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The Spatial Modeling and Analysis of Ancient Sites of Khonj County Using Hybrid AND-GIS Analysis

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Abstract

In the new thinking of the scientific and academic community of Iran, applying science and guiding it to meet the fundamental needs of human society is one of the most important tasks. The identification of these phenomena with the help of GIS theoretical spatial sciences leads to the identification of how each of the human phenomena has been established in the past. Spatial modeling for spatial analysis and scattering of archeological sites in Khonj County is the main purpose of the present research. In terms of purpose and terms of methodology, this research is applied and descriptive-analytical, based on the library, model, and spatial studies. The selected indicators were collected in two stages by studying the records (research projects, statistics, books), using the viewpoints of the experts (taking advantage of Delphi's method and extracting the opinions of academic theorists and managers of related organizations), and they were integrated using the Delphi method. In this section, 14 indicators were identified, and then the ANP-Dematle hybrid analytical model was used to identify the effect of indicators and criteria on each other and ranking. Finally, they were overlapped by GIS software using fuzzy analysis. Research results show: the latitude variable (a3) has the highest impressment (0.120) and then variables of the gradient (c3) and height (b1) with impressment of 0.118 and 0.117 are in the next ranks, respectively. The results of the analysis of fourteener indicators in the ArcGis software environment, which are effective in determining the spatial scattering of 93 archaeological sites show that distance and proximity to water, good soil, and high altitude are some of the reasons for the formation of settlements in this county. The most important reasons that

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influence the settlement patterns of this region are dependence on three important characteristics: water, good soil for agriculture as well as suitable height.

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1. Introduction

Primitives were compelled to prepare the first maps with the need to display the phenomena in nature. Using the perception and tools of their time, they have recorded their perceptions of nature and even the supernatural on the walls of caves and shelters, rocks, temples, stones, hide, wood, and other materials, and have organized their geographical information in an organized way and the form of a graphic folder [1]. Traditionally, all these recordings were drawn on paper or film until the advent of computer systems and were only lines, dots, and surfaces that showed terrestrial and geographical information [2]. With the formation and development of mapping systems as templates - image for mathematical and narrative expression of the ideal situation of different phenomena - man realized that he could use the information and spatial resources for better and more accurate planning [3]. In the new thinking of the scientific and academic community of Iran, the application of science and its guidance towards meeting the basic needs of human society is one of the most important tasks. Using science and guiding it to meet the fundamental needs of human society is one of the most important tasks. Certainly, archeology in this transition, relying on the theoretical foundations and theories that evaluate both human beings and their environment [4] has a safe place to strive for human well-being. What is increasingly important in archaeological studies, with such a basis, is the emphasis on the fact that in an umbrella term assessment, the talents and apparent bottlenecks of the earth have been assessed as the basis on which human activities take place. Finally, solutions can be subjected through which the optimal operating conditions of these levels can be provided [5]. The natural and geographical factors are shown slightly within archeological studies concerning way and method of distribution of population centers, concentrated points, the role of geomorphological processes in fundamental changes, the permanent concentration of humans and even in the locations where these effects are characterized in displacement or destruction of habitats [6]. particularly, the effects of climate change, which is one of the most important factors influencing the way civilizations are known, have been overlooked in their studies and have sometimes been poorly viewed [7]. The roots of the development of the Geographic Information System (GIS) in archeology must be traced to an academic discipline in the late nineteenth and early twentieth centuries, in the emergence of spatial thinking in theoretical perspectives and the formation of anthropology. It can be said that in anthropological thought at the time - in very broad spatial terms - space was seen as a reference for describing the cultural diversity of a region [8]. Due to modern archeology, in the late 1960s, researchers turned to other disciplines such as geography and economics to use their methods and ideas for spatial analysis [9].

Looking specifically at geography can be said that ideas such as Weber's (1929) model of industrial sites and the central place theory of Chrystaler (1966) in the late 1960s were fully related to environmental perspectives and settlement patterns [10]. The identification of these phenomena, inter alia, with the help of GIS's theoretical spatial sciences, leads to the identification of how each of the human phenomena has been settled in the past. In other words, identifying the landforms in which the traces of past civilizations are evident is not very comprehensible with a field study, since new research tools and techniques along with theorizings - that have emerged over the past two decades about the spatial identity of human centers in the past - reveal a new perspective on

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the spatial identity of these civilizations [11]. Archeology has fully accepted official and quantitative spatial analysis, and most of the archaeological analysis and spatial analyzes were carried out very quickly in the geographic information system environment. The development of GIS activities in archeology over the past thirty years has been accompanied by the propagation of theoretical issues in anthropology and archeology, advances in computer technology, and increased access to them [12]. The Geographic Information System allows the user to enter, store, manage, analyze, retrieve, and model data in the program [6]. Utilizing this program to conduct special analysis in archeology on spatial thinking and to settle ancient sites and their scattering, meanwhile, forced us to pursue the goal of examining the spatial distribution and scattering of ancient sites in the Khonj County, using a geographic information system.

2. Study Scope

Khonj County is located in the south of Fars province and west of Larestan County [13]. In various centuries and historical and geographical sources, it is mentioned in various forms, the oldest of which is recorded as Hong [14]. Later, it changed into various forms such as Kooshk [15], Xonaj [16], Khonj Bal [17], Khonj Fal [18], Honj and Bal[1] [19], Honj, Xonj and Xowanj [20], Xowanj [21], Dar-Al-Uliya Fars [15]. Today, however, the name of this county is used in the form of Khonj [22, 23].
The county has two central regions i.e. Central and Mahmaleh (with the center of Mahmaleh village) and four rural districts of Seifabad, Tank Nark, Mahmala, and Baghan. Khonj is part of the Fars tropical region and its heights are part of the South Zagros mountain range [13]. Products such as dates, cereals, and cotton are produced in the plains between these heights [24]. The rangelands, plains, and pastures of its hillsides have long been the site of nomadic winter quarters [20, 24]. In 1943, Khonj was a rural district in Lar County that had four subordinate villages. In 1976, it became part of the Evaz section of the same county. In August 1989, it became a district and in March 2004, it became an independent county. The population of this county in the 2006 census was 37.978 people (Fars Province Statistical Yearbook [25]); the inhabitants are Muslims Sunnite, Shafi'i school [22] and they speak in Khonji - Larestani speech - dialect (Khonji[26]). The county of Khonj is located on a relatively large plain (Approximately sixty meters long and thirty kilometers wide), 265 km south of Shiraz, at an altitude of about 44 meters. The county is surrounded by the Lithe Mountains in the north, the Mohneh Mountain in the south, the Siahkooh and the Sorkhkooh in the west, and the Vera Mountain in the east [22]. The position of Khonj between the plain and mentioned mountains has exposed it to seasonal floods, as the damages caused by the floods entered the county in 1986 and 1992. In recent years, measures have been taken to build settlements on the slopes to eliminate the risk of flooding [24]. Khonj enjoys a long-time warm period and short winter and an average annual temperature of 20°C (Ibid: 181). The county has long been of communicative importance. The roads of Khonj to Firozabad and Shiraz, Khonj to Evaz and Lar (about 120 km in the east), and Khonj to Mahmaleh and Lamerd (in the south to about 120 km) are the most important (Iran-e-Emrouz, Full Map:[27]). Since 1966, Khonj became a city. Most of its people are active in trade (including with the Gulf States) [22].

[1]Bal is the same as Fal and it is a large area in Larestan and professor Vladimir Minorsky has also recorded titles of Bal and Pal under lexical entry of 'Lar' in Islamic Encyclopedia and today it is included in areas of Bikheh Fal and Galedar at Larestan zone. It seems old area of Khonj was located in Fal zone, but since Ibn Battuta has implied this term with 'and' as a conjunction (i.e. Honj and Bal) thus it is thought names of Khonj and Fal were mentioned together because they were two cultivate areas at that time and located at their neighborhood and gradually due to multiple uses of this term there were blended together as a single word [19]

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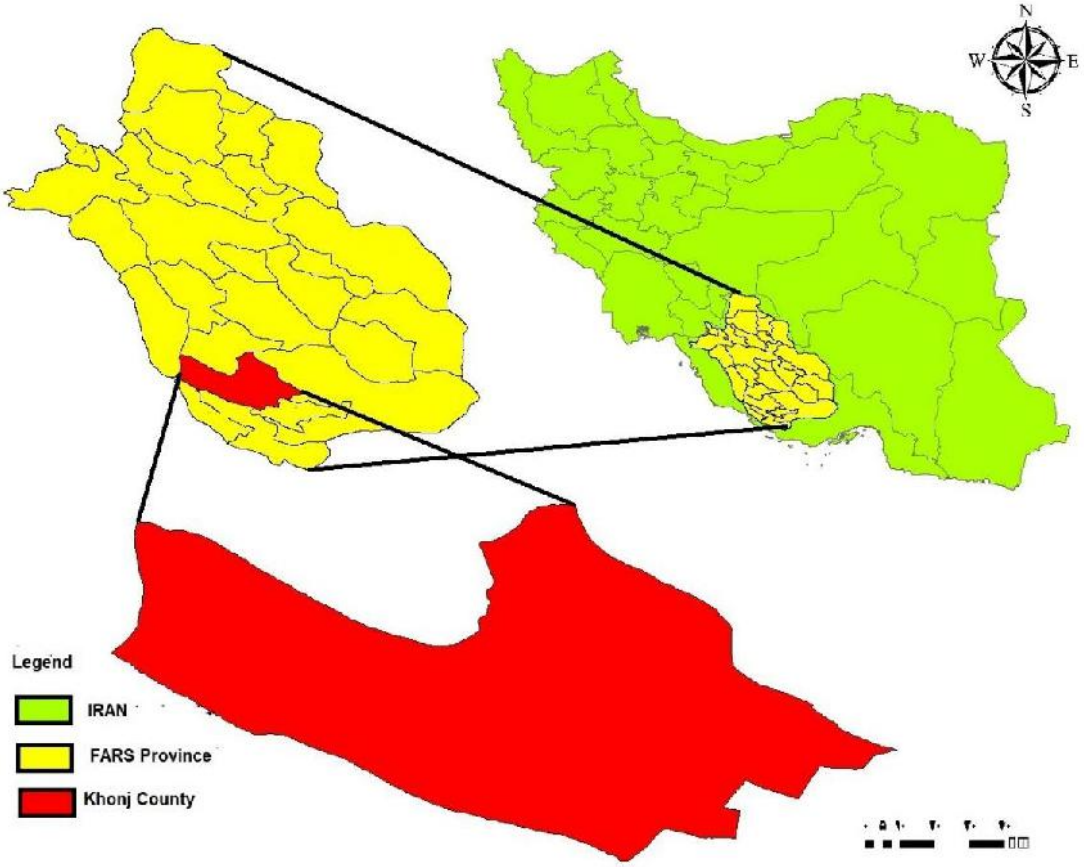


Figure 1: Geographic Situation of Khonj County

3. Methodology

In terms of the purpose of the study, the present study is applied one, and from the methodological point of view, it is considered as a descriptive-analytical. Through studying the research literature and domestic, foreign records as well as experiences to extract indicators, first, 14 indicators effective in the scattering of ancient centers and points in Khonj - using a survey of 20 experts and mergers, using the Delphi method - were identified and extracted in four villages. The meta-analysis was then performed on these indicators affecting the scattering of the ancient sites of Khonj and its effects were analyzed and inferred with an analytical procedure.

Table 1: Research Indexing

Parameters	Analysis code	Parameters	Analysis code
Distribution of urban centers	a1	Landform	c2
Distribution of rural centers	a2	Gradient	c3
Latitude	a3	Gradient direction	d1
Height	b1	Vegetation	d2
Precipitation lines	b2	Distance from river	d3
Uneven features	b3	Fault	e1
Geology	c1	Seismic points	e2

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According to the pattern of impressment and effectiveness in the process of determining the ancient sites of this city, after extracting some indicators, the combined technique ANP-Dematel has been used for modeling in the form of causal display of indicators, weight determination, and its priority; in such a way that the ultimate weight of the model used for the final and native model is used and it shows the results in three levels. Then, to standardize the maps and layers, to produce maps, the parameters were weighted and standardized through the AHP-Fuzzy model. Inter alia, the spatial analysis was performed through ArcGIS software, in this way, 93 archeological sites in this county were identified by the field studies of the author, and by overlapping these points, the status of each trace concerning the 14 indices was identified and ultimately the final status of the points was overlapped through the fuzzy model.

3.1. Dematel Method

One of the decision-making tools based on graph theory is the Dematel method, which enables us to plan and solve problems [28]. This methodology may be a validator for the interrelationships between variables, criteria, or a constraint for relationships in a developmental and systematic process. The final product of the Dematel process is the presentation of the involved factors as two groups of cause and effect as well as the relationship between them is as a perceptual structural model [29].

Step 1: Creating a General Impressment Matrix (Tc) and NRM:

At this stage, using the Dematel method, the Tc matrix is obtained after determining the threshold limit for the general relations (T) matrix, and according to that, the Network Relations Map (NRM) is drawn.

Step 2: Calculating of Unweight Super Matrix W:

The sum of the effects of each criterion concerning the criteria of other clusters in the overall impressment matrix is calculated and shown by the Dematel method in the Tc matrix. Initially, the overall Tc impressment matrix should be normalized. The impressment of the sub-criteria of each cluster or the main criterion about the sub-criteria of the other clusters is considered as separate matrices. The matrix is normalized in either of these matrices by dividing ingredients at any row to the sum of ingredients of the same row. The normalized overall impressment matrix of $T_c^a$is obtained by normalizing all matrices. This normalized value of the criteria effects in relation to the criteria of other clusters will be used in the ANP method to construct the unweighted W supermatrix.

Step 3: Creating an Overall Group Impressment Matrix:

An overall group impressment matrix is a matrix similar to the T_D matrix, each ingredient of which is obtained from the sum of all the ingredients of each of these matrices (their corresponding matrix). To normalize this matrix, the ingredient of each row is divided by the sum of the ingredients of the same row.

Step 4: Calculating the Weight Super Matrix:

The weight supermatrix W_w is obtained by composing of normalized overall group impressment matrix T_c^a with unweighting supermatrix W in equation 3.2.

$$W_W = T_D^a \times W \tag{3.1}$$

Step 5: Calculating Limited Super matrix:

To compute limited supermatrix, weight supermatrix W_w will be multiplied by itself so that the values of vectors of the limit matrix to become a fixed value. In other words:

$$\lim_{z\to\infty} W_W^Z \tag{3.2}$$

Where, Z tends to infinity. Limited supermatrix vectors indicate the relative weight of the criteria.

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3.1.1. Weighting using of (AHP-Fuzzy) model

A method called developmental analysis was proposed by Chang in 1992. This method was later improved by himself in 1996. Chang's extended method has been used more than any other method for fuzzy hierarchical analysis calculations. The numbers used in this method are fuzzy triangular numbers. To generalize the AHP technique to fuzzy space, Chang has used the concept of the degree of feasibility. The degree of feasibility is to determine how likely a fuzzy number is to be larger than another fuzzy number.

The concept of the degree of feasibility or the degree of probability of being larger should be explained before expressing Chang's proposed algorithm:

Take two these triangular fuzzy numbers F1 = (l1, m1, u1) and F2 = (l2, m2, u2).

If m1≥ m2 then the probability value for F2>F1 is 1. The probability for F2>F1 is the vertex of the intersected area between F1 and F2.

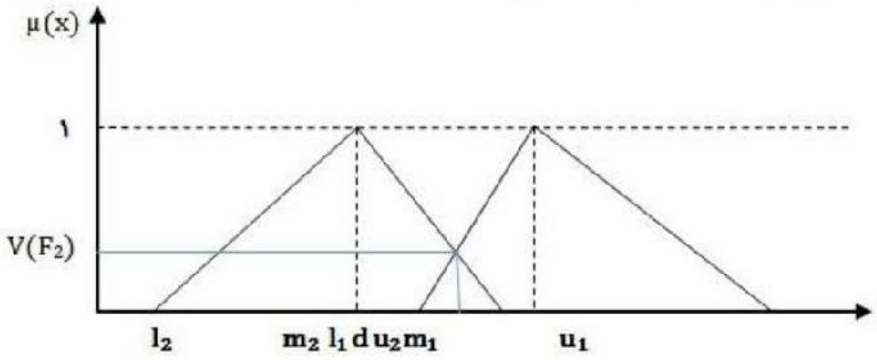


Figure 2: Fuzzy Model

4. Findings and Data Analysis

4.1. A: Research findings

After preparing the direct relations matrix and calculating the overall relations matrix by applying the threshold limit to filter some minor (insignificant) traces, the overall impressment matrix was calculated as (Table 2).

The sum of the rows and columns in the T-matrix is calculated and the vector R, as well as the vector C, is calculated, respectively, and the degree of impressment and effectiveness can be calculated. (Table 3)

The causal graph (Figure 2) is plotted according to the ordered pair (R_i + C_j, R_i - C_j). Criteria with a (R_i - C_j) value of less than zero are among the effectiveness (effect) criteria, and if they are greater than zero, that criterion will be impressment (cause).

4.1.1. Calculation of Relative Weights of Indicators

To calculate unweighted supermatrix, the T_C matrix should be normalized at first. To do this, the impressment of the sub-criteria of each criterion concerning the sub-criteria of other clusters is considered as separate matrices and each element is divided by the sum of the cluster row so that finally to calculate unweight matrix [30]. Then, we normalize the group impressment matrix.

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Table 2: Overall Impressment Matrix, Source: Authors (2019)

	a1	a2	a3	b1	b2	b3	c1	c2	c3	d1	d2	d3	e1	e2
a1	0	0.17	0.16	0.22	0.18	0.2	0.18	0.19	0	0.19	0.23	0.22	0.19	0
a2	0	0	0.13	0.14	0.11	0.14	0.15	0	0	0.11	0.15	0.14	0.14	0
a3	0	0	0	0.13	0	0	0	0	0	0	0	0.11	0	0
b1	0	0	0	0	0	0.13	0.11	0	0	0.13	0	0	0.13	0
b2	0	0	0	0.13	0	0	0	0	0	0.13	0.12	0	0.14	0
b3	0	0.17	0.17	0.2	0.19	0	0.16	0.14	0	0.16	0.17	0.17	0.15	0
c1	0	0.11	0.11	0.14	0	0.12	0	0	0	0	0.14	0.13	0.13	0
c2	0	0	0	0	0.11	0	0	0	0	0	0	0	0	0
c3	0	0	0	0	0	0	0	0	0	0	0.14	0.13	0.12	0
d1	0	0	0	0.12	0.13	٠	0.14	0.11	0	0	0.15	0.14	0	0
d2	0	0	0	0.13	0.12	0.15	0.13	0	0	0	0	0	0	0
d3	0	0	0	0	0	0.16	0.16	0.11	0	0.13	0.16	0	0	0
e1	0	0	0	0.18	0.17	0.11	0	0	0	0.14	0.18	0.18	0	0
e2	0.12	0.14	0.17	0.21	0.19	0.2	0.18	0.15	0	0.19	0.22	0.2	0.16	0

Table 3: The Sum of the Impressment and Effectiveness of each Criterion, Source: Authors (2019)

	a1	a2	a3	b1	b2	b3	c1	c2	c3	d1	d2	d3	e1	e2
R_i	2.33	1.22	0.23	0.49	0.52	1.67	0.88	0.11	0.39	0.79	0.53	0.73	0.97	2.14
C_j	0.12	0.6	0.74	1.59	1.2	1.2	1.21	0.71	0	1.18	1.66	1.42	1.16	0
R+C	2.25	1.82	0.97	2.08	1.72	2.87	2.09	0.82	0.39	1.97	2.19	2.15	2.13	2.14
R−C	2.01	0.62	−0.51	−1.1	−0.69	0.47	−0.33	−0.6	0.39	−0.39	−1.12	−0.69	−0.19	2.14

Table 4: Limited Super Matrix for Measuring Relative Weights of Sub-Criteria

	a1	a2	a3	b1	b2	b3	c1	c2	c3	d1	d2	d3	e1	e2
a1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
a2	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
a3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
b1	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
b2	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

4.2. B: The Analysis of the Findings

In this section, after extracting fourteener indicators by the participatory method by surveying experts using ANP-Dematel analytical-hybrid model, modeling was done to distribute the ancient

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sites of Khonj County. Weight and weighted scores were characterized for indicators in this model (Fig 2; Table 5). The determination of optimal parameters of the model, alternately, is assumed as one of the basic findings in this study.

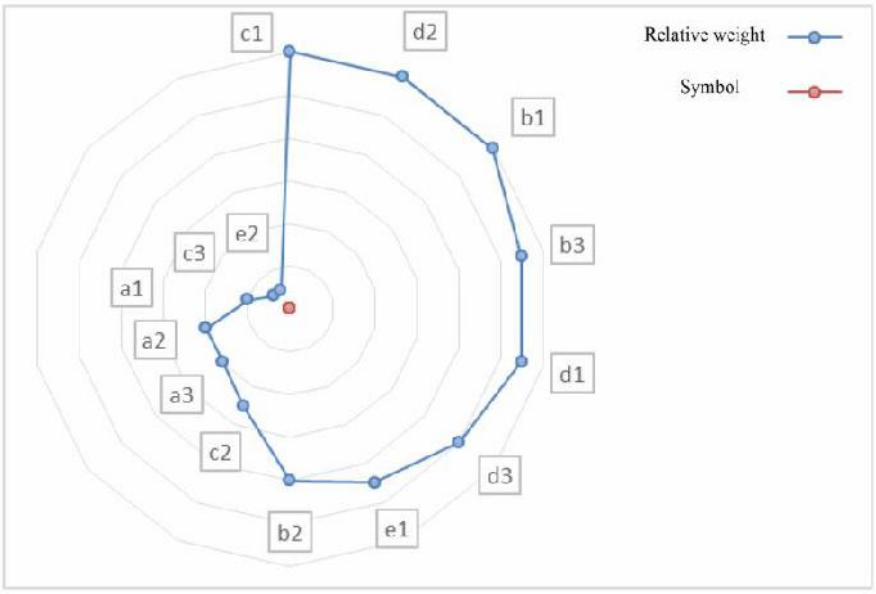


Figure 3: Results of Super Matrix and Diagram Weight Values of Sub-Criteria

Table 5: Limited Super Matrix and Ranks of Sub-Criteria and Major Criteria

Indicator	Symbol	Relative weight	Rank
Distribution of urban centers	a1	0.017	12
Distribution of rural centers	a2	0.035	11
Latitude	a3	0.120	1
Height	b1	0.117	3
Precipitation lines	b2	0.079	8
Uneven areas	b3	0.114	4
Geology	c1	0.040	10
landform	c2	0.047	9
Gradient	c3	0.118	2
Gradient direction	d1	0.108	5
Vegetation	d2	0.009	13
Distance from river	d3	0.100	6
Fault	e1	0.086	7
Seismic points	e2	0.008	14

According to the findings, the latitude (a3) criterion with the impressment of 0.120 is the most effective index, followed by the slope (c3) and altitude (b1) with the impressment of 0.118 and 0.117 are in the next ranks, respectively. In terms of effectiveness, similarly, sub-criteria of seismic points (e2) with the effectiveness of 0.008 is in the first rank and sub-criteria of distribution of urban centers

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(a1) and distribution of rural centers (a2) with the effectiveness of 0.017 and 0.035 are in the next ranks.

4.2.1. Weighting Using of (AHP-Fuzzy) Model

Due to the different coefficients of each of the selected indicators in the scattering of archeological sites, the multivariate weighting method (AHP-FUZZY) was used to determine the weighting of the indicators (Equation 1). Experts, at this phase, expressed preference of a criterion to another (or a class versus another) using lingual phrases and based on Chang's method, accordingly, pairwise comparison matrix formed. Table 6 shows the lingual phrases of pairwise comparisons for indicators. The linguistic terms of the pairwise comparisons of the indicators are shown in Table 6.

Table 6: The Lingual Phrases of Pairwise Comparisons for Indicators

Equal	Very low preference	A little preference	Preferred	Good	Relatively good	Very good	Excellent	Absolute preference
1, 1, 1	1, 2, 3	4, 3, 2	5, 4, 3	6, 5, 4	7, 6, 5	8, 7, 6	9, 8, 7	10, 9, 8

The weighted value of the fourteen selected indicators was first calculated using pairwise comparisons in the AHP-FUZZY model. To this end, a binary comparison table (Table 7) was formed and the weighted average of the survey was included by the Delphi method.

Table 7: (a) Pairwise Comparison by Fuzzy Numbers (A1 to A7)

	A1	A2	A3	A4	A5	A6	A7
A1	1،1،1	2،3،4	6،7،8	8،9،10	3،4،5	3،4،5	6،7،8
A2	1.2،1.3،1.4	1،1،1	5،6،7	5،6،7	2،3،4	2،3،4	4،5،6
A3	1.6،1.7،1.8	1.5،1.6،1.7	1،1،1	2،3،4	1.3،1.4،1.5	1.6،1.7،1.8	4،5،6
A4	1.8،1.9،1.10	1.5،1.6،1.7	1.2،1.3،1.4	1،1،1	1.4،1.5،1.6	1.4،1.5،1.6	5،6،7
A5	1.3،1.4،1.5	1.2،1.3،1.4	3،4،5	4،5،6	1،1،1	1.2،1.3،1.4	6،7،8
A6	1.3،1.4،1.5	1.2،1.3،1.4	6،7،8	4،5،6	2،3،4	1،1،1	6،7،8
A7	1.6،1.7،1.8	1.4،1.5،1.6	1.4،1.5،1.6	1.5،1.6،1.7	1.6،1.7،1.8	1.6،1.7،1.8	1،1،1
A8	1.6،1.7،1.8	1.3،1.4،1.5	1.4،1.5،1.6	5،6،7	1.5،1.6،1.7	1.5،1.6،1.7	2،3،4
A9	1.5،1.6،1.7	1.4،1.5،1.6	1.3،1.4،1.5	1.3،1.4،1.5	1.5،1.6،1.7	1.4،1.5،1.6	3،4،5
A10	1.5،1.6،1.7	1.4،1.5،1.6	1.5،1.6،1.7	1.2،1.3،1.4	1.6،1.7،1.8	1.5،1.6،1.7	1.2،1.3،1.4
A11	1.5،1.6،1.7	1.3،1.4،1.5	1.5،1.6،1.7	1.3،1.4،1.5	1.3،1.4،1.5	1.4،1.5،1.6	2،3،4
A12	1.3،1.4،1.5	1.3،1.4،1.5	1.3،1.4،1.5	1.5،1.6،1.7	1.2،1.3،1.4	1.3،1.4،1.5	1.2،1.3،1.4
A13	1.3،1.4،1.5	1.2،1.3،1.4	3،4،5	6،7،8	1.2،1.3،1.4	1.2،1.3،1.4	4،5،6
A14	1.1،1.2،1.3	1.3،1.4،1.5	3،4،5	7،8،9	1.1،1.2،1.3	1.1،1.2،1.3	5،6،7

Accordingly, $\sum_{j=1}^{m} = M_{gi}^{j}$ value is derived for each of rows of this matrix as follows:
Distribution of urban centers = (1+2+3+4+5+7+7), (1+3+4+5+6+8+8), (1+4+5+6+7+9+9) = (29), (35), (41)
Then, this mathematical expression $\sum_{i=1}^{n} \times \sum_{j}^{m} m_{gi}^{j}$ was used for calculation of each of rows:

$$\sum_{i=1}^{n} \times \sum_{j}^{m} m_{gi}^{j} \Rightarrow (29+23+12+11+9+4+3), (35+27+17+14+10+5+2) \\ (41+32+20+17+12+6+2) = (91.186), (110.09), (130.02) \tag{4.1}$$

Therefore, $\left(\sum_{i=1}^{n} + \sum_{j}^{m} m_{gi}^{j^{-1}}\right)$ value amounts the following after standardization:

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Table 7: (b) Pairwise Comparison by Fuzzy Numbers (A8 to A14)

	A8	A9	A10	A11	A12	A13	A14
A1	6،7،8	5،6،7	5،6،7	5،6،7	3،4،5	3،4،5	1،2،3
A2	3،4،5	4،5،6	4،5،6	3،4،5	3،4،5	2،3،4	3،4،5
A4	4،5،6	3،4،5	5،6،7	5،6،7	3،4،5	1.3،1.4،1.5	1.3،1.4،1.5
A4	1.5،1.6،1.7	3،4،5	2،3،4	3،4،5	5،6،7	1.6،1.7،1.8	1.7،1.8،1.9
A5	5،6،7	5،6،7	6،7،8	3،4،5	2،3،4	2،3،4	1،2،3
A6	5،6،7	4،5،6	5،6،7	4،5،6	3،4،5	2،3،4	1،2،3
A7	1.2،1.3،1.4	1.3،1.4،1.5	2،3،4	1.2،1.3،1.4	2،3،4	1.4،1.5،1.6	1.5،1.6،1.7
A8	1،1،1	2،3،4	4،5،6	3،4،5	3،4،5	1.3،1.4،1.5	1.4،1.5،1/6
A9	1.2،1.3،1.4	1،1،1	4،5،6	3،4،5	3،4،5	1.2،1.3،1.4	1.3،1.4،1.5
A10	1.4،1.5،1.6	1.4،1.5،1.6	1،1،1	3،4،5	1.2،1.3،1.4	1/2،1.3،1.4	1.4،1/5،1.6
A11	1.3،1.4،1.5	1.3،1.4،1.5	1.3،1.4،1.5	1،1،1	3،4،5	1.4،1.5،1.6	1.4،1.5،1.6
A12	1.3،1.4،1.5	1.3،1.4،1.5	2،3،4	1.3،1.4،1.5	1،1،1	1.2،1.3،1.4	1.3،1.4،1.5
A13	3،4،5	2،3،4	2،3،4	4،5،6	2،3،4	1،1،1	1.2،1.3،1.4
A14	4،5،6	3،4،5	4،5،6	4،5،6	3،4،5	2،3،4	1،1،1

$$\left(\sum_{i=1}^{n}+\sum_{j}^{m} m_{gi}^{j^{-1}}\right) \Rightarrow \left(\frac{1}{91.186}\cdot\frac{1}{110.09}\cdot\frac{1}{130.02}\right) = (0.011),(0.009),(0.008) \qquad (4.2)$$

Accordingly, S_1-value amounts the following for each of rows in pairwise comparison matrix:

$$(29,35,41)^{*}(0.011,0.009,\ \text{and}\ 0.008) = (0.319,0.319,\ \text{and}\ 0.316) = s_1 \qquad (4.3)$$

Finally, the magnitude of each of the S values relative to each other is obtained. The analysis on finding utilizing the AHP-Fuzzy model may indicate that the parameter of uneven areas has the highest weight value (0.096) among research indicators and then indicators of precipitation lines and landform have respectively devoted subsequent higher preferences with (0.094) and (0.090).

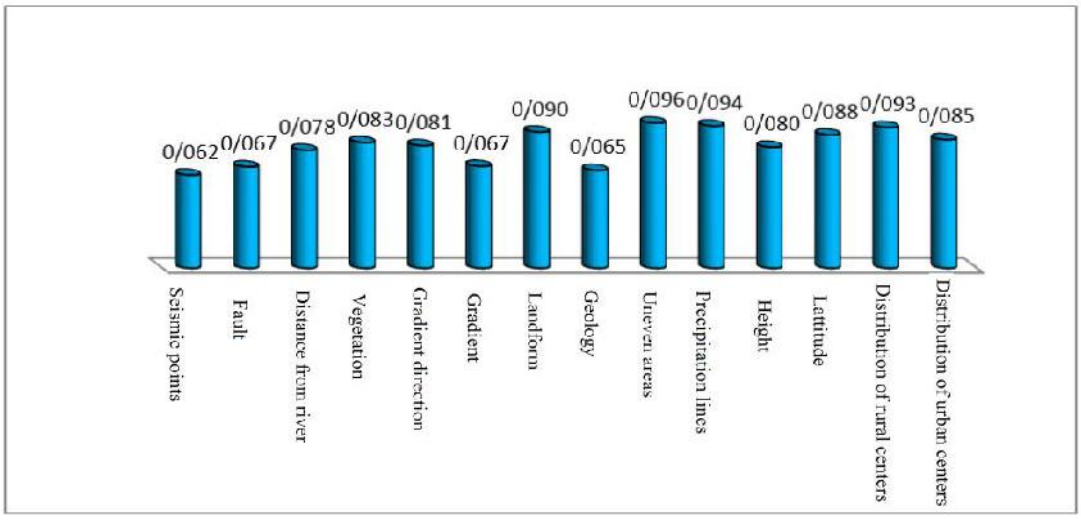


Figure 4: Standard Value for AHP-Fuzzy Model

In the continuation of this analysis, the status of 14 indicators for 93 archeological sites identified by the author was identified using ArcGIS software. It should be noted that the results of the spatial analysis section are consistent with the model studies.

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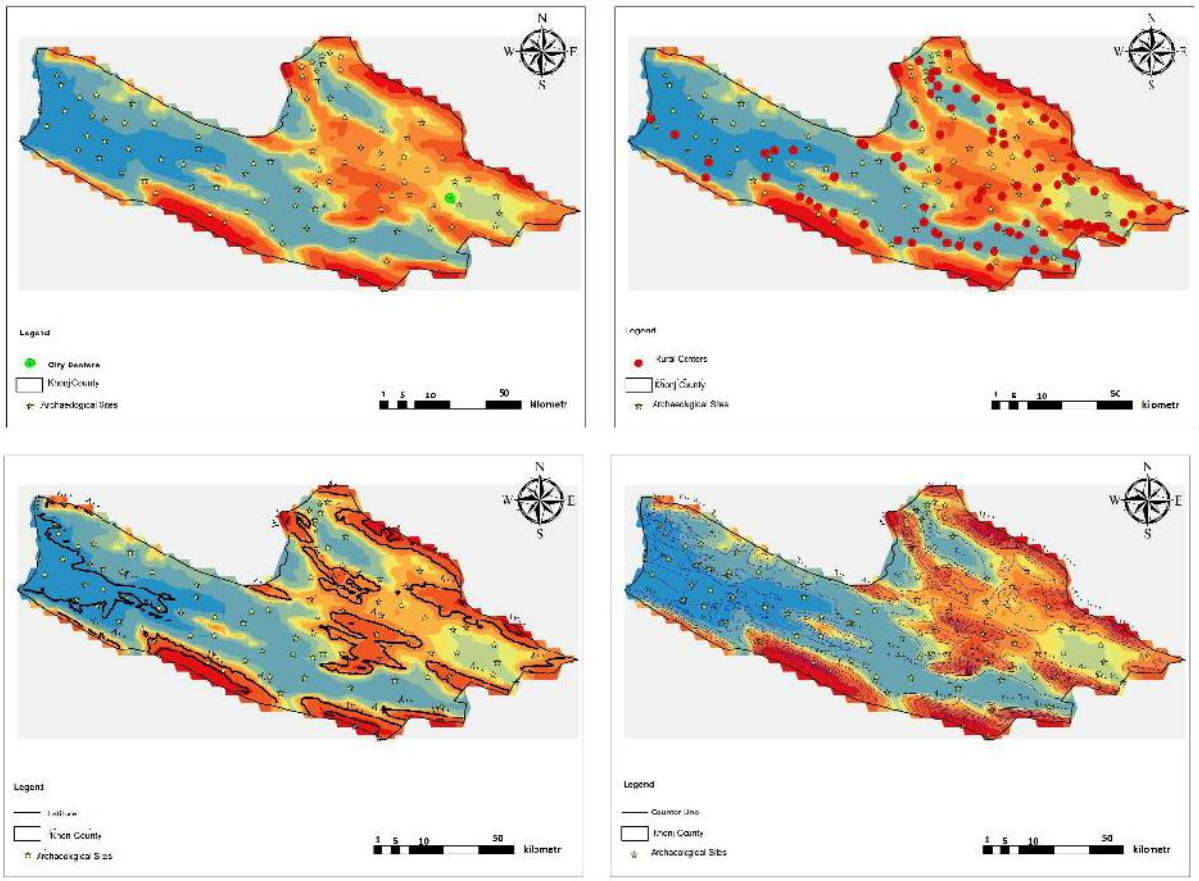


Figure 5: Status of Distribution Centers of Urban Centers, Distribution of Rural Centers, Latitude, and Height

As we can see from the results of the spatial analysis section of the ArcGIS software:
Concerning landscapes and ambient geographical features, this analysis may display and interpret the settlement pattern for 93 landscapes in Khonj city at any period and zone. This analysis shows that distance, proximity to water, good soil, and specific height are the reasons for the formation of settlements in this county. One of the most important reasons that affect the settlement patterns of this region is its dependency on three important characteristics, i.e. water, good soil for farming, and suitable height. By producing new data, GIS software may show it well how the relationship is between settlements and ambient resources with these settlements.

5. Conclusion

With the formation and development of mapping systems as patterns for human mathematical and narrative expression, the formation of the ideal state of various phenomena, the man realized that he could use the information and spatial resources for better and more accurate planning. The natural and geographical factors are shown slightly within archeological studies concerning way and method of distribution of population centers and concentrated points and role of geomorphological processes in fundamental changes and permanent concentration of humans and even in the locations where these effects are characterized in displacement or destruction of habitats. Climate effects, particularly, have been overlooked as one of the most important factors influencing the development and sustainability of well-known civilizations in their studies and have sometimes had a weak view

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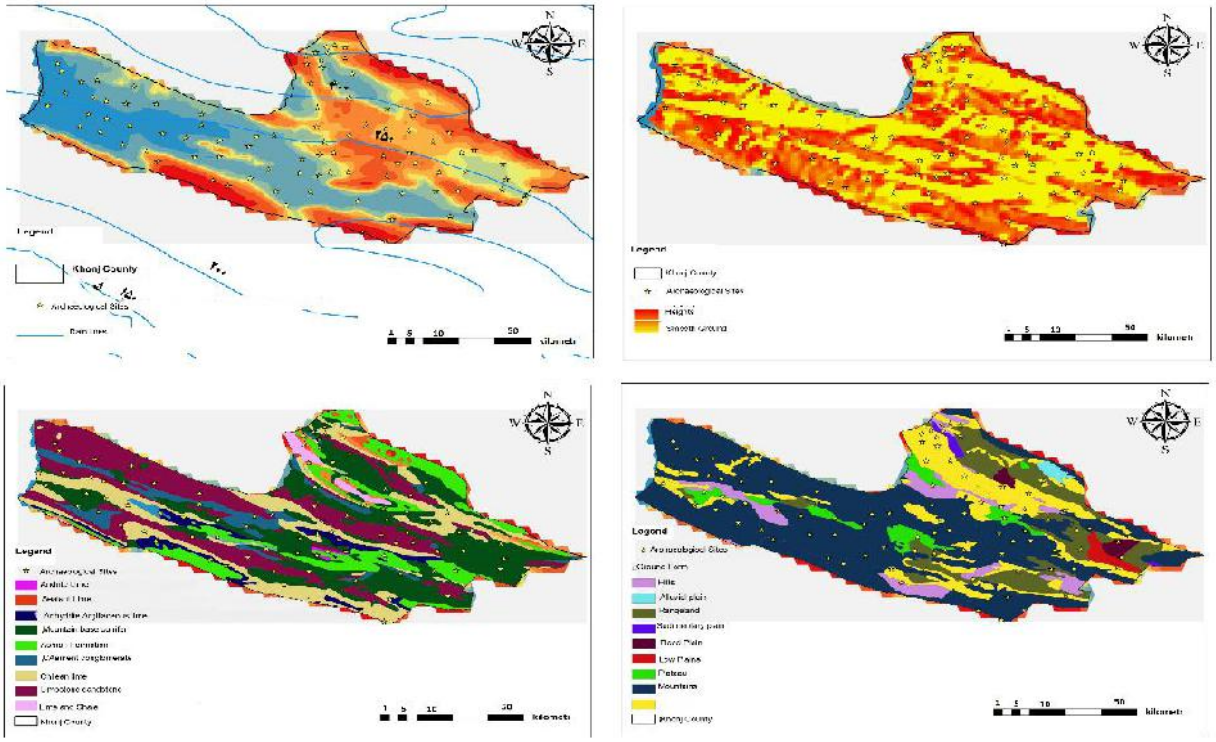


Figure 6: Status of Precipitation Indicators, Unevenness, Geology, and Landform

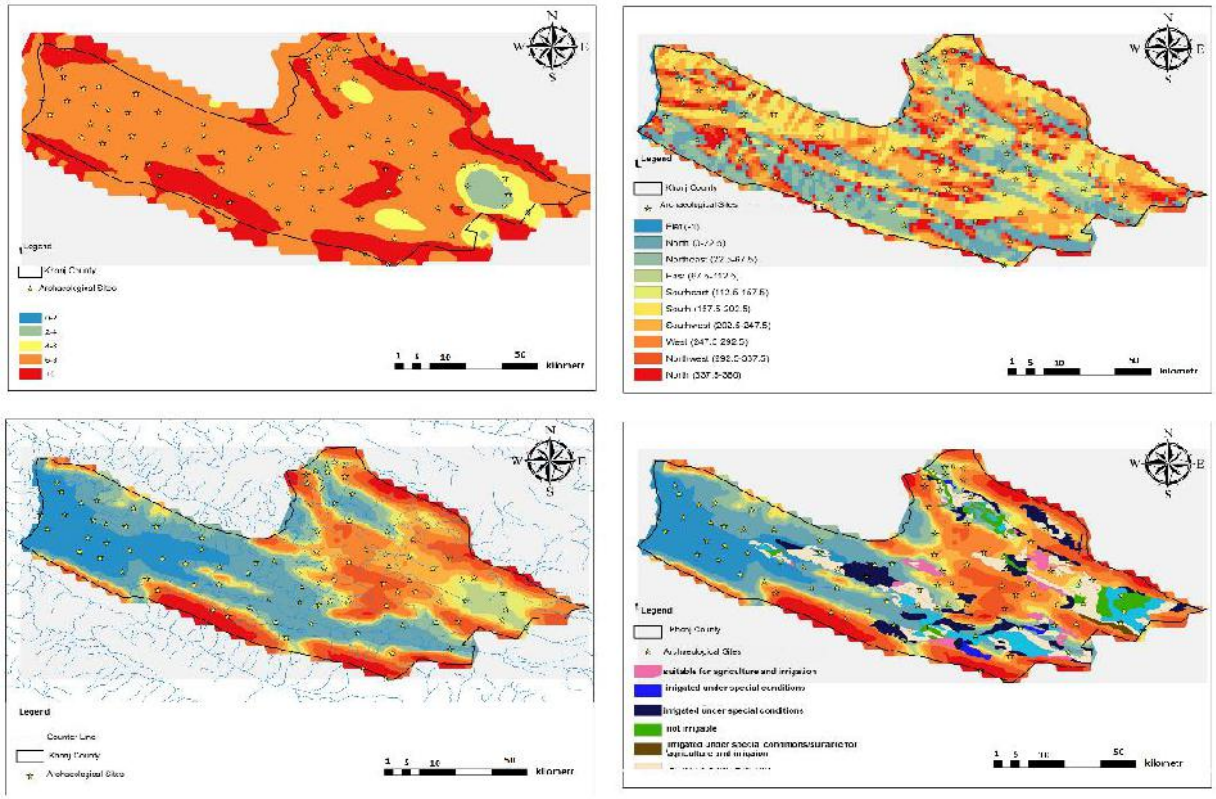


Figure 7: Situation of Slope Indicators, Slope Direction, Vegetation, and Distance from the River

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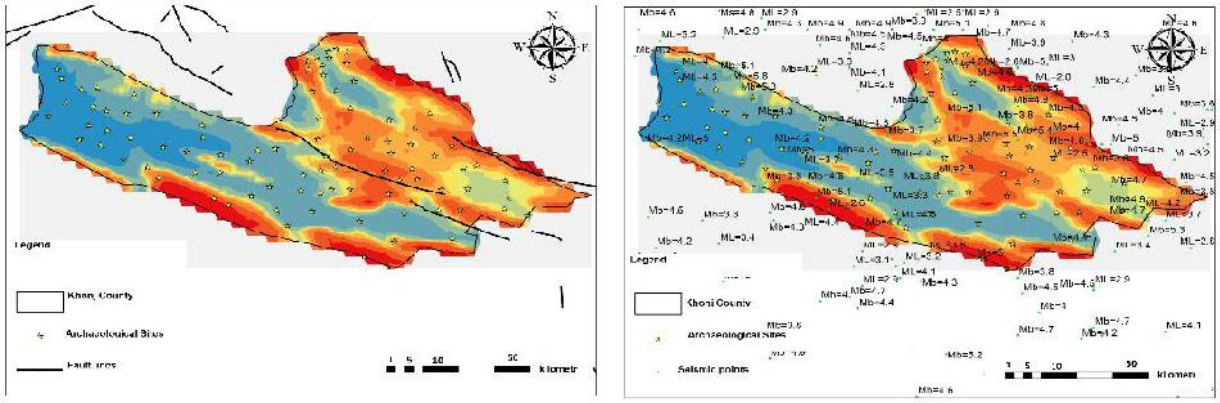


Figure 8: Status of Fault Indicators and Seismic Points

of it.

The findings resulted from analysis on the hybrid model show that, according to the findings, the latitude (a3) criterion with the impressment of 0.120 is the most effective index, followed by the slope (c3) and altitude (b1) with the effectiveness of 0.118 and 0.117 respectively, are in the next ranks. Likewise, in terms of effectiveness, sub-criteria of seismic points (e2) with the effectiveness of 0.008 is in the first rank and sub-criteria of distribution of urban centers (a1) and distribution of rural centers (a2) with the effectiveness of 0.017 and 0.035 are in the next ranks.

The results derived from analysis on 14 parameters in the effective medium of ArcGis software for determination of the spatial distribution of 93 archeological sites may show that variables of distance and proximity to water and suitable soil, certain height are considered as the reasons to the formation of settlements at this county. The dependency on three important properties i.e. water, suitable soil for farming, and appropriate height are assumed as the foremost reasons that can affect settlement patterns in this zone.

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