using AHP

In order to prioritize the criteria in the AHP model, the aim of the research, which is to locate the flood spreading arena, is at the highest level, and in the second level, the criteria are determined. Based on the experts' comments, library studies, scientific resources and available information, and Understanding the studied area, weighting each of the criteria is done. Hierarchical methods require the formation of a hierarchical tree. For the formation of this tree, factors that are important for decision making are expressed in a hierarchical way in the form of a decision tree. Then, for the paired comparison, the elements of each level are compared to their corresponding element at the higher level in paired and weighted the weights. In this way, the diameter of the matrix is number 1, which indicates the same importance of the criteria itself. And the other parameters are compared two to two and get a number from 1 to 9 in their preference (Table 2). For standardizing and calculating the weight and relative preferences of each option, the paired comparison matrix has been used for approximation (arithmetic mean). This method is used to first sum the values of each of the columns and then divide the values of each element of the matrix into the sum of the columns of the same element, and at the last step the average elements of each row are obtained, Then, by combining these weights, the final weight of each criterion or parameter is determined.

Table .2. The Preferred values for paired comparison

preferences	Numerical Value
Extremely preferred	9
Very strongly preferred	7
Strongly preferred	5
Moderately preferred	3
Equally preferred	1
Interval preferred	2,4,6,8

The weighting criterion is based on the role played by the environmental index in flood spreading and in-water penetration. The matrix method is used in the software to compare the pair (Fig. 4). After weighing and doing the calculations in Expert Choice software (Fig. 5) and according to the vehicle build rate (the compatibility rate should be less than 0.1), the final weights were obtained that in this position the highest weight was taken into the slope index (0.341) and the lowest weight was assigned to the height index (0.027) (Table 3).



	slope	Alluvial thickness	Electrical conductivity	Litology	Landuse	Drainage density	Transmissivity	Elevation
slope		2.0	3.0	4.0	5.0	6.0	7.0	8.0
Alluvial thickness			2.0	2.0	3.0	4.0	5.0	6.0
Electrical conductivity				2.0	3.0	4.0	4.0	5.0
Litology					2.0	2.0	3.0	4.0
Landuse						2.0	3.0	3.0
Drainage density							2.0	3.0
Transmissivity								2.0
Elevation	Incon: 0.02							

Fig.4. Paired comparison matrix of criteria

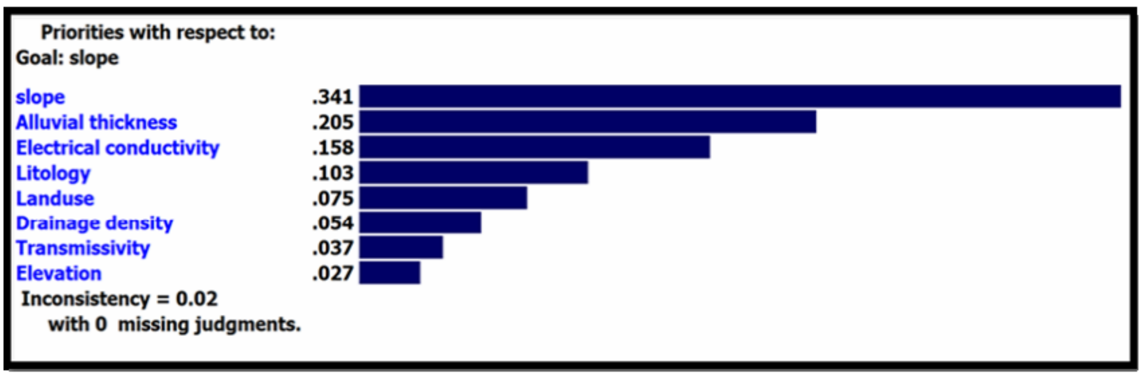


Fig.5. The obtained weight of the criteria and the degree of consistency

Table. 3. The final weights of criteria

Elevation (m)	Transferability (m^2/day)	Drainage density (km/km^2)	Land use	Geology	electrical conductivity (µmho/cm)	Alluvium Thickness (m)	Slope (%)
0/027	0/037	0/054	0/075	0/103	0/158	0/205	0/341

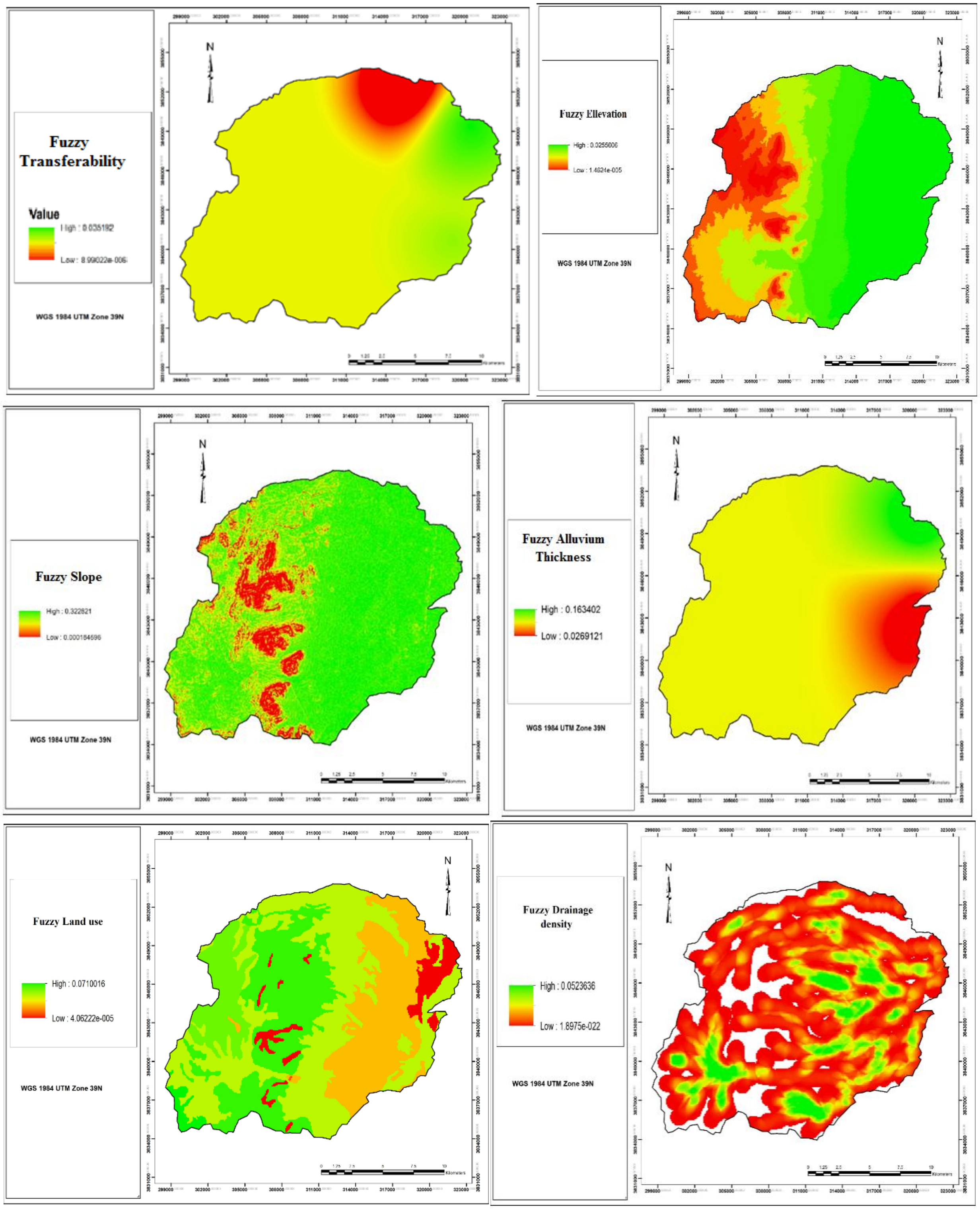
3.3. Fuzzification of data layers

After weighing the criteria in Expert Choice software, the weight of each of the criteria in the corresponding layer was multiplied in Arc GIS10.2 software Equation (1).

$$F(x) = w_t u\,(xi) \qquad (1)$$

Where f (x) is the fuzzy weighted layer, wt is the weight of each of the AHP criteria and uxi is the fuzzy function of each of the layers. After fuzzification and multiplication of weights in the fuzzy layers, the gamma operator was executed on fuzzy layers. Subsequently, the information layers and criteria were determined using sub franking fuzzy functions (Fig. 6) and all information layers with a quantitative property In the form of a raster, they were worth from zero to one (Equation 2).

$$f(x)=\{X_{max}\frac{1}{0}x)/\Delta) \qquad \begin{array}{l} x \succ a \\ b \succ x \succ a \\ b \prec x \end{array} \qquad (2)$$


Fuzzy Transferability
Value
High : 0.035182
Low : 8.99022e-006
WGS 1984 UTM Zone 39N
Fuzzy Ellevation
High : 0.0255606
Low : 1.4624e-005
WGS 1984 UTM Zone 39N
Fuzzy Slope
High : 0.322821
Low : 0.000184596
WGS 1984 UTM Zone 39N
Fuzzy Alluvium Thickness
High : 0.163402
Low : 0.0269121
WGS 1984 UTM Zone 39N
Fuzzy Land use
High : 0.0710016
Low : 4.06222e-005
WGS 1984 UTM Zone 39N
Fuzzy Drainage density
High : 0.0523636
Low : 1.8975e-022
WGS 1984 UTM Zone 39N
N

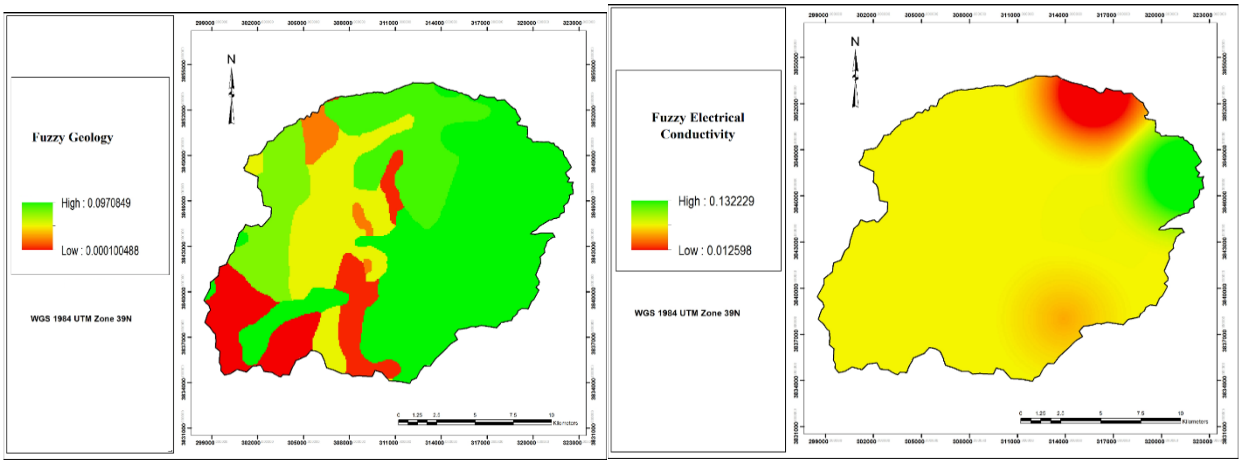


Fig. 6. Effective Fuzzified index on zoning

Based on the combination of fuzzy layers, the map generated based on the gamma function of 0.9 was determined as the final level of land suitability for locating the flood spreading areas, which categorized into five completely inappropriate, inappropriate, moderate, appropriate and perfectly suitable classes (Fig. 7) As well as the area of land parcels per hectare and calculated as percentages (Table 4). In the relevant classification, 42.49% were found to be an inappropriate and inappropriate class, 19.27% in the classroom with a moderate proportion, and finally 37.78% in the appropriate and appropriate classroom. According to the final map, the most suitable zone for flood spreading is in the east and south-east of the region, and then in the southwest of the region, due to the proper slope, having flood deposits are the most suitable areas for flood spreading. The central part of the plain is very small and moderate due to its high slope. Finally, the results show that the integration of the AHP / FUZZY model is a suitable model for the phenomena associated with the Earth's surface.

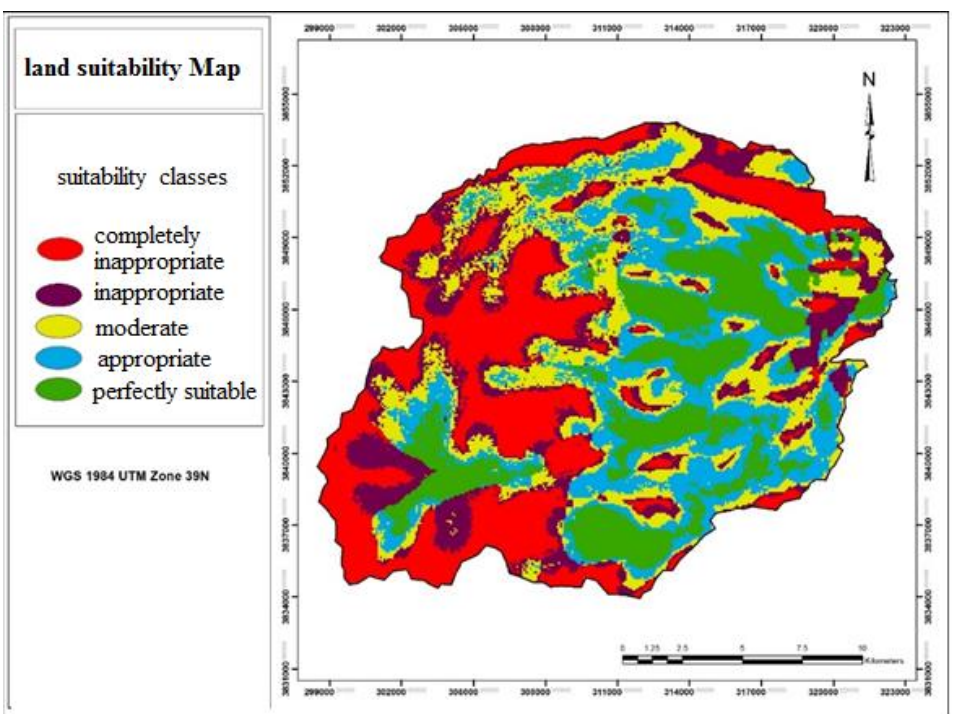


Fig. 7. Final land suitability map for zoning of flood spreading areas.

Table 4. Land suitability classes for zoning flood spreading areas

Land suitability classes	the area of land(hectare)	the area of land(percentages)
completely inappropriate	8609.90	25.57
inappropriate	5854.07	17.39
moderate	6480.31	19.27
appropriate	683501	20.30
perfectly suitable	5884.35	17.48

4. Concluding remarks

So far, enormous methods have been used for flood spreading, but the results of the combination of the two methods used in the present study indicate that, based on these criteria, one of the suitable methods for locating areas suitable for flood spreading, combining The fuzzy method is Analytic Hierarchy Process (AHP), because the fuzzy method uses fuzzy membership criteria, and the use of fuzzy capability to enter the decision-making point in the location stages increases the decision-making process and assures the locating results Increasing. In fact, the defect in the method of AHP is its inability to take into account the uncertainty of judgments in the matrix of paired comparison of criteria, which is eliminated by using fuzzy logic in the Ahp / Fuzzy combination method, and instead of considering an explicit number in a paired comparison, A range of values is considered to address uncertainty in the decisions of the decision makers. Therefore, considering the acceptable results of the Ahp / Fuzzy compilation method and considering the interrelationship between options and criteria, this combination method is a reliable and reliable method for decision making.

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