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The most important climatic factors affecting distribution of *Zygophyllum atriplicoides* in semi-arid region of Iran (Case Study: Isfahan Province)

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Abstract

Zygophyllum atriplicoides is one of the important species of Iran rangelands that has special importance owing to some properties like high distribution rate, coverage percentage, density, and plant biomass that make it possible to supply a part of forage needed by livestock during spring and winter as well as to avoid soil degradation against water and wind erosions. This research tries to study the most important climatic factors affecting distribution of *Z. atriplicoides* using multivariate statistical methods and selecting ecological important 69 variables in Isfahan province. Four factors, such as cooling temperature, precipitation, cloudiness, and wind were determined by the factor analysis method and variables variance of 34.45, 29.43, 11.79, and 9.06 were obtained, respectively totally represents 84.74 of the changes. The mean of factor scores and climatic variables in three populations of the *Z. atriplicoides* species as the dominant species, *Z. atriplicoides* species as the associated species and regions without the *Z. atriplicoides* species were determined. Furthermore, the factor score matrix was used as the input of the hierarchical cluster analysis and 6 climate zones were identified in Isfahan province. The most important climatic factors affecting the species distribution were determined by incorporating the vegetation map, factors map, and climatic zones. The effect of altitude was also analyzed in the species distribution. Results showed that the temperature factor is the most important climatic factor affecting distribution of the species in the Isfahan province and the precipitation factor influences the species distribution. Also, the effect of altitude and soil salinity on analysis of *Z. atriplicoides* populations could not be ignored.

Keywords: Cluster analysis; Factor analysis; Isfahan province; Multivariate statistical methods; *Zygophyllum atriplicoides*

1. Introduction

The relationship between vegetation and climate mentioned in manuscripts remained from Ionians between fifth and third centuries BC. The first effect has been stated by the Menestor in a limited manuscript related to the fifth century BC. Menestor was completely new of the correlation between evergreen and deciduous vegetations and climate (Unal *et al*., 2003). The first extensive work about plant geography and ecology was performed by Theophrastus, one of Plato students who lived between 285 and 370 BC. The study of Theophrastus titled "Studying atmospheric symptoms and their relationship with plants perfumes" is completely translated and represents clear picture of beliefs of Theophrastus about plant geography that are today also accepted and demonstrated (Unal *et al*., 2003). Current researches on different ecosystems of the world and in various scales show the intense effect of climate on vegetation. Vegetation plays an important role in the climatic zonation and can be addressed as a sign of different climatic and

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topographic patterns. Therefore, climate and vegetation maps all together can be used to analyze and define bioclimatic zones (Pineda-Martinez *et al*., 2007). The first serious attempt to use computer and integrate data related to the climate, soil, and vegetation was performed by FAO (1978-1981) in order to determine bioclimatic regions in the world (White *et al*., 2001). Some bioclimatic and agroclimatic classifications are very large and others only include a small region of the world (Zuo *et al*., 1996). There is possibility to classify climate in order to classify the bioclimate in macro and micro levels. Most climatic classifications that are performed on bioclimates only relied on some limited variables, like temperature, precipitation or a combination of both, while the climate is a compound phenomenon that cannot represent the climate of a region by using some limited variables. So, most factors should be considered in classification of a region climate. Studying the climate using various variables can clarify the factors affecting the distribution of vegetation as well. Many studies have been performed using multivariate methods to determine bioclimatic regions around the world (Vilmout, 1987; Gerstengarbe *et al*., 1999; Holden *et al*., 2004; Wan *et al*., 2010). Many researchers have studied the effect of climatic factors on the distribution and development of plant types (Mather and Yashioka, 1968; Box, 1981; Sheded, 1998; Beaumont *et al*., 2005; Zangin *et al*., 2010; Khodagholi *et al* ,.2006; Yaghmaei *et al* ,.2009). *Zygophyllum* includes 100 species in the world (Bellstedt *et al*., 2008); they are in Iran, in some regions like Arak, Khorasan, Tehran, Semnan, Fars, Sistanva Balouchestan, and Isfahan. This plant grows widely in dry areas and deserts especially in Iran and Turan and in the lower part of the Oman Gulf area (Afyani, 1992; Mozafarian, 2002). The topographic factor is effective in the distribution of the *Zygophyllum atriplicoides* plant. The soil salinity from heights is increased to the plate and height of this plant is decreased from highlands to the flat (Asghari, 1993). Mohammadi (2010) by studying some ecologic features of the *Z. atriplicoides* species in some semi-arid regions of Isfahan concluded that the vegetative growth of this species starts with temperature increase. The plant bedtime starts with considerable decrease of temperature and time of seed scattering and falling leaves is accompanied by the drastic reduction of precipitation and weather aridity. Importance of the *Zygophyllum* species quantitatively returns to its extent in the province area in a way that has included about one third of the Isfahan province area. This research tries to study different climatic elements and looks for the most important factors affecting the determination of *Z. atriplicoides* species habitats in the Isfahan province. Factor analysis (FA) method was used to determine the interaction between first variables and components, in addition to decreasing the number of climatic variables, and the effect of each factor in different places were specified using the cluster analysis (CA) and these places are divided into homogenous areas. Finally, the distribution of the species in each place was analyzed.

2. Materials and Methods

The studied region of Isfahan has an area of 106179 km^2 and its geographic coordinates are 30° 42'-34° 30'N and 49° 36'-55° 45' E. The altitude varies between 707 and 4000 m above mean sea level (AMSL) which created different climates from very dry to wet in the level of province and has provided different habitats for the presence of the *Z. atriplicoides* species (Fig. 1). In this research, 19 climatic elements were selected after controlling accuracy of data from climatological and synoptic stations within the province and nearby cities. The length of the statistical period was from the establishment of the station to 2005. When climatic data are classified in separate months of the year and the annual average, a number of 234 climatic variables (18×13) was obtained. The aim of this research was to determine the most important factors affecting the distribution of *Z. atriplicoides* species. July and January were selected to represent the maximum and minimum deputy of the year. The beginning of the growing season of *Z. atriplicoides* species is mid March (Mohammadi, 2010). Data of March were also studied as effective data. In total, data of July, January, and March months and the annual average were considered for each climatic element. Variables of number of snow days, cloudy days, frost days and days with precipitation more than 1, 5, and 10 mm in July were rare, so they were not used in the data analysis. Finally, in order to input data of statistical analysis, 69 climatic variables were studied. Data were collected from weather stations. In this study, the Kiriging's interpolation method was used in a network of 11 × 11 (843 cells) km. Therefore, a matrix with 69 columns (variables) and 843 rows (places) were obtained. Factor analysis was used to decrease the number of variables according to the principal components analysis and varimax rotation method in the SPSS Ver. 16 (Farshadfar, 2001). The factor loading matrix that shows correlation between climatic variables and the factor score matrix that shows the local pattern of extracted factors in three levels of the region were obtained. Factor score matrix was used for drawing factors map in the Surfer software ver.10 (Khodagholi *et al*., 2006). Finally, using the vegetation map (1:250000) of the Isfahan province and field inspections, three regions were divided for the habitats of *Z. atriplicoides* species. These regions are as follows:

1. The *Z. atriplicoides* species as the dominant species,
2. The *Z. atriplicoides* species as an associated species, and
3. Regions without the *Z. atriplicoides* species.

In the next step, vegetation map was gridded exactly according to the gridding used to interpolate climatic variables and factor scores in a way that the vegetation map with 843 cells with clear width and length was provided. Finally, cells of three defined regions of the *Z. atriplicoides* species were determined and the most important factors affecting the three regions were identified by conforming them with variables map and factor scores and specifications of each of them were interpreted.

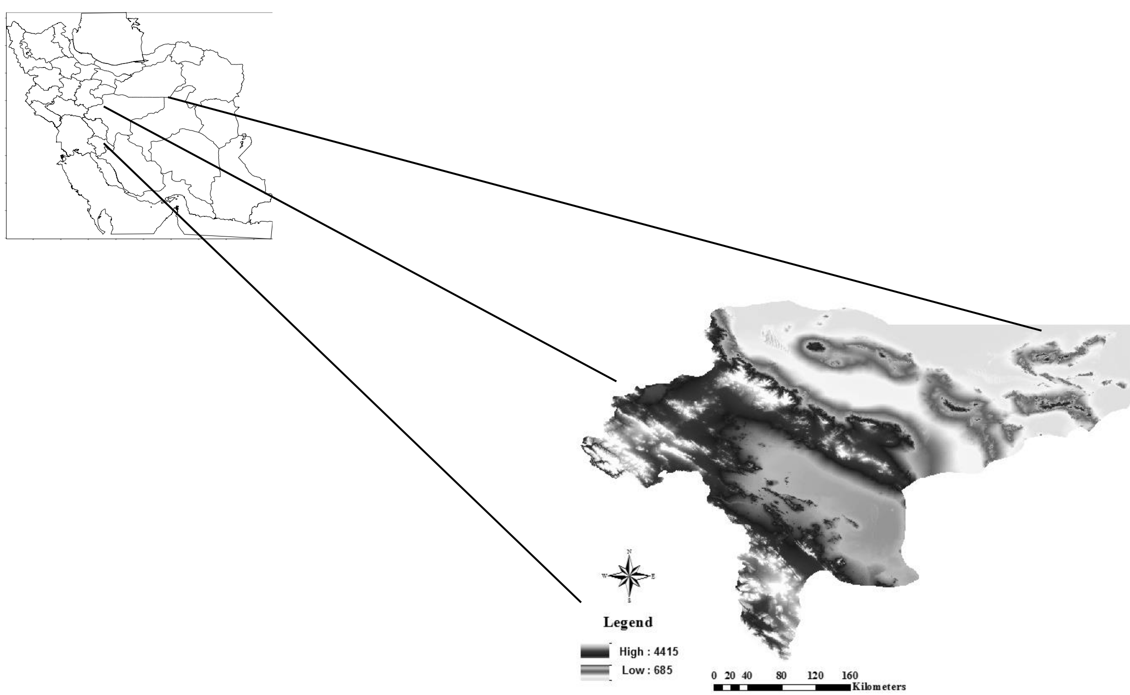

Fig. 1. Isfahan geographical position

3. Results

The results show that the distribution of the *Z. atriplicoides* species in the Isfahan province is as a result of the interaction between 4 different factors justifying about 84.74 of the total variance (Table 2). With regard to values, the factor loading, that is, correlation value between variables and extracted factors (r ≥ 0.6) was named extracted factors (Table 3).

A) Cooling temperature

This factor includes 34.45% of the total variance of primary variables. All temperature variables with negative correlation are in the subset of this factor; this factor was named cooling temperature factor. This factor changes from -1.4 in the east range of the province (Khorva Biabanak) to 2.6 in most western parts of the province (Chadegan station).

Table 1. Selected climate variables

Number	Element Name	Variables number	Number	Element Name	Variables number
1	Average of mean daily temperature (°C)	4	11	Number of frost days	3
2	Average of minimum daily temperature (°C)	4	12	Average of daily relative humidity (%)	4
3	Average of maximum daily temperature (°C)	4	13	Number of days with thunder storm	4
4	Average of annual total precipitation (mm)	4	14	Number of days with snow	3
5	Average of seasonal total precipitation (mm)	3	15	Number of days with dust	4
6	Number of rainy days (mm)	4	16	Daily duration of sunshine hours	4
7	Number of days precipitation equal or more than 1 mm	3	17	Number of cloudy days	3
8	Number of days precipitation equal or more than 5 mm	3	18	Daily wind speed (mean knots)	4
9	Number of days precipitation equal or more than 10 mm	3	19	Number of wind observation	4
10	24 hour maximum precipitation (mm)	4			
	Totally	69			

Table 2. Eigen value, percentage and cumulative percentage of variance factors

Factor	Eigen value	Percentage of variance	Cumulative variance
1	38.42	34.45	34.45
2	10.58	29.43	63.88
3	6.52	11.79	75.68
4	4.65	9.07	84.74

Table 3. Rotated loading factor matrix

Variables	Cooling temperature factor	Precipitation factor	Cloudiness factor	Wind factor
January mean temperature	-0.965			
January mean minimum temperature	-0.961			
Annual frost days	0.960			
March mean minimum temperature	-0.957			
March frost days	0.949			
Annual mean temperature	-0.943			
March mean temperature	-0.933			
Annual mean minimum temperature	-0.932			
January mean maximum temperature	-0.921			
January frost days	0.915			
Annual mean maximum temperature	-0.894			
July mean temperature	0.893			
March mean maximum temperature	-0.865			
July mean maximum temperature	0.838			
January snow days	0.744			
Annual snow days	0.738			
July sunshine hours	-0.729			
Annual mean relative humidity	0.729			
January mean relative humidity	0.714			
March mean relative humidity	0.698			
July precipitation	0.692			
March snow days	0.690			
January dust days	-0.685			
July dust days	-0.622			
March dust days	-0.619			
Annual dust days*				
July mean maximum precipitation*				
July mean relative humidity*				
January thunderstorm days		0.960		
January precipitation		0.932		
Winter precipitation		0.922		
January rainy days with equal or more than 10 mm		0.904		
January mean maximum precipitation		0.886		
March precipitation		0.883		
Annual precipitation		0.876		
Annual thunderstorm days		0.860		
Autumn precipitation		0.856		
March thunder storm days		0.856		
March rainy days with equal or more than 10 mm		0.853		

Table 3. Rotated loading factor matrix (Continue)

Variables	Cooling temperature factor	Precipitation factor	Cloudiness factor	Wind factor
Annual mean maximum precipitation		0.852		
Annual rainy days with equal or more than 10 mm		0.852		
January rainy days with equal or more than 5 mm		0.823		
March mean maximum precipitation		0.808		
March rainy days with equal or more than 5 mm		0.805		
January rainy days with equal or more than 1 mm		0.804		
Annual rainy days with equal or more than 5 mm		0.763		
January precipitation days		0.743		
March precipitation days		0.703		
March rainy days with equal or more than 1 mm	0.630	0.657		
Annual rainy days with equal or more than 1 mm	0.653	0.641		
Spring precipitation		0.623		
Annual precipitation days*				
July thunderstorm days*				
Annual sunshine hours			-0.942	
January sunshine hours			-0.927	
March sunshine hours			-0.838	
Annual cloudy days			0.800	
March cloudy days			0.740	
January cloudy days			0.734	
March wind speed			-0.640	
January wind speed			-0.614	
January number of wind observation				0.950
March number of wind observation				0.949
Annual number of wind observation				0.947
July number of wind observation				0.940
July wind speed				-0.630
Annual wind speed				-0.630

*The variables with extraction factors have lesser correlation than ±0.60

B) Precipitation

This factor includes 29.43 of the total variance of the primary variables. As shown in Table 3, we understand that all variables in relation to precipitation except snow days have been placed in the subgroup of this factor. This factor was named precipitation factor due to the strong correlation ($r = 0.6$) of precipitation variables with this factor. The minimum value of this factor is related to the east and south east region (Varzaneh station) and the maximum score is related to the west (Feridounshahr station) and south west region of the province.

C) The cloudiness factor

This factor includes 11.79% of the total variance of primary variables, including variables of cloudy days ($r =+0.6$) and number of sunshine hours ($r = -0.6$). This factor shows that regions with greater exposure to sunshine have less cloudy days. The minimum score of this factor is -1.8 in the south region and the maximum value is 2.4 and is related to the North West region (Kashan station) of the province. Reason for the increased number of cloudy days in this region of the province can be adjacency to sand dunes of the country center with increasing dust and also adjacency to north regions of the country can be cause of this cloudiness (Fig. 2).

D) The wind factor

This factor includes 9.07% of the total variance of the primary variables, including all the variables that are related to the number of the observation wind. The wind factor divides several different climatic regions in the province area. Some parts of the east and south-east and also a part of the west regions of the province have most of the observed wind in the province area. East regions due to adjacency to central deserts of the country are windward and have greater number of observed wind and high speed of wind, but observing more wind in the west region of the province can be attributed to sudden change in the region climate and the pressure difference. Although this region have high observed values of wind, but wind speed due to the mountainous barriers and even proliferation of settlements is not significant. Also, central regions and a part of the west region of the province have the lowest score.

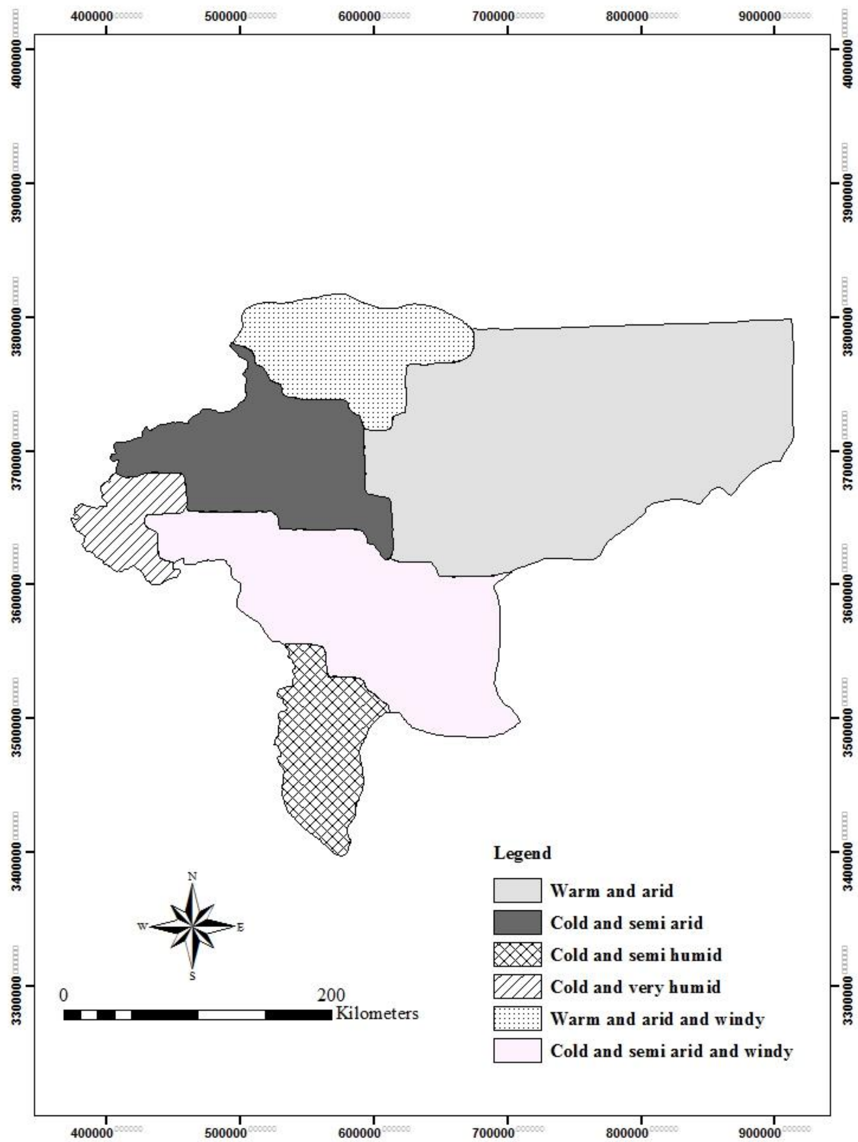

Fig. 2. Climatic zoning of the study area (Isfahan province)

The cluster analysis was performed using the Ward hierarchical method in order to determine the zones of the region vegetative climates on the factor scores matrix and the number of 6 climatic zones was identified in the province area (Fig. 2). Determining the most appropriate number of clusters was performed by the T^2 pseudo test (Nocke et al., 2004). Obtained factor scores and annual average were named as the two important climatic factors of temperature and precipitation and calculation of Domarten coefficient (Table 4).

The Domarten coefficient is calculated according to the following relationship:

$I = \frac{P}{t+10})$

In this relationship, I is the dryness coefficient, P is the average daily precipitation, and t is the temperature average in Degrees Celsius. If this relationship is considered on an annual basis, so I<20 value represents the dry climate and 20<I< 30 value represents the semi-dry climate (Jafari and Tavili, 2010).

Table 4. Average of area climate zones factor scores

Number	Zone Name	Cooling Temperature Factor	Precipitation Factor	Cloudiness Factor	Wind Factor	Annual mean temperature	Annual mean precipitation	Domarten Coefficient
1	Cold and very humid	1.97	1.57	0.90	0.50	10.6	555.33	52.34
2	Cold and semi-arid	0.87	-0.38	0.60	-0.49	14.4	184.05	12.77
3	Cold and semi-arid and windy	0.74	-0.49	-0.84	0.80	14.6	138.78	9.49
4	Warm and arid and windy	-0.48	-0.53	1.8	0.23	18.66	118.46	6.35
5	Cold and semi-humid	0.15	2.57	-0.79	0.018	13.59	484.1	35.62
6	Warm and arid	-0.77	-0.063	-0.19	-0.35	18.22	99.68	5.47

Cold and very humid zone

This region is located in the western part of the province and Fereidoonshahr is its representative. The cooling factor of this region is the most and also is distinguished from other regions, because of up to 550 mm of precipitation. High sea level (>200 m) and low temperature led to the existence of *Z. atriplicoides* species in this part of the province. Also, it has the least area among all the 6 divided zones.

Cold and semi-arid zone

This region covered the north western parts of the province and confined to Golpaiegan from east and Natanz from west and Meime station is the representative index of this area. Domarten coefficient was lower than 20 and high cooling temperature regarding the other effective factors causes this factor be nominated in this way. In referring to the distribution map of *Z. atriplicoides* species and vegetation map across the province, it was found out that *Z. atriplicoides* presented in this part with reducing height and increasing temperature, partially rather than the western part along with *Artemisia sieberi* species and one of the *Salsola* species.

Cold and semi-arid and windy zone

This region ranged from western to south-eastern part of the province. It confined to Chadegan from the west and Varzane from the north and Isfahan from the north. Wind factor is the main index in this area minus cloudiness factor implying high radiation. A glance at the obtained parameters in Table 3 demonstrates that this region has cold and semi-arid climate. For the reason of locating related area within two different climatic zones, *Z. atriplicoides* is not observed in western mountainous parts and it made a habitat in south-eastern part along with other species. Gavkhooni wetland located in the south-eastern part and increasing soil salinity also led to the non-existence of related species in some part.

Warm and arid and windy zone

This zone is located in the north part of the province and Kashan station is its representative. High temperature, low precipitation, and blowing strong wind are the reasons for the naming. This region owned the least average height across the province and with regard to vegetation map In relation to species along with other ones presented in the wide part of the area except for Karkas heights.

Cold and semi-humid zone

This region covered the southern parts of province and Semirom station is its representative. Rain factor was the effective index of the region, while low temperature and high precipitation are two limiting factors for *Z. atriplicoides* presence in this part of the province.

Warm and arid zone

This region covered the wide eastern part of the province that confined to Ardestan in the west and to Khor and Biyabanak in the east. High temperature, low precipitation and very low Domarten coefficient of the same region led to this denominating. Since *Z. atriplicoides* species is compatible with desert condition and low height, the patches of dominant type was seen in this zone and in the other parts was widely accompanied with *A. sieberi*, *Ephedra strobilacea*, and *Hammada salicornica*. Field monitoring indicated that related species was seen in 3 km distance from Soheil Village environs of Naein County nearby Anarak County as a dominant type. This region owned the highest area of the climatic region.

By adapting vegetation map to factorial scores gridding map and climatic zones, cells of each defined regions (*Z. atriplicoides* type as a dominant species, *Z. atriplicoides* type as a accompanied species and regions free of *Z. atriplicoides*) were determined and each cell's score was extracted, and average scores of the five factors were characterized by means of information of each type of cells, as shown in Table 4.

Z. atriplicoides as the prevailing species

This type owned about 5.33% of the province areas, equal to 565934.07 ha with regard to vegetation map and extracted cells. The results showed that heating temperature factor owned the most importance for this type. As shown in Table 4, the gained factor is opposite to the heating factor and equal to cooling factor that reduction of it led to more presence of related species. The lowest score is related to wind factor which seems as the least effect in the presence of species across the province. Thereafter, precipitation factor was specified with the lowest score. Consequently, it was revealed that the presence of species as dominant species was not influenced by precipitation. It is noteworthy that the average height of this type was 1383.02 m.

Z. atriplicoides as an accompanied species

In this type, *Z. atriplicoides* was often seen as the second or accompanied type. Accompanied *Z. atriplicoides* in most part of the province was *A. sieberi* and also some species like *Salsola* and *Stipa*. It contains 66.78% of the province and is equal to 7090633.62 ha. Table 4 shows that temperature as a heating factor led to its presence and precipitation factor had the lowest ratio. According to obtained results and comparing with type 1, it was revealed that precipitation factor owned low scores in both types, so it is concluded that the presence of *Z. atriplicoides* species was not depended on precipitation factor, though *Z. atriplicoides* is a desert species that can be adaptable with dry condition.

Z. atriplicoides free zone

This region covered about 30% of the province area and is equal to 318643 ha. According to the achieved results shown in Table 4, two cooling temperature factors (temperature reduction) and precipitation are of limiting factors for the presence of this species across the province. It is noteworthy that in some region including Isfahan city vicinity, the presence of the species has been limited as a result of the land use change from rangelands to farmland. Besides, it was not seen in Karkas height as a result of raising height and in Gavkhooni wetland as a result of salt affected soil surface. The average height of this region was 2106.6 m. The average annual climatic variable for 3 zones is listed in Table 5. Furthermore, Figure 3 illustrates the distribution map of *Z. atriplicoides* across the province.

4. Discussion

Concerning the achieved results, climatic factors such as temperature, precipitation, cloudiness, and wind factor had the highest effect in the presence and absence of *Z. atriplicoides* across the province. They contained respectively 34.45, 29.43, 11.79, and 9.06% and entirely 84.47% of total variance. Consequently, they are comparable to the works of other researchers (Khodagholi *et al*., 2006; Badraddin Yusuf Mohammad, 1997; Pineda-Martinez *et al*., 2007; Evrendilek and Berberoglu, 2008; Khodagholi *et al*., 2006) in studying the plant-climatology of Zaianderood basin and they discovered that precipitation, heating temperature, wind direction and speed, summer precipitation and dust factors expressed 95.95% variance of the primary variables. Moreover, the results of Badraddin Yusuf Mohammad (1997) using factorial-clustering analysis method proved that using novel statistical methods is very useful in comparison with traditional ones. Also, Nocke *et al*. (2004) concluded that clustering analysis technique acts as an appropriate tool in order to reducing large volume of climatic data and increases the accuracy when they are being studied. Furthermore, the results showed that the largest cluster was related to the regions with low height (eastern areas of the province) and the smallest one was related to mountainous regions (western areas of the province). Hossell *et al*. (2003) found the largest cluster in south, east and middle of England with low height, while the smallest one referred to western Britain and Ireland. However, temperature factor was achieved as cooling, but demonstrated high negative correlation in type 1 and 2 limits with climatic variables. It reveals that the presence of species depends on temperature factor across the province as vegetation growth is limited by cooling the weather in accordance with Mohammadi (2010). Additionally, according to Tables 4 and 5, temperature precipitation factor determines the distribution of species across the province. In regions with up to 250 mm precipitation, the distribution of it is more limited, while in eastern parts including Naein County with average annual precipitation of 98.7 mm, it is dominant. In western parts of the province with high precipitation, including Fereidoonshahr County with 568.5 mm and Golpaiegan County with 273.7 mm. The distribution of the studied species was limited, which is in conformity with the findings of Onsori (1996). This researcher suggested that habitat of *Z. atriplicoides* includes region with low precipitation ranging from 70 to 250 mm. Moreover, the results indicated that sea level was an index of the species distribution across the province. Free *Z. atriplicoides* area with average height of 2106.6 m confirmed this issue. Shabankare (2000) suggested that with raising sea level, the start of vegetation growth and development of plant' initial leaves delayed. However, this study aimed to recognize the most important climatic factors affecting *Z. atriplicoides* species distribution, but the results showed that near two third of the province area was potentially ready for the plant existence and accounted as habitat of this species. Although some factors such as topography and salinity could affect the existence of this species. As in lands of Daghe-Sorkh and Gavkhooni pond (eastern part of the province), the studied species was not grown because of salinity. Abd El-Wahab *et al.* (2008) in studying the diversity and distribution of medicinal plants (herbs) in relation to climatic factors in Sina desert found out that soil physical properties, topography, and salinity are the main factors in distribution of *Z. atriplicoides* species in this desert. Generally, according the achieved results, it seems that temperature and precipitation are two climatic indicators for the habitat of *Z. atriplicoides* species across the province and other factors like sea level, soil salinity and land-use change (in some densely-populated parts of the province) affected its existence.

Table 5. Factor scores average in different types of *Zygophyllum atriplicoides*

Type Name	Average Height (m)	Cooling Temperature Factor	Precipitation Factor	Cloudiness Factor	Wind Factor
Z.atriplicoides as the prevailing specie	1383.02	-0.197	-0.227	0.143	-0.361
Z. atriplicoides as accompanied specie	1366.8	-0.337	-0.256	0.039	-0.144
The area free from any *Z.atriplicoides*	2106.6	0.846	0.656	-0.121	0.415

Table 6. Average of annual primary variables in different types of *Zygophyllum atriplicoides*

Variable	*Z.atriplicoides* as the prevailing specie	*Z. atriplicoides* as accompanied specie	The area free from any *Z.atriplicoides*
Annual mean temperature (°C)	17.06	17.37	13.61
Annual mean minimum temperature (°C)	10.16	10.54	6.20
Annual mean maximum temperature (°C)	23.97	24.21	21.01
Annual mean precipitation (mm)	118.37	113.33	308.88
Annual precipitation days	32.07	34.09	43.66
Annual rainy days with equal or more than 1 mm	21.12	20.44	31.95
Annual rainy days with equal or more than 5 mm	8.48	7.75	9.81
Annual rainy days with equal or more than 10 mm	3.42	3.03	17.23
Annual mean maximum precipitation (mm)	51.89	47.83	70.04
Annual frost days	61.83	58.04	98.79
Annual mean relative humidity*	35.59	35.45	40.66
Annual thunderstorm days	4.57	4.46	7.28
Annual snow days	6.14	5.01	14.18
Annual dust days	16.94	17.61	11.22
Annual sunshine hours	3251.38	3247.98	3251.95
Annual cloudy days	32.79	32.30	33.12
Annual wind speed (Knot)	4.89	4.75	4.27
Annual number of wind observation	2197.98	2237.23	2414.30

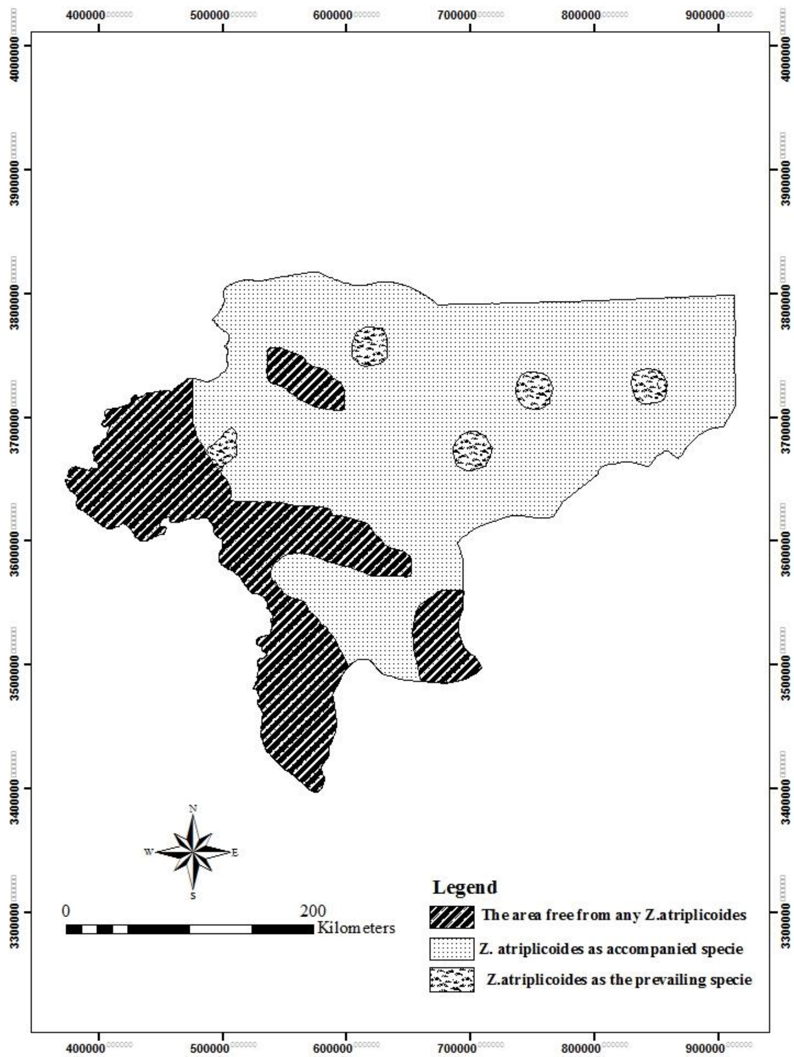

Fig. 3. Distribution map of *Z. atriplicoides* in the study area (Isfahan province)

Moreover, the present study examined that the performance of multivariate statistical methods in specifying effective climatic elements could have influence on species distribution and also distinguished it from other classical methods which only consider several climatic variables when determining the bioclimatic regions. *Z. atriplicoides* could tolerate long-term drought periods and be used as one of the effective species in conserving Iran dry region rangeland', consequently, recognizing the climatic factors influenced the distribution of the studied species and could help in precise management and planning for grassland reclamation.

5. Conclusion

Generally, according to the achieved results, it seems that temperature and precipitation are two climatic indicators for the habitat of *Z. atriplicoides* species across the province and other factors like sea level, soil salinity and land-use change (in some densely-populated parts of the province) affected its existence. Moreover, the present study examined the performance of multivariate statistical methods in specifying that the effective climatic elements could have influence on species distribution and also distinguished it from other classical methods which only consider several climatic variables when determining the bioclimatic regions. *Z. atriplicoides* could tolerate long-term drought periods and be used as one of the effective species in conserving Iran dry region rangeland', consequently, recognizing the climatic factors influenced the distribution of the studied species and could help in precise management and planning for grassland reclamation.

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