Geography and human relationships, vol7, no3, Winter 2025, pp:113-134

Modeling the Relationship between Environmental- Natural Variables with the Spatial Distribution of Castle Settlements of East Azerbaijan by using ARAS model and GIS

Parviz Pourkarimi, Karim Hajizadeh

Assistant Professor, Department of Tourism Management, Faculty of Management and Accounting, Allameh Tabataba'i University, Tehran, Iran., p.purkarimi@atu.ac.ir
Full Professor, University of Mohaghegh Ardabili, Department of Archaeology, Ardabil, Iran, k_hajizadeh@uma.ac.ir

Submit date: 2024.02.26 accept date: 2024.04.09

Abstract

In past times, castle settlements as one of the centers of human collective life was affected by various environmental-natural variables such as climate, elevation, distance from the river, land form, slope, aspect, soil type and vegetation. In this regard, the present study is based on field and documentary data and using ARAS model and GIS, seeks to model the relationship between environmental-natural variables with the spatial distribution of castle settlements of east Azerbaijan province. Based on obtained date from field and documentary studies, 100 castle settlements from different prehistoric, historic and Islamic periods in the geographical area of East Azerbaijan province were identified and evaluated, which are forming materials and statistical society of this research. to analyze the data, after forming the database, spatial distribution of the identified castle settlements were evaluated and analyzed in relation to the variables of climatic classes, elevation levels, land use/vegetation, soil type, slope, aspect, distance from the river and land form. Findings of these data analysis in the form of ARAS model show that distance from the river, land form (plain and mountain) and elevation levels have the most effect on the spatial distribution pattern of these settlements. Other natural variables such as climatic classes, slope, soil type, land use/ vegetation and aspect have been effective in the spatial distribution of these settlements in terms of importance and impact, respectively.

Key words: east Azerbaijan, natural factors, castle settlement, ARAS model.

doi: 10.22034/GAHR.2024.444197.2063 ESSN: 2645-3851

1. Introduction

Archaeology as a scientific system for processing models and creating logical analogies and reconstructing natural environment was owed to geography and in reconstruction of the natural environment of the past of human settlements is related with environment and landscapes inseparably; because special patterns of formed life on earth are results of interactive effects that existed between human and environment. Human influence from natural environment always provides the causes of spatial distinction in terms of population density and settlement and causes to form special patterns of settlement in different historical periods (Rezaei, 2018: 8). The effect of natural factors in formation and distribution of human settlements had been more than other factors; as such natural environment was the bed for all human activities and had much effect on settlement and human settlements function. Human influence and his settlements were of natural factors, function of knowledge and his technical skills and had an inverse relationship with it. As such, the lower the human technical knowledge is in the face of natural environment, the greater its impact, and vice versa (Mousavi Kouhpar and et al, 2011: 2). In past, natural factors and mainly water played a determining role in location and formation of human settlements. The primary core of emerging and forming human societies and human settlements since its inception, whether in the form of nomadism or sedentism was along water resources such as rivers and springs and water was the source of rise and fall of civilizations on the earth. In addition of water resource, elevation and topography, climate, vegetation, geographical situation and other natural-environment elements had been effective in location on point for settlement and formation of human settlements and spatial distribution pattern of these settlements.

Castle settlements as one of the first forms of human social life in the natural arena was specifically related to environmental and natural factors and discussion about why and how these settlements came into being is not possible without considering natural- environmental factors. In between, castle settlements of east Azerbaijan province which were built in different historical periods were effected by natural- environmental conditions seriously and effect of natural- environmental conditions of east Azerbaijan in emerging castle settlements is undeniable. At the same time, answering to these questions will be difficult that which natural factor was the main factor in choosing a place to build a castle settlement? Is the combination and importance of several factors simultaneously visible in these settlements? How was the spatial distribution pattern of castle settlements of East Azerbaijan province and how have natural- environmental factors been influential in this regard? In this research, these topics are findable. In fact, current study aims to evaluate and rank the natural factors affecting on the location, formation and spatial distribution of castle settlements of East Azerbaijan province based on archeological and geographical studies.

2. Research background

4- Study and knowing elements and effective factors in location, formation and spatial distribution of human settlements are of the most important discussion that from the distant past attracts the attention of thinkers and researchers in related fields and various theories and models have been proposed to evaluate and rank the impact of these elements. In this regard, some researchers evaluate and analyze the effect of natural- environmental factors on

spatial distribution of human settlements of past period such as cities and archeological sites, but in no research have addressed the issue of natural- environmental variables in spatial distribution of castle settlements of east Azerbaijan province. Therefore, present study aims to evaluate and rank effective natural- environmental variables in spatial distribution of castle settlements of east Azerbaijan province by using field data and relying on the findings and results of previous studies. Table (1) lists the studies that are closely related to the subject of this research.

Table 1: Research background

Researcher	Findings
Mousavi Kouhpar and et. al, (2011)	Based on research results, among variables of elevation, weather, distance from the river, vegetation and precipitation rate, two factors of elevation and weather are the most effective environmental factors in formation of ancient settlements of Mazandaran province.
Maghsoudi and et. al, (2012)	In this research, the way of distribution of ancient sites is evaluated in relation to variables of climate, slope, geology, distance from the river, geomorphology, land use and elevation and results show that in plains and foothills, the least coefficient of variations belongs to the factor of distance from the river.
Heidarian and et. al, (2013)	Results show that elevation, slope, vegetation and distance from the river had more effect than other natural factors on ancient sites distribution. Although, other factors also have a role in this relation.
Bahraminia and et. al, (2014)	Based on research results, among variables of elevation, slope, aspect, distance from the river, distance from the connecting road, land structure and existed faults, distance from the river factor has the most effect on spatial distribution of ancient sites.
Aftab and et. al, (2015)	Study results show that access to water resources, precipitation, weather; land use and land form had the most effect on scattering ancient centers of west Azerbaijan province.
NaseriSome and Niknami (2017)	Findings show that region characteristics, specially water resources, elevation and climate are of important factors in forming establishment patterns of BostanAbad county. In between, rivers' role causes that sites form in a line pattern method along with rivers' flow.
Maghsoudi and et. al, (2016)	Based on research results, most of settlements are established at the end part of the alluvial fans. Among this, Transverse displacement on alluvial surface was mostly due to change of channel bed or flood events.

Shaikhi and et. al, (2016)	In this research, variables of distance from springs, distance from rivers, distance from aqueducts and water wells, distance from malraux roads and distance from cemeteries are evaluated as effective variables in scattering ancient sites. Based on research findings, distance from permanently rivers had the most effect on establishing ancient places.
Behzad and Asadian (2017)	Based on research results, among variables of elevation, slope, geographical directions, precipitation, temperature, erosion, distance from river, distance from fault, land use and type of geological formation, three factors of precipitation, geographical direction and type of geological formation have the most effect on antiquities destruction.
RiahiyanGohorti and et. al, (2019)	Basd on research results, elevation from sea and the way accessing to water resources have the most role in location and form of studied region settlements. Based on this, the role of environmental factors are important in tradition of migration and relocation within the region and evaluation of scattering the settlements are based on the chronology stone and copper which indicates an increase in population in this area.

3. Research method

Every scientific research needs to apply instruments and models for doing considered methods. Study method in present research is to evaluate and rank the natural factors affecting on spatial distribution of castle settlements of studied region in terms of entity and research method is descriptive- analytic and data gathering method is library and field. Required information for this research are gathered in theoretical foundations section by library and documental method and quantity data and geographical coordination of castle settlements of studied region are obtained by using GPS and statistical reports of general directorate of cultural heritage, handicrafts and tourism of east Azerbaijan province. In order to show the spatial distribution of castle settlements, Arc GIS software and data analysis of ARAS multi-criteria method are used.

5-

4. Studied area

Eest Azerbaijan province by area of 45491 square kilometers, specifies about 2.8 percent of total area of Iran to itself. This province is located in the northwest of Iran and between orbits of 36 degree and 45 minutes to 39 degree and 26 minutes of northern latitude and meridians of 45 degree and 5 minutes to 48 degree and 22 minutes of eastern longitude. The Aras River specifies its northern borderline with the Republics of Azerbaijan, Armenia and Nakhjavan Autonomous state. This province has a common borderline of 200 km with Azerbaijan Republic and 45 km with Armenia, whereas it has a common borderline in north, it is the only province of Iran which is neighbor with Armenia. The Qotur River and waters of Urmia Lake also form its western border with west Azerbaijan province. East Azerbaijan has 420 km border with west Azerbaijan in the west and southwest, 400 km border

with Ardabil province in the east and 145 km border with Zanjan province in the south (National Planning and Budget Organization, 2016: 39).

6-

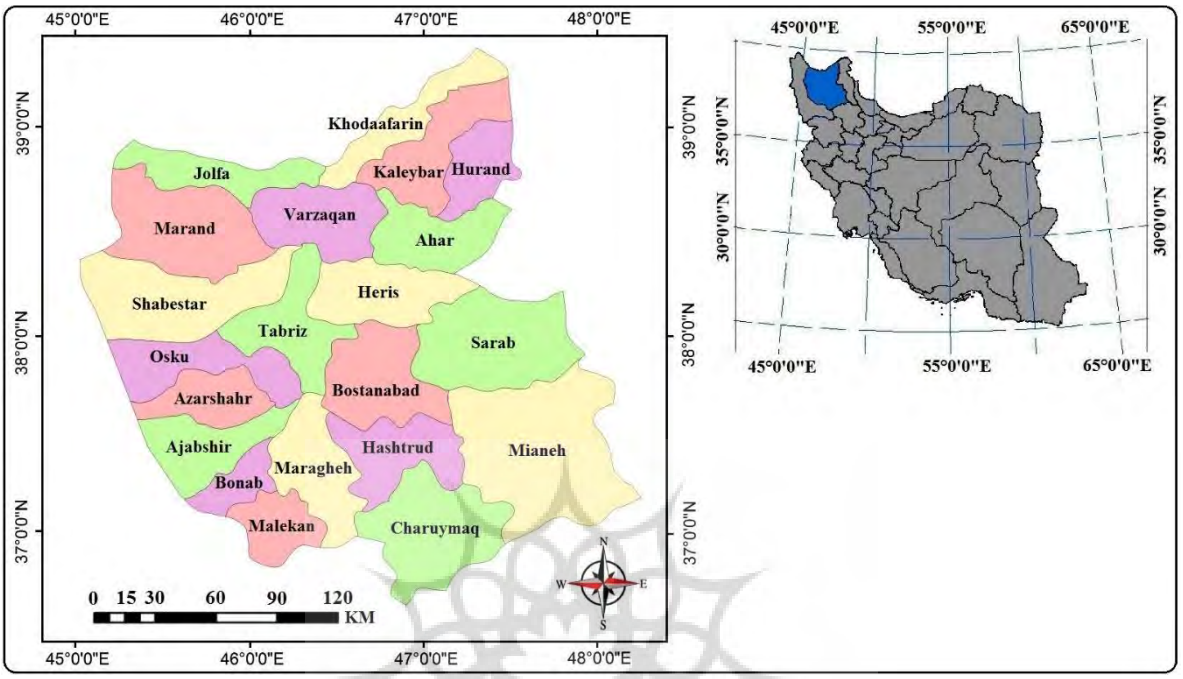

Figure 1: Location of East Azerbaijan Province in Iran

5. Research findings

1.5. Spatial and temporal distribution of castle settlements of east Azerbaijan province

Based on library and field surveys and by using data and statistical reports of general directorate of cultural heritage, handicrafts and tourism of east Azerbaijan province, 100 castle settlements in east Azerbaijan province were identified and evaluated. These castles have been shown by digitizing on polygon maps by using GIS software with different colors. Some of castle settlements are single-period and are characteristics for a special period, but many of castles have several settlement periods which numbers and their percent are listed separately in table (2), and all percentages are based on the total summation of province castle settlements.

Table 2: Distribution of castle settlements in East Azerbaijan province by County, area and period

County	Area (km2)	Per.	Number of castles	Per.	Prehistoric	Per.	Historic	Per.	Islamic	Per.
Khodafarin	1526	3.35	12	12	1	2.5	8	10.25	6	10.52
Kaleybar	2072	4.55	12	12	7	17.5	11	14.10	3	5.26
Hurand	1670	3.67	1	1	0	0	1	1.28	0	0
Jolfa	1670	3.67	3	3	0	0	2	2.56	3	5.26
Marand	3286	7.22	5	5	2	5	5	6.41	3	5.26
Varzeqan	2368	5.20	14	14	9	22.5	12	15.38	7	12.28
Ahar	1404	3.10	6	6	4	10	4	5.12	1	1.75
Heris	2345	5.15	4	4	2	5	3	3.84	3	5.26
Sarab	3452	7.60	7	7	5	12.5	6	7.70	4	7.01
Mianeh	5595	12.30	10	10	2	5	7	8.97	6	10.52
Bostanabad	2795	6.15	2	2	0	0	1	1.28	2	3.5
Hashtrud	1990	4.37	5	5	2	5	2	2.56	3	5.26
Charuymaq	3208	7.05	2	2	1	2.5	1	1.28	2	3.5
Tabriz	2167	4.76	3	3	0	0	2	2.56	3	5.26
Shabestar	2630	5.78	1	1	0	0	1	1.28	1	1.75
Osku	1763	3.88	2	2	0	0	2	2.56	2	3.5
Azarshahr	840	1.85	0	0	0	0	0	0	0	0
Ajabshir	738	1.62	3	3	1	2.5	3	3.84	1	1.75
Bonab	779	1.71	2	2	2	5	2	2.56	1	1.75
Malekan	1007	2.22	2	2	0	0	1	1.28	2	3.5
Maragheh	2186	4.80	4	4	2	5	4	5.12	4	7.01
Total	45491	100	100	100	40	100	78	100	57	100

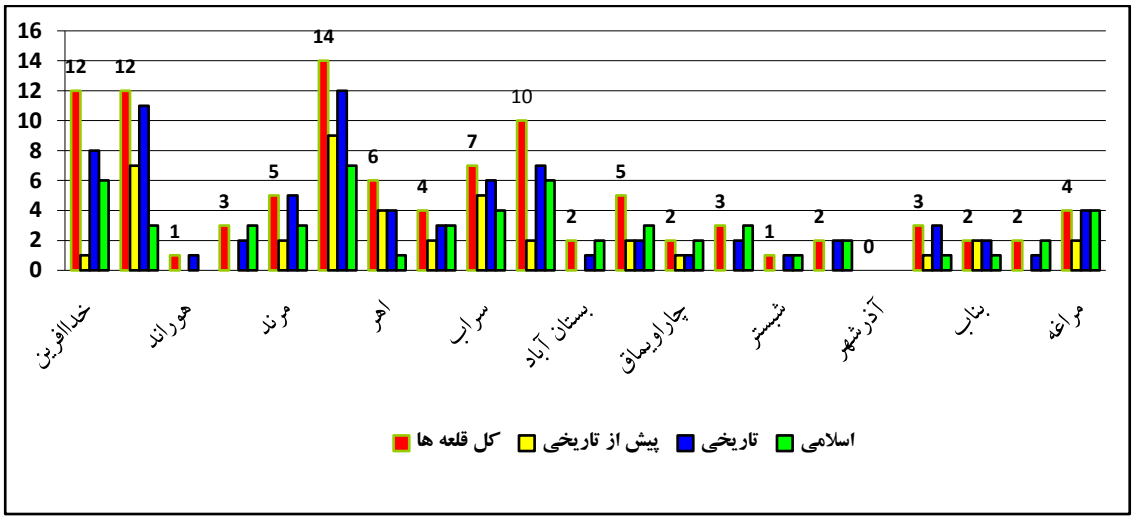

Figure 2: Distribution of castle settlements in East Azerbaijan province by County and period

2.5. Effective natural-environmental factors in spatial distribution of castle settlements of east Azerbaijan province

Various environmental- natural factors have an impact on the location, formation and spatial distribution of castle settlements in east Azerbaijan province, which 8 cases of these factors are evaluated in spatial distribution of these settlements in the following:

1.2.5. Climatic classes

Climatic is effective in settlement system of geographical settlements directly or indirectly. In fact, climate effects on weather directly and effects on roughness, water resources and vegetation indirectly and finally determine the livelihood system (Saidi, 2010: 5). Climate and weather have an important effect on human life from past period up to now. Archeologically, formation of human settlements in every region is effected by environment and the climate of that region. Based on obtained data, the most climatic extension in east Azerbaijan province is semi-arid climate (52.73%) and the most distribution of castle settlements of this province is in this region (50 castle). The least climatic extension of this province is related to dry climate (1.09%) which in this type of climate, there are three castle settlements (table 3). Based on this, spatial distribution of castle settlements of east Azerbaijan province in relation with climatic classes has been shown in figure (3).

Table 3: distribution of castle settlements of East Azerbaijan in different climatic classes

Climate classes	Area (km2)	percent	Number of castles	percent
Arid	497.4237	1.0965	3	3
Semi-arid	23920.3349	52.7331	50	50
Mediterranean	8650.4283	19.0701	23	23
Sub-humid	7501.2695	16.5367	14	14
Humid	3594.2012	7.9235	8	8
Super-humid	1197.4175	2.6397	2	2

2.2.5. Elevation levels

Form and land face and especially elevation factor is very effective in distribution and formation human settlements. Basically, very high altitudes do not attract people. Generally, very high elevation is undesirable and difficult for settlement due to slope, lack of soil formation, difficulty in communications, pressure decreasing and low oxygen (Istalaji and Ghadiri Masoom, 2005: 126). Sites distribution in different elevation levels is one of the important factors that are important in ancient centers. The elevation factor, in addition to argue roughness or smoothness of ancient settlements bed, also effects on amount of precipitation and vegetation by decreasing temperature and thus the richness of vegetation. According to direct relationship of the elevation increase in decreasing temperature and frosting, ancient sites compaction will be very low in very high areas (Rezaloo and et. al, 2018: 351). In evaluation of spatial distribution of castle settlements in east Azerbaijan province, place situation of these settlements are evaluated in relation to sea level. Based on obtained data in relation to elevated points of east Azerbaijan province, most of spatial distribution of castle settlements is located in altitude between 1000 to 2000 meters (73%). This is because of providing better defensive conditions in more elevation which castles builders have paid especial attention to it from the distant past. As this altitude (1000 to 2000 m), decrease or increases, the distribution of castle settlements decreases; so that at altitude of more than 2500 meters castle settlements cannot be found (table 4). Based on this settlements' elevation from sea level has been shown in figure (4).

Table 4: Distribution of East Azarbaijan Castle Settlements at different elevation levels

Elevation floors (m)	Area (km2)	percent	Number of castles	percent
0-500	865.5163	1.90	4	4
500-1000	2279.0763	12246.1809	10	10
1000-1500	12246.1809	26.93	32	32
1500-2000	19921.5944	43.81	41	41
2000-2500	7999.8944	17.59	13	13
Over 2500	2153.6290	4.73	0	0

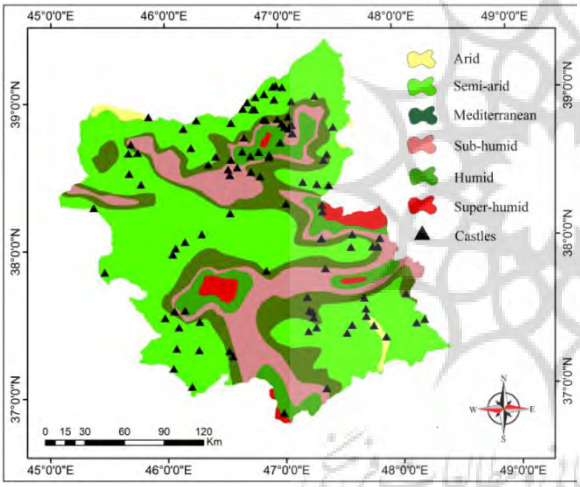

Figure 3: Spatial distribution of castle settlements of East Azerbaijan in different climatic classes

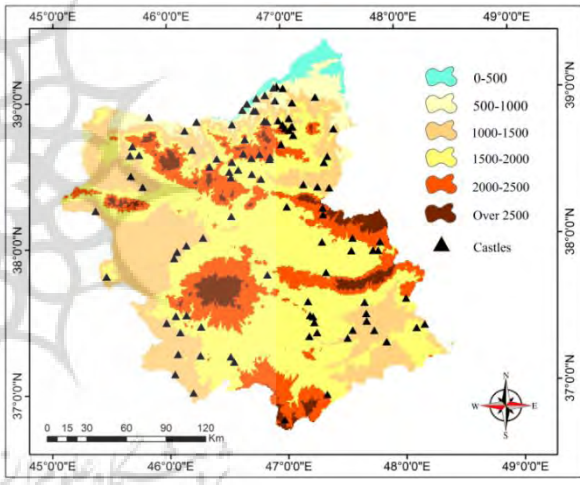

Figure 4: Spatial distribution of East Azarbaijan castle settlements at different elevation levels

3.2.5. Land use and vegetation type

Studying the pattern of ancient centers distribution in relation to land use is noteworthy because it is likely that the area that currently used as pastures or agricultural lands had suitable lands for cultivation and uses of pasture for nomads. Therefore, it is argued that in the past, pastures and agricultural lands provided suitable conditions for human habitation; because in the past, humans were depended on places that along with enough lands for their cultivation could also hunt and gathering food (Seyed Sajjadi, 2005: 122). In studied region, Based on obtained data, pastures

(50.30%) has the most extension of land use in east Azerbaijan province and the most distribution of castle settlements were seen in this type of lands (48 castles) and agricultural lands (41 castles) (table 5). Based on this, spatial distribution of castle settlements of east Azerbaijan province in relation with land use and vegetation type has been shown in figure (5).

Table 5: distribution of East Azarbaijan castle settlements by land use and vegetation type

Land use	Area (km2)	percent	Number of castles	percent
Wasteland	1123.7957	2.47	0	0
Jungle	1577.2914	3.46	6	6
Residential	335.5065	0.73	5	5
Rock	42.8489	0.09	0	0
Pasture	22884.7319	50.30	48	48
Water bady	38.5605	0.08	0	0
Agriculture	19487.9583	42.83	41	41

4.2.5. Soil type

Soil is influenced by climate, geological features, roughness, water resources and vegetation in every region has different capabilities for different agricultural products and as a result it effects on region livelihood structure and settlement pattern of human settlements. Therefore, in the distribution of ancient settlements, soil quality and quantity has been very important for its further exploitation. Based on obtained data of soil type layer, east Azerbaijan province has nine types of soil, which "Inceptsols" type have the most expansion (42.90%). The most distribution of castle settlements of this province is in "Rock outcrops/ Enistols" soil (37 castles) and then "Inceptsols" soil (32 castles) and "Rockoutcrops/ Enistols" soil (19 castles); whereas in "Water Body" soil and "Bad lands" soil, no castle settlement has not been seen (table 6). In evaluation of spatial distribution of castle settlements of east Azerbaijan province, location pattern of these settlements are considered in terms of soil type. Based on this, the effect of soil type in location and spatial distribution of castle settlements of east Azerbaijan province has been shown in figure (6).

Table 6: Distribution of East Azarbaijan Castle Settlements by Soil Type Classes

Soil type	Area (km2)	percent	Number of castles	percent
Aridisols	5104.1384	11.16	9	9
Entisols/Aridisols	435.9249	0.95	1	1
Entisols/Inceptisols	3054.5973	6.68	1	1
Inceptisols	19615.4307	42.90	32	32
Bad Lands	746.0622	1.63	0	0
Rock Outcrops/Entisols	10970.7488	23.99	37	37
RockOutcrops/Inceptisols	5303.9205	11.60	19	19
Urban	54.6831	0.11	1	1
Water Body	430.1531	0.94	0	0

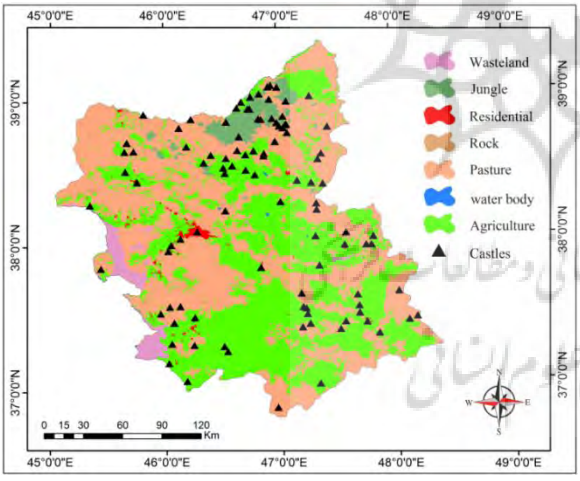

Figure 5: Spatial distribution of East Azarbaijan castle settlements by land use and vegetation

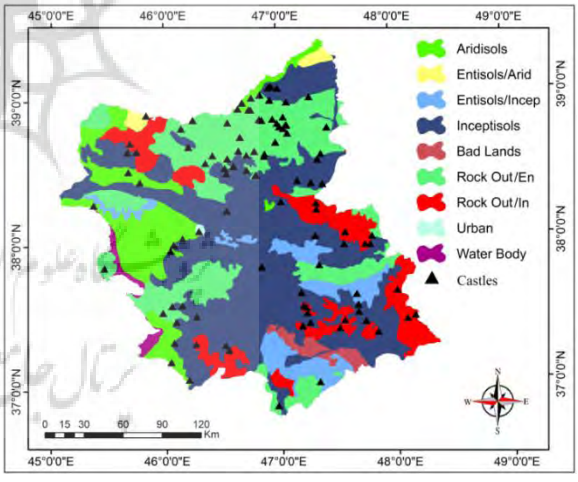

Figure 6: Spatial Distribution of East Azarbaijan Castle Settlements by Soil Type

5.2.5. Slope

One of the characteristics that had been effective in location human settlements since ancient times is slope of the earth. The amount (percent) and aspects of a region have affected on soil quality, water

resources control, degree of erosion, vegetation, how to build settlements and etc. Differences in the slope of ground sometimes indicate their various uses (Rezaloo and et. al, 2018: 352). Based on obtained data from slope layers in east Azerbaijan province, most of castle settlements are located in slopes between 2 to 8 percent and among them slopes 2-5 percent have the most extension and are the most normal place for location and formation of castle settlements and defensive fortifications that have the most number of castles in itself (table 7). In evaluation of spatial distribution of castle settlements in east Azerbaijan province, location pattern of these settlements are considered in terms of land slope percent. Based on this, the effect of slope percent in spatial distribution of castle settlements in east Azerbaijan province has been shown in figure (7).

Table 7: Distribution of East Azarbaijan castle Settlements in Relative Slope

Slope (%)	Area (km2)	percent	Number of castles	percent
0-2	8362.9207	18.39	12	12
2-5	13774.6759	30.29	27	27
5-8	9012.5836	19.82	27	27
8-12	6566.7114	14.44	16	16
12-15	2885.2882	6.34	9	9
15-30	4577.7757	10.06	9	9
Over 30	285.9357	0.62	0	0

6.2.5. Aspect

Geographical directions and slope have an important role in ecological environment of a region. Its first effect is on climate and mass movements. Another effect is the amount of sunlight received and formation of slope convection that can have a significant impact on the ecological environment and human settlements (Aftab and et. Al, 2014: 46). Based on obtained data from aspects in east Azerbaijan province, most of castle settlements are located in lands with southern aspect and the lowest numbers of castles are located in flat lands and without slope (table 8). In evaluation of spatial distribution of castle settlements in east Azerbaijan province, location pattern of these settlements are evaluated in terms of aspects. Based on this, the effect of aspects in spatial distribution of caste settlements in east Azerbaijan province has been shown in figure (8).

Table 8: Distribution of East Azarbaijan castle Settlements in Relative Aspect

Aspect	Area (km2)	percent	Number of castles	percent
Flat lands	0.7008	0.0015	0	0
North	6397.1122	14.07	6	6
Northeast	5000.3720	10.99	12	12
East	4488.7712	9.87	15	15
Southeast	5098.4872	11.21	8	8
South	6622.0764	14.56	19	19
Southwest	6555.4982	14.41	11	11
West	5574.3460	12.26	13	13
Northwest	5728.5271	12.59	16	16

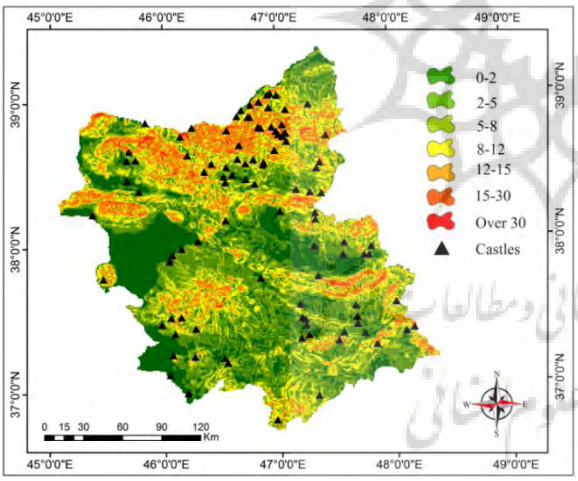

Figure 7: Spatial Distribution of East Azarbaijan castle Settlements in Relative Slope

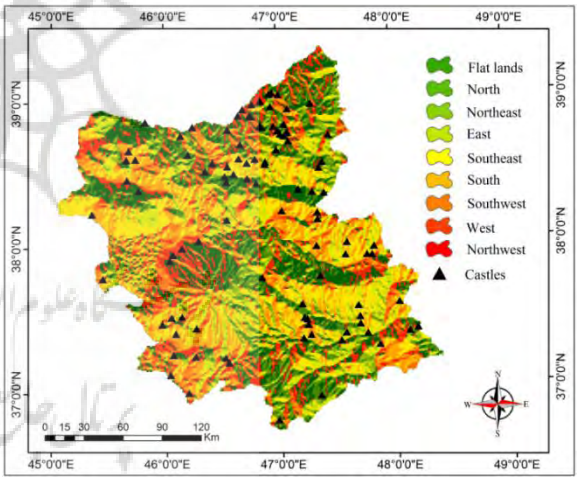

Figure 8: Spatial Distribution of East Azarbaijan castle Settlements in Relative Aspect

7.2.5. distance from the river

Water resources are influenced by climate, geology and topography and as one of the basic foundations play a basic role in determining the settlement system in formation of geographical settlements. In fact, the need for water is a very important element in the geographical distribution

and settlement of humans and human's life generally has been formed around the water centers. Access to water resources is one of the most important factors in formation of settlements and the way they scattered. Supplying and easy accessibility to water resources had been paid attention as one of the most important and effective factors in location and formation of settlements in Iran and other civilizations. Data obtained from evaluations and archeological excavations show that early core of old societies have been formed in proximity of water resources (Valipour, 2008: 56). Due to climatic diversity and natural landscape, the Iran plateau does not have reliable surface water resources everywhere and biological centers are often formed in areas that have safe surface water. The general geographical study of Iranian settlements clearly shows the relationship between biological centers and access to water resources. In the past, water played a determining role in the location and formation of a settlement, but todays, geographical factors and natural limiting factors have less involvement in the location, formation and physical development of settlements; because todays, by development of science and technology and Emphasizing the impact of cultural, economic and political factors, the impact of geographical phenomena and environmental factors has decreased (Rezaloo and et. al, 2018: 350). In evaluation of scattering castle settlements of east Azerbaijan province, location pattern of these settlements are considered in relation to main water resources (permanent and seasonal rivers). Based on obtained data from layers related to hydrography of this province, the most numbers of castle settlements (55 percent) are located in distance less than 2000 meters from the river and proportionally the more distance from the river, the number of castle settlements decrease (table 9). Based on this, the distance of castle settlements of east Azerbaijan province from water resources and rivers has been shown in figure (9).

Table 9: Distribution of East Azarbaijan Castle Settlements in Relative Distance from the River

Distance from river (m)	Area (km2)	percent	Number of castles	percent
0- 2000	18259.4358	40.11	55	55
2000-4000	12937.8555	28.42	22	22
4000-6000	7998.6986	17.57	16	16
6000-8000	3275.9811	7.19	3	3
Over 8000	3049.2081	6.69	4	4

8.2.5. Landform

Landform is a land complication or land face that its formation is structured by natural processes in a way that can be defined and described by index complications and if identified, the landform shows information about its structure together with combination, texture or integrity. Existence of different types of landforms and their diversity mainly is controlled by changing in the shape and position of

the land. Therefore, classification and identifying different regions is essential according to their morphometric characteristics (Mokarram & Negahban, 2015: 57). Based on obtained data, most area of east Azerbaijan province is covered by mountains and highlands (96%) and by dividing this province into two parts of mountainous and plain, the number of castle settlements in mountainous region is very much (95 castles); whereas the number of castle settlements in plain region is 5 castles (table 10). Based on this, spatial distribution of castle settlements in east Azerbaijan province in relation with landform (plain and mountainous) has been shown in figure (10).

Table 10: Distribution of East Azarbaijan castle Settlements in Plain and Mountainous Areas

Landform	Area (km2)	percent	Number of castles	percent
Mountain	43747.2953	96.11	95	95
Plain	1769.6636	3.89	5	5

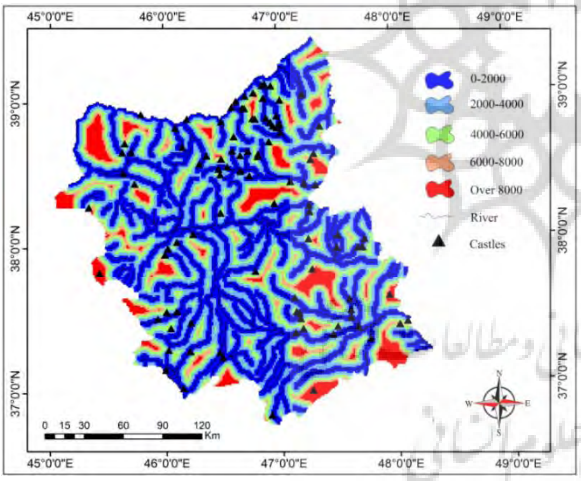

Figure 9: Spatial Distribution of East Azarbaijan Castle Settlements in Relative Distance from the River

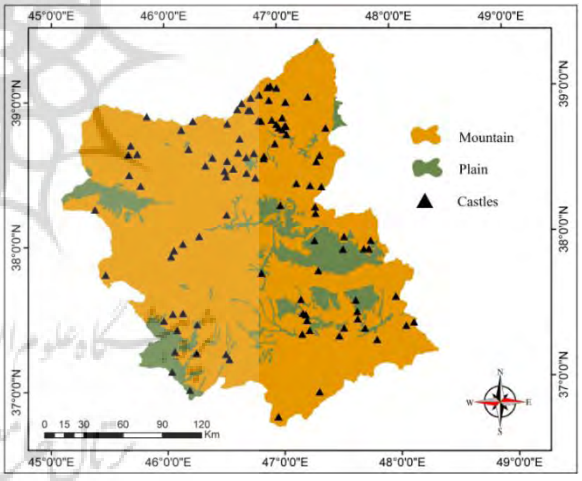

Figure 10: Spatial Distribution of East Azarbaijan castle Settlements in Plain and Mountainous Areas

6. Ranking of natural variables in spatial distribution of castle settlements of east Azerbaijan province by ARAS model

ARAS model is one of the multi-criteria decision-making methods, which were introduced by Edmundas Kazimieras Zavadskas & Zenonas Turskis in 2010. ARAS stands for Additive Ratio Assessment. ARAS method is the same as the TOPSIS, VIKOR and ELECTRE methods and its decision matrix is as alternative-criteria. This method for analyzing needs criteria weight. Therefore, first the criteria weight should be calculated by methods such as Shanon Entropy or AHP method and then alternatives should be ranked by ARAS method. In this method, the sum of weighted and normalized values of criteria for every alternative that represents the conditions of an alternative, divides on sum of weighted and normalized values of the best alternative. This ratio is called optimization degree. Based on this degree of optimization, alternatives are ranked (Zavadskas & Turskis, 2010, Zavadskas et al., 2010, Tupenaite et al., 2010).

By using ARAS model, natural variables (climatic classes, elevation levels, land use and vegetation, soil type, slope, aspect, distance from the river and landform) were ranked and scaled based on experts' opinion during following steps. At the first step of ARAS technique, initial decision matrix was formed. In fact, Initial decision matrix of this method is evaluation of 8 index based on the experts' opinion in which 10 experts scored every alternative based on spectrum of 1 to 5 (1=very low to 5=very high). Initial decision matrix showed in table (11), which experts are determined by E1 to E10.

Table 11: initial decision matrix

Alternative	Criterion									
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Climatic classes	1	2	2	2	5	3	3	3	4	5
Elevation levels	4	3	5	3	3	2	1	4	3	4
Land use	1	1	3	4	1	2	4	2	3	2
Soil type	3	2	2	5	3	2	4	1	1	1
Slope	1	1	3	4	3	2	5	5	3	1
Aspect	3	2	2	1	3	3	1	2	1	3
Distance from river	5	5	3	5	2	5	2	5	5	4
Landform	4	2	4	4	5	5	5	3	3	5

In the second step, it means determining the ideal value, an imagined alternative called A0 is created, which is ideal mode and its value for positive criteria is equal to maximum value of criteria column and for negative criteria is equal to the least value.

$$x_{0j} = \max_i x_{ij}, \quad for\ beneficial\ criteria \tag{1}$$

$$x_{0j} = \min_i x_{ij}, \quad for\ non-beneficial\ criteria \tag{2}$$

In this step, the ideal value was determined based on equations (1) and (2).

Because decision matrix is based on Likert spectrum, therefore, ideal value for each criterion is 5, which is specified in table (12) by A0.

Table 12: Decision matrix with ideal value

Alternative	Criterion									
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
A0	5	5	5	5	5	5	5	5	5	5
Climatic classes	1	2	2	2	5	3	3	3	4	5
Elevation levels	4	3	5	3	3	2	1	4	3	4
Land use	1	1	3	4	1	2	4	2	3	2
Soil type	3	2	2	5	3	2	4	1	1	1
Slope	1	1	3	4	3	2	5	5	3	1
Aspect	3	2	2	1	3	3	1	2	1	3
Distance from river	5	5	3	5	2	5	2	5	5	4
Landform	4	2	4	4	5	5	5	3	3	5

In third step, it means normalization of the decision matrix; initial decision matrix is normalized by using the following equation.

$$x_{ij}^{*} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \tag{3}$$

In this step, decision matrix was normalized by using equation (3) (table 12). In order to normalization each entry divides on sum of entries of each column. Normal matrix has been bringing in table (13).

Table 13: Normalization of initial matrix

Alternative	Criterion									
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
A0	0.185	0.217	0.172	0.152	0.167	0.172	0.167	0.167	0.179	0.167
Climatic classes	0.037	0.087	0.069	0.061	0.167	0.103	0.100	0.100	0.143	0.167
Elevation levels	0.148	0.130	0.172	0.091	0.100	0.069	0.033	0.133	0.107	0.133
Land use	0.037	0.043	0.103	0.121	0.033	0.069	0.133	0.067	0.107	0.067
Soil type	0.111	0.087	0.069	0.152	0.100	0.069	0.133	0.033	0.036	0.033
Slope	0.037	0.043	0.103	0.121	0.100	0.069	0.167	0.167	0.107	0.033
Aspect	0.111	0.087	0.069	0.030	0.100	0.103	0.033	0.067	0.036	0.100
Distance from river	0.185	0.217	0.103	0.152	0.067	0.172	0.067	0.167	0.179	0.133
Landform	0.148	0.087	0.138	0.121	0.167	0.172	0.167	0.100	0.107	0.167

In fourth step, it means weighting the normal decision matrix, entries of normal matrix are multiplies in criteria weight to obtain weighted matrix.

$$\hat{x}_{ij} = x_{ij}^{*} * w_j \qquad (4)$$

In this step, by using equation (4), normal matrix was weighted. Because in this research, experts' weight is considered equal, therefore weighted matrix (Table 14) is the same as normal matrix.

Table 14: Weighted matrix

Alternative	Criterion									
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
A0	0.185185	0.217391	0.172414	0.151515	0.166667	0.172414	0.166667	0.166667	0.178571	0.166667
Climatic classes	0.037037	0.086957	0.068966	0.060606	0.166667	0.103488	0.100000	0.100000	0.142857	0.166667
Elevation levels	0.148148	0.130435	0.172414	0.090909	0.100000	0.068966	0.033333	0.133333	0.107143	0.133333
Land use	0.037037	0.043478	0.103488	0.121212	0.033333	0.068966	0.133333	0.066667	0.107143	0.066667
Soil type	0.111111	0.086957	0.068966	0.151515	0.100000	0.068966	0.133333	0.033333	0.035714	0.033333
Slope	0.037037	0.043478	0.103488	0.121212	0.100000	0.068966	0.166667	0.166667	0.107143	0.033333
Aspect	0.111111	0.086957	0.068966	0.030303	0.100000	0.103488	0.033333	0.066667	0.035714	0.100000
Distance from river	0.185185	0.217391	0.103488	0.151515	0.066667	0.172414	0.066667	0.166667	0.178571	0.133333
Landform	0.148148	0.086957	0.137931	0.121212	0.166667	0.172414	0.166667	0.100000	0.107143	0.166667

In fifth step, it means calculating the ARAS index (S) and desirability degree of alternatives, by using the following equations, the ARAS index and desirability degree of alternatives was calculated (in percentage) and the final ranking was done based on it.

$$S_i = \sum_{j=1}^{n} \hat{x}_{ij} \qquad (5)$$

$$k_i = \frac{S_i}{S_0} * 100 \qquad (6)$$

In this step, based on equations (5) and (6), final score of criteria has been calculated and desirability degree was determined and based on it alternatives ranking was done, which are shown in table (15).

Table 15: Ranking of alternatives

Alternative	Si	K	rank
A0	1.744	-	-
Climatic classes	1.033	%59.238	4
Elevation levels	1.118	%64.101	3
Land use	0.781	%44.794	7
Soil type	0.823	%47.199	6
Slope	0.948	%54.350	5
Aspect	0.736	%42.227	8
Distance from river	1.442	%82.668	1
Landform	1.374	%78.766	2

7. Conclusion

Natural complications and phenomena have great impact on location, spatial distribution, sphere of influence, communication and the shape and visual physical appearance of human settlements and castle settlements also are no exception. In this regard, in the present study, in order to evaluate and rank the effective natural factors in spatial distribution of castle settlements of east Azerbaijan province, eight natural variables (climatic classes, elevation levels, land use and vegetation, soil type, slope, aspect, distance from the river and landform) were evaluated and analyzed as the effective variables in the distribution of these settlements. Spatial analysis of the research maps indicates that the studied natural variables have played an effective role in location, spatial distribution, sphere of influence, communication and the shape and visual appearance of the castle settlements in East Azerbaijan province. Obtained results from evaluation and ranking effective natural factors in spatial distribution of castle settlements of east Azerbaijan province by using ARAS model show that distance from the river, landform (plain and mountainous) and elevation levels have the most effect on the spatial distribution pattern of these settlements. Other natural variables such as climatic classes,

slope, soil type, land use/ vegetation and aspect have been effective in the spatial distribution of these settlements in terms of importance and impact, respectively. Therefore, accessing water resources and river and locating in heights and mountainous places with steep slope, has been one of the most important natural elements in location, formation and spatial distribution of castle settlements of east Azerbaijan.

References

1- Aftab, A., Ghorbani, A., Taghilo, A. A., and Soltanzadeh, V., Study the effect of natural factors on the spatial distribution of ancient centers using GIS in West Azerbaijan, Journal of Spatial Planning, 2014, 4(3): 37-60. [in Persian].

2- Bahraminia, M., Khosrowzadeh, A., and Esmaeili Jelodar, M. E., Analysis of the Role of Environmental Factors in the Spatial Distribution of the Neolithic and Chalcolithic Sites of Ardal County, Chaharmahal VA Bakhtiari Province, Journal of Archaeological Studies, 2014, 5(2): 21-37. [in Persian].

3- Behzad, A., and Asadian, F., Impact of environmental factors on destruction of archaeological sites by TOPSIS model (case study archaeological sites of Darreh Shahr and Abdanan of Ilam province), Journal of Territory, 2017, 14(53): 1-19. [in Persian].

4- Heidarian, M., Analyzing the Role of Natural Factors in Spatial Distribution of Prehistoric Sites of Sonqor Plain, Pazhoheshha-ye Bastan Shenasi Iran, 2014, 3(4): 139-152. [in Persian].

5- Istalaji, A., and Ghadiri Masoom, M., Investigation of geographical factors in the Settelment Establishing systems with emphasis on quantitative techniques, Geographical Research, 2005, 53: 121-136. [in Persian].

6- Maghsoudi, M., Zamanzadeh, M., Fazeli, H., & Chezgheh, S., Study on the role of physical structures in the settlement pattern of prehistoric sites of Tehran Plain Using GIS, Journal of Spatial Planning, 2012, 4(16): 109-137. [in Persian].

7- Maghsoudi, M, Zamanzadeh, M, Navidfar, A, Mohammadi, A, & Yosefi Zoshk, R. Environmental conditions study governing on ancient sites with an emphasis on grain size sediment river analysis (Case study: Ancient sites of Meymanatabad and Mafinabad), Quaternary Journal of Iran, 2016, 2(1): 41-51. [in Persian].

8- Mokarram, M., & Negahban, S., LandformClassificationusing Topographic Position Index (Case study: Southern Darabcity), Scientific Research Quarterly of Geographical Data, 2015, 23(92): 57-65. [in Persian].

9- Mousavi Kouhpar, S. M., Heydarian, M., Aghayari, M., Vahdatinasab, H., Khatib Shahidi, H., & Naistani, J., The Analysis of the Role of Natural Factors in Spatial Distribution of Archaeological Sites, in Mazandaran Province, 2011, 43(75): 1-19. [in Persian].

10- Naseri Some, H., & Niknami, K., Role of natural factors in spatial distribution of archaeological sites, during the chalcolithic period in Bostanabad, Azerbaijan, 2017, 48(4), 533-556. [in Persian].

11- National Planning and Budget Organization, Statistical Yearbook of East Azerbaijan Province, Management and Planning Organization of East Azerbaijan Province, 2016. [in Persian].

12- Rezaei, M. H., The Role of Environment Factors on Formation of Bakun Period Settlements in the Kazeroun Plain, Southern Iran, Pazhoheshha-ye Bastan Shenasi Iran, 2018, 7(14): 7-24. [in Persian].
13- Rezaloo, R., Purkarimi, P., Ayremlou, Y., Tahmasebi, F., The Analysis of the Geographic phenomena influence in Spatial Distribution Bronze (3000-1500 B.C) age settlements in Ardabil, Journal of Studies of Human Settlements Planning, 2018, 13(2): 341-361. [in Persian].
14- Riahiyan Gohorti, R., Naqshineh, A. S., and Saeidi Harsini, R., Analyzing the contribution of environmental factors to spatial distribution of copper stone settlements in southern part of the cultural region of Halil River (Kahnuj, Qaleh Ganj, and Southern Rudbar plains), Journal of Research on Archaeometry, 2019, 5(2): 71-90. [in Persian].
15- Saidi, A., the Principles of Rural Geography, 2010, Tehran, Samt. [in Persian].
16- Seyed Sajjadi, S. S., the First Cities of the Iranian Plateau, 2005, V1, Tehran, Samt. [in Persian].
17- Shaikhi, F., Masoudinia, Z., Gholamalifard, M., & Mirzaii, M., Application of weight-evidence in modeling the linkage between environmental variables and distribution pattern of archaeological sites Case study: Borujen and lordegan cities of Chaharmahal and Bakhtiari, Scientific Research Quarterly of Geographical Data, 2017, 26(103): 187-199. [in Persian].
18- Tupenaite, L., Zavadskas, E.K., Kaklauskas, A., Turskis, Z., & Seniut, M., Multiple criteria assessment of alternatives for built and human environment renovation, Journal of Civil Engineering and Management, 2010, 16(2): 257-266.
19- Valipour, H., Study of Economic and Social Structures of Tehran Plain Societies in the Fifth and Fourth Millennium BC, PhD Thesis in Archeology, 2008, University of Tehran. [in Persian].
20- Zavadskas, E. K., & Turskis Z., A new additive ratio assessment (ARAS) method in multicriteria decision-making, Technological and Economic Development of Economy, 2010, 16(2): 159-172.
21- Zavadskas, E.K., Turskis, Z., & Vilutiene, T., Multiple criteria analysis of foundation instalment alternatives by applying Additive Ratio Assessment (ARAS) method, Archives of civil and mechanical engineering, 2010, 10(3): 123-141.