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Bioclimatic Classification of South East of Iran Using Multivariate Statistical Methods

Khatibi Rasool[1,*], Soltani Saeed[2], Khodagholi Morteza[3]

[1]Department of Soil and Water, Zabol University, Zabol, Iran
[2]Department of Natural Resources, Isfahan University of Technology, Isfahan, 84156-83111, Iran
[3]Soil Conservation and Watershed Management Research Department,
Isfahan Agricultural and Natural Resources Research and Education Center, AREEO, Isfahan, Iran
*Corresponding author: r_khatibi60@yahoo.com

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Abstract Traditional zoning by necessity and based on one or a few climate variables, tended to separate climatic zones while the climate contains several variables and is a cumulative process. Effective management and proper exploitation of each ecosystem requires a comprehensive understanding of its components. Climate can exert direct and indirect effects on all components of ecosystems. While most systems of bioclimatic classification depend on limited variables such as precipitation, temperature, and their combinations, describing the climate of a region requires the evaluation of more factors. The present study was an attempt toward the bioclimatic classification of South east of Iran (including Sistan and baluchestan Province). Using multivariate statistical methods, 72 climatic variables, which affected the distribution of dominant plant species in the study area, were selected. After performing principal component analysis to identify the main factors, cluster analysis was conducted to determine the bioclimatic classes and their characteristics. Overall, six climatic factors (i.e. temperature and warm season rainfall, Warm season winds, Spring dust, Spring and autumn wind, Relative humidity and Cool season rainfall) were found to explain 98% of the total variance in primary variables. Cluster analysis Ward's method divided the study area into 7 bioclimatic zones. The comparison of the obtained results with the results of four common methods of climate classification (Koppen's, Gaussen's, Emberger's, and de Martonne's methods) suggested the higher ability of multivariate statistical methods to discriminate between bioclimatic zones. The dominant species in each zone were finally described.

Keywords: *factor analysis, bioclimatic classification, sistan and baluchestan province, multivariate statistical methods, Koppen's method, Gaussen's method, Emberger's method, de Martonne's method*

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1. Introduction

The environmental potential of an area depends on many factors. Among these factors, climatic factors play an important role in determining the progress, environmental development and economic development of a region along with land, water and biological agents. In assessment of the environmental potential of each region, much attention has been to the climate. The basic question in the early stages of assessing the climatic potential of an area is whether the climatic resources vary over time and place? And what is the exact nature of the climatic resources? These are climatic classification steps that determine the spatial characteristics of the climatic resources. The main objective of climatic classification is to identify geographical areas with having the same climate or similar potentialities [1]. Climate has been shown to be dominant in determining species' distributions [2]. Not surprisingly the purpose of these classifications has also varied from exploring the patterns of climate across the country [3,4], to relating climatic patterns to species distributions across restricted areas of the country [5,6], and to linking land use to conservation priorities [7]. The common assumption in these classifications, however, has been that climate is constant, even though climate is changing as a result of human activities [8]. Climate change will affect the pattern of biological potential across the whole country affecting not only species distributions and population levels, but also the policies and management that protect those species and habitats of conservation concern [9]. The climatic elements that determined an eco-climate zone are connected with each-other. Their comprehensiveness and coactions give stable contours of eco-climatic indexes. The determination of an eco-climatic zone takes in consideration indexes that are repetitive and sustainable on time and space. These indexes have a biotic and biotic nature. In every case factors that condition eco-climatic of a macro zone or micro zone are geophysics as: latitude, altitude above sea level, atmospheric and biotic phenomena's and presence of natural or cultivated vegetation. The bioclimatic concept is wide and from ecologic viewpoint shows the combination of content elements that determine plant and animal life. The bio-climate zone is considered as a combination among the vegetation area and climatic elements with indexes: temperature, precipitations, wind, air humidity etc. This combination creates a complete, continued and stable view of an area or some ecologic areas in relation to indexes of bio climate content elements. On eco zones environment resources are in correlation with biotic resources. They present a special importance from the point of study, evaluation, usage, preservation and improvement of natural resources [10]. Climatic zoning involves the identification of zones and regions with similar climate. Numerous researchers including Koppen, Emberger, de Martonne, Ivanov, Hansen, and Silianinov have focused on developing methods of climate classification. Climate is the most important determinant of vegetation cover at the global scale. Despite their significance, other factors such as soil, topography, and human are less important than climate in determining plant species in an area [11]. Due to different weather conditions, a variety of climates and vegetation areas have developed on Earth. Climate also affects the biological properties and distribution of plants and creates distinguishable vegetation types in various parts of the world [12]. Since plants can well reflect the effects of environmental and natural phenomena, they play a major role in climate classification [13]. Following the development of accurate quantitative methods, conventional climate classification approaches have been preceded by novel methods such as factor analysis and cluster analysis. Such novel techniques distinguish climate zones based on statistical climate data rather than the researcher's opinion [14]. Sabeti [15] and Javanshir [16] were the first researchers who used multivariate techniques for climate classification in Iran. Masoudian [14] evaluated 37 climatic factors at an annual level and concluded that Iran's climate consisted of six climate factors and 15 climate regions. Pabout [17] divided Iran to three bioclimatic zones, namely Caspian, Irano-Turanian, and Baluchi climates. This classification was performed mainly based on rainfall (although elevation was also taken into account in case of the Caspian climate). Despite its shortcomings, Pabout's classification was a valuable system considering the lack of climatic information at that time. Javier Amigo et al. [18] extracted rainfall and temperature data from 140 weather stations in Chile and classified the country into four bioclimatic zones, i.e. tropical, Mediterranean, temperate, and northern climates. Ndetto et al. [19] performed a basis analysis of climate and urban bioclimate of Dar es Salaam city in Tanzania. They argued that in a world affected by urbanization and climate changes, it is necessary to clarify the urban microclimate and bioclimate in different areas. They hence used synoptic meteorological data (from 2001 to 2011) to assess urban climate and human biometeorological conditions. In an attempt toward the phytosociological and bioclimatic classification of Pacific coasts in North America, Peinado et al. [20] adopted Blanquet's approach and cluster analysis and identified 22 vegetation regions and floristic associations which were characterized by their floristic composition. According to Pedrotti [21], numerous types of vegetation maps can exist since different intrinsic properties (e.g. floristic compositions), structures, and population dynamics of floristic associations can each yield a specific map. Moreover, maps may be different due to their scales and mixed characteristics. In a study on the application of climatic parameters in vegetation distribution, Gavilan [22] used over 100 phytoclimatic indices and climatic parameters extracted from 260 weather stations in Iberian Peninsula (Spain). The results of multivariate and estimative statistical methods showed different levels of correlation between climatic parameters. After categorizing 111 climatic parameters into five larger groups, temperature and precipitation were found to have the greatest effects on vegetation distribution. DE Gaetano and Schulman [23] classified agricultural climates of USA and Canada using the principal component analysis and cluster analysis. Primary variables in this classification included maximum temperature, minimum temperature, relative humidity, wind speed, number of shiny hours and precipitation. This classification has similarities with boundary of natural perennial species in accordance with the use of many variables. In a study in Minas Gerias (Brazil), Junior et al. [24] applied Koppen's method for climate classification using raster precipitation and temperature data during 1961-1990. They presented a map of the obtained climate classes, i.e. tropical rainy climate, dry climate, and temperate tropical climate. Yurdanur et al. [25] specified climatic regions of Turkey using cluster analysis. In this study, five different techniques were applied initially to decide the most suitable method for the region. They concluded that Ward's method was the most likely one to yield acceptable results. In this study, seven different climatic zones were found. Dinpajouh et al. [26] used multivariate statistical methods for climate classification of Iran in their agricultural studies. Using factor analysis. Gerami Motlagh et al. [27] report Boushehr Provinces (Iran) to have six climate zones. In an attempt toward bioclimatic classification of Chaharmahal and Bakhtiari Province (Iran), Soltani et al. [28] adopted multivariate statistical methods and factor analysis using 71 climatic factors with greatest effects on distribution of vegetation. The most important factors in factor analysis were temperature, precipitation, and Radiation which explained 91.8% of variance in primary variables. Hierarchical cluster analysis based on Ward's method lead to the identification of five bioclimatic zones in the province. Yaghmayi et al. [29] used multivariate statistical methods for the bioclimatic classification of Isfahan Province (Iran). They found precipitation, wind, and Radiation to explain 92.3% of variance in primary variables. Cluster analysis of these three factors revealed seven bioclimatic zones in the province. It is critical to apply a comprehensive method which uses most effective climatic factors to provide a realistic image of an area's climate. Statistical methods mainly aim to maximize intragroup homogeneity and intergroup heterogeneity, i.e. climatic zones need to have the greatest level of internal homogeneity while maintaining maximum difference with each other [30].

Therefore, our purpose in this research is to study the most effective elements on the distribution and expansion of vegetation types by studying the various elements of meteorology that are taken in meteorological stations. And with factor analysis method, while reducing the number of variables, the interaction between the primary variables is recognized and the effect determine the intensity of each extraction factor in different locations. Then, using the weight or score of each of the factors in different locations by using the cluster analysis method, these points are divided into homogeneous regions and finally, presented. The precise of bioclimatic zoning in the southeastern region of Iran in Sistan and Baluchistan province. The results were then compared with the traditional (common) classifications based on Koppen, Gaussen, Emberger, and de Martonne methods.

2. Materials and Methods

2.1. Study Area

As Figure 1 shows, the study area was located in South east of Iran and covered the Broad Region (Sistan and baluchestan province).

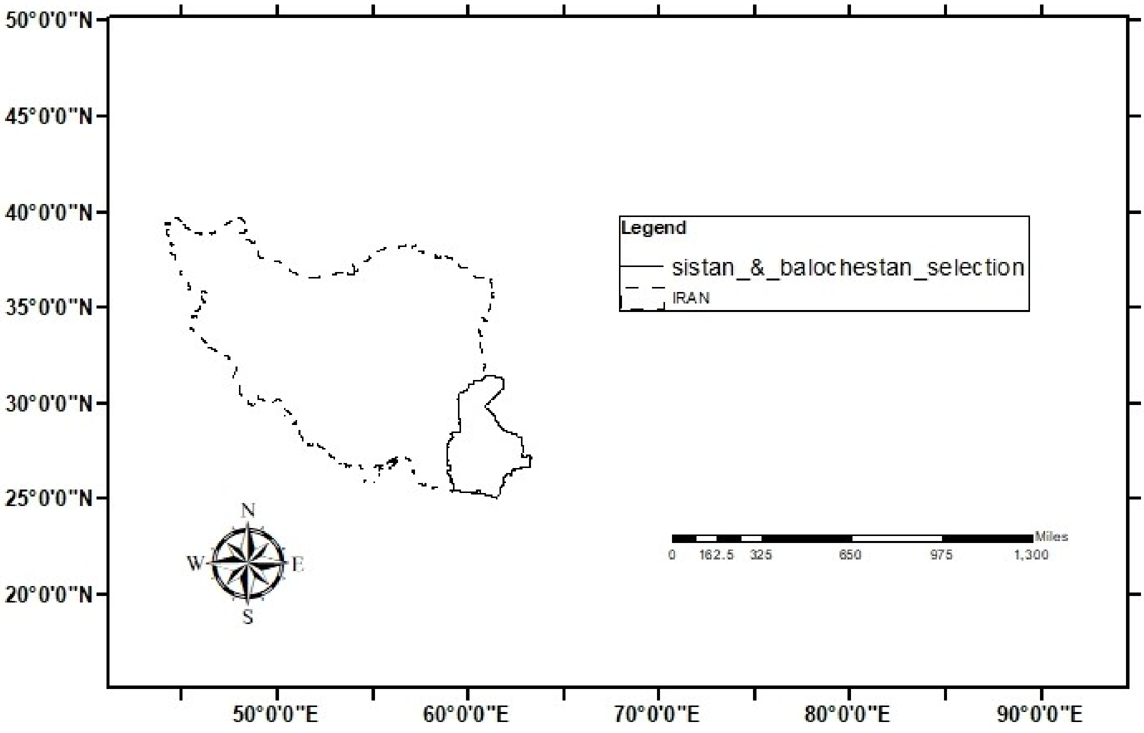

Figure 1. The study area location (Sistan and baluchestan province) in Iran

Table 1. Climatic and bioclimatic variables included within the classification

Variable type(Monthly and annual)	Unit	Number of Variables
The average of minimum temperature	°C	1
The average of maximum temperature	°C	1
The average of temperature	°C	13
The average of Relative humidity	percent	7
The average of maximum Relative humidity	percent	1
The average of minimum Relative humidity	percent	1
Monthly Precipitation	mm	13
Days with Thunder storm	daily	6
Days with Dust	daily	7
The average of Wind speed	knot	13
Sunshine	hours	1
Winter Precipitation	mm	1
Spring Precipitation	mm	1
Summer Precipitation	mm	1
Autumn Precipitation	mm	1
Days with Precipitation of winter season	mm	1
Days with Precipitation of spring season	mm	1
Days with Precipitation of summer season	mm	1
Days with Precipitation of fall season	mm	1

2.2. Methods

In the present study, 72 climatic variables with the greatest effects on the distribution of dominant plant species and vegetation types in the study area were extracted from the data provided by Iran Meteorological Organization (Table 1). Data were obtained from synoptic and climatology stations in the mentioned province and their adjacent areas. The collected data were checked for accuracy and then used to create a database. Evaluations were made over a 28-year period from 1990 to 2018.

The results of climate analysis cannot be generalized to broad zones unless interpolation techniques are adopted to convert discrete data to continuous data [31]. Considering the density and variability of the selected variables in the current study, a variogram analysis using the most variable parameter, i.e. precipitation, was performed to determine the appropriate grid size. Ultimately, a 13 km × 13 km grid was used for the interpolation of climatic parameters in the study area. The result was a matrix with 72 columns (variables) and 790 rows (locations). Kriging was then conducted to estimate all the 72 variables at all 790 points (pixels). A factor analysis, with the obtained values as inputs, was performed to evaluate the climatic conditions of South east of Iran. Factor analysis serves as a data reduction tool. Predictions made by this tool about the unobservable factors will be used in subsequent analysis. The ultimate goal of factor analysis is to produce matrices of factor loadings and factor scores, which are used as the basis for all interpretations. Factor loadings are correlations between input variables and factors obtained from the analysis. Factor scores describe the spatial patterns of the factors throughout the study area. They are used not only in creating factor maps, but also as preliminary data in cluster analysis. Principal component analysis and varimax rotation were applied on the preliminary data matrix to reduce the number of variables. Since factors with eigenvalues below one are not superior to a main variable (which has a variance of one) [32], factors with eigenvalues more than one were selected. Also, based on results, the Scree Plot introduced six factors were suitable for this research. (Figure 2). Kaiser-Meyer-Olkin (KMO) measure was then used to determine the effectiveness of factor analysis (Table 2). The calculated KMO index (0.98) showed the perfect performance of the factor analysis. Since bioclimatic classification of the study area was the main goal of this research, hierarchical cluster analysis based on Ward's method was applied on the factor scores matrix. Hierarchical cluster analysis applies a set of algorithms and techniques to build clusters based on the existing similarities and dissimilarities [33]. Ward's method actually minimizes the variance within clusters, while maximizing the variance between clusters [34]. After clustering the matrix of factor scores using the mentioned method, the scores of cells within each cluster were summed and the most significant factor in each area. Finally, the climate of South east of Iran including Sistan and baluchestan Province was classified and each class was named based on the sum of factor scores and primary climatic variables. Afterward, kriging was performed on the vegetation map of the study and vegetation types were determined at all 790 locations (cells of the grid). The relations between vegetation types and climatic variables were then evaluated. The factor score of each area can best describe the most important climatic feature of that area since these scores are the outcome of numerous subgroup variables.

3. Results

The first step in the administration of factor analysis is to confirm its performance (through methods such as the KMO index). According to Kaiser, who considers KMO index values above 0.9 as indicators of excellent performance of factor analysis [33], the factor analysis had great performance in the present study (KMO index = 0.98). Factor analysis of the matrix of preliminary data yielded six factors with eigenvalues above one (Table 3). These six factors explained 98% of the total variance in preliminary data and produced the bioclimatic classes in the study area.

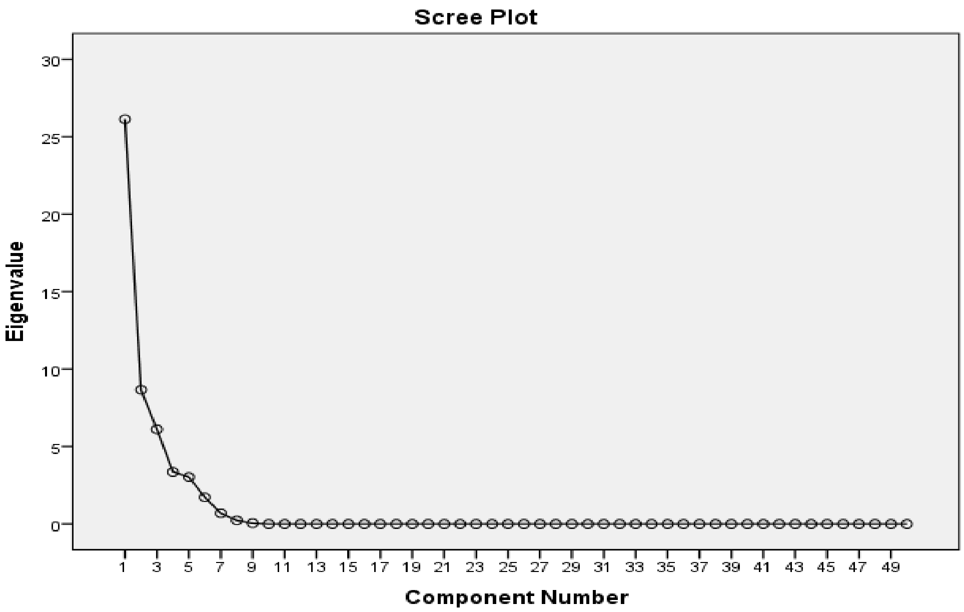

Figure 2. The Scree Plot graph that represents the number of appropriate factors

Table 2. View about Coefficient K.M.O

Amount of K.M.O	Data fit for factor analysis
Greater than or equal to 90	perfect
80-90 percent	Very good
70-80 percent	good
60-70 percent	normal
50-60 percent	weak
Less than 50 percent	unacceptable

Table 3. The Eigen Value, percent variance and the cumulative variance of each factor

factors	Eigen Value	Variance (%)	Cumulative (%)
1	52.277	31.703	31.703
2	17.333	19.049	50.74
3	12.223	14.501	65.24
4	6.720	12.683	77.92
5	6.063	10.648	88.63
6	3.442	9.474	98.07

The factor loading matrix, showing correlations between variables and factors, was also obtained from factor analysis and varimax rotation. The elements of the matrix were first arranged based on their absolute values. Values over ± 0.7 were then retained and others were eliminated (Table 4). Since absolute values below 0.7 were equal to or less than 0.3, a cut-off point of 0.7 was selected. Moreover, values over ± 0.7 could reflect correlations between parameters and factors. Factor scores are standardized values with a mean value of zero (which shows the factor score in that area) and a variance of one.

The abbreviations marked with an asterisk (*) in Table 4 are: **1. T_APR**: temperature in April month, **2. APR_HUMIDITY**: relative humidity percent in April month, **3. PR_JAN:** precipitation in April month, **4. APR_DUST**: dusty days in April month, **5. JAN_WIND**: windy days in April month, **6. WINTER_PR**: the number of precipitation days in winter season, etc.

Table 4. Rotated factor loading matrix greater than ± 0.7

variables \ Factors	Temperature & summer rainfall	Winds of the warm seasons	Spring dust	Winds of the cool seasons	Relative humidity	Winter rainfall
T_APR*	.893					
T_MAY	.895					
T_JOUAN	.835					
T_SEP	.856					
T_OCT	.865					
T_NOV	.847					
T_DEC	.829					
T_ANNUAL	.874					
APR_HUMIDITY*					.926	
MAY_HUMIDITY					.917	
JUAN_HUMIDITY						
SEP_HUMIDITY						
ANNUAL_HUMIDITY					.843	
PR_JAN*						
PR_FEB						
PR_MAR						
PR_APR	-.847					
PR_MAY						
PR_JUAN	.864					
PR_JULY						
PR_AUG	.832					
PR_SEP	.869					
PR_OCT						
PR_NOV						
PR_DEC						
PR_ANNUAL						
APR_DUST*			.877			
MAY_DUST			.815			
JUAN_DUST			.849			
JULY_DUST						
AUG_DUST						
SEP_DUST						
ANNUAL_DUST						.883
JAN_WIND*				.882		.878
FEB_WIND				.857		
MAR_WIND		.911				
APR_WIND		.921				
MAY_WIND		.914				
JULY_WIND						
AUG_WIND		.938				
SEP_WIND		.952				
OCT_WIND		.880				
NOV_WIND				.811		
DEC_WIND				.911		
ANNUAL_WIND		.857				
WINTER_PR*						
SPRING_PR*						
SUMMER_PR*						
AUTUMN_PR*	.801					

Ultimately, the following factors were extracted and named.

1. Temperature and summer rainfall factor

whereas the important variables of temperature (8 variables), such as the temperatures of April, May, June, September, October, November and December Months, and the long-term annual temperature, and also the five significant rainfall variables, such as The precipitation of the months of April, June, August, September and summer season of rainfall is in this subgroup, this factor was called the temperature and summer rainfall.

On the other hand, this factor explain 31/70 percent of the total variance of the initial variables, The 13 variables mentioned above have positive and negative correlations of more than 0.7 with this factor (Table 3).

Figure 3 shows the spatial distribution of this factor in Sistan and baluchestan province. As seen, the temperature and summer rainfall increase from the center of the province to the south, This is due to the fact that the southern parts of the province are located in the vicinity of the Persian Gulf and the Oman Sea (large water resources), and temperature is always rising and sultry.

On the other hand, exactly this area of the province, in the summer season, disposable to monsoon precipitations coming to this area from India. For this reason, the temperature and summer rainfall in the region are higher compared to the northern part of the province. (Figure 3)

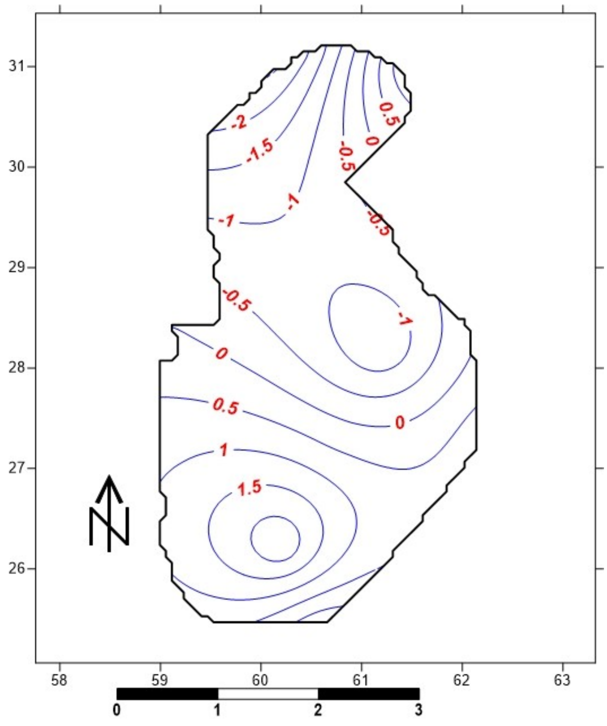

Figure 3. Spatial distribution of temperature and summer rainfall factor in the study area

2. The Winds of the warm seasons

This factor alone justifies 19.05 percent of the total variance of the data, as seven variables with this factor have correlation and more than + 0.7 (Table 3). Since there is a strong correlation between this factor and variables such as the average wind speed in May, June, July, September, October months, and Average annual wind speed, this factor is named Winds of the warm seasons.

Figure 4 shows the spatial distribution of this factor in the study area, which is considered to be the lowest amount of this factor in the southern regions of the province and the highest in the northern part of the province. (Figure 4)

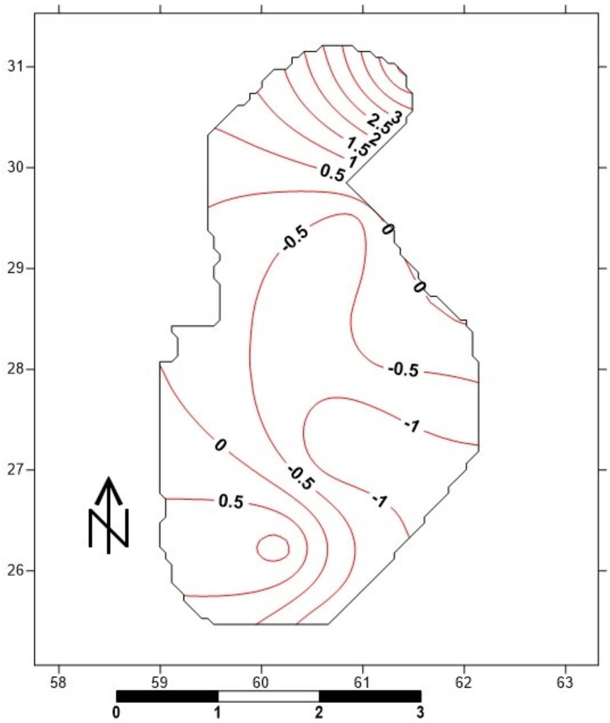

Figure 4. Spatial distribution of The Winds of the warm season's factor in the study area

3. Spring dust factor

This factor explain 14. 50 percent of the total variance of the data, as the dust variables of the months of April, May, June have a strong correlation and more than +0.7 with this factor (Table 3) Figure 5 shows the spatial distribution of this factor in the study area, according to this Figure, approximately from the center of the province toward the east is increasing the value of this factor and the other hand The amount of this factor is decreasing from center to the west, the southwest and south of the province. The most of spring dust factor is seen in the northern regions of the province. (Figure 5)

4. The Winds of the cool seasons

Because variables such as the average wind speed in months of January, February, November and December had a very high correlation with this factor, this factor were named Winds of the cool seasons. According to the Table 3 this factor explain 12. 68 percent of the total variance of the data, so that four variables with this factor have correlation and more than + 0.7 (Table 3).

Figure 6 shows the spatial distribution of this factor in the study area, as seen the eastern regions of this province have the most amount of this factor and Parts of the north and center of this province have the lowest from this factor. (Figure 6)

5. Relative humidity factor

This factor singly explain 10.65 percent of the total variance of the primary variables, so that the three important variables of the relative humidity of the months of April, May and the annual relative humidity have the strong correlation and more than + 0.7 with this factor (Table 3).

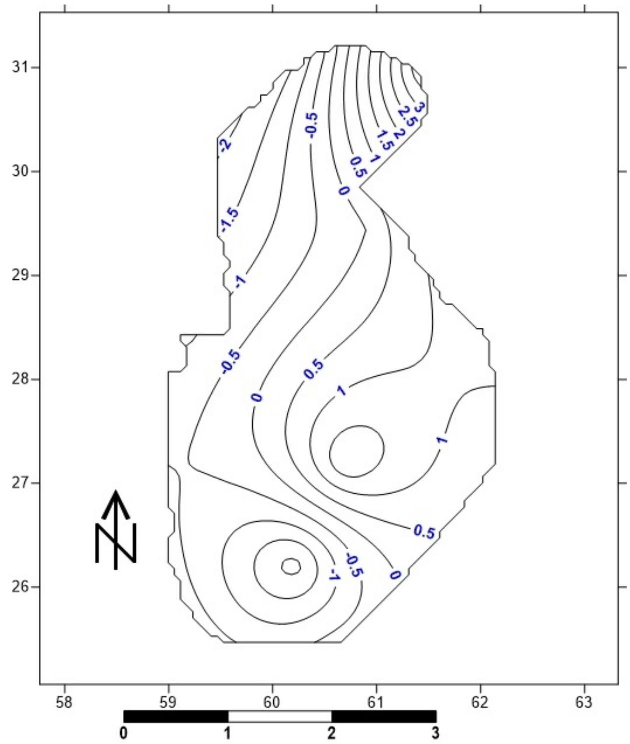

Figure 5. Spatial distribution of The Spring dust factor in the study area

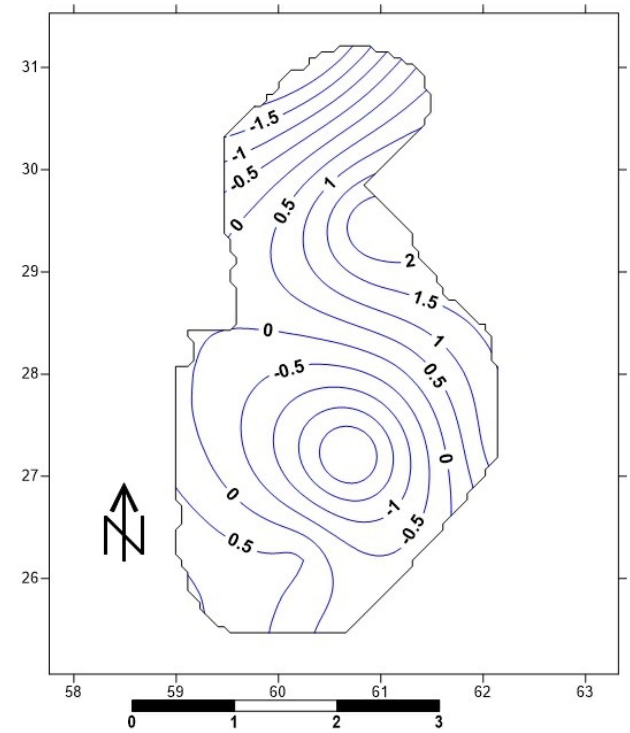

Figure 6. Spatial distribution of The Winds of the cool season's factor in the study area

Figure 7 shows the spatial distribution of this factor in the study area, according to the map, the least amount of this factor is seen in the northern, eastern - central and western regions and the highest amount is found in the southern areas of the province that Due to the geographical location of the Sistan and Baluchestan province and its proximity to the Persian Gulf and Oman Sea, it seems reasonable that it must be high in this area.

Figure 8 shows the spatial distribution of this factor in the study area, the highest amount of this factor is seen in areas with high altitudes in Sistan and Baluchestan province and this causes that more rainfall in these areas occurs in the cold seasons

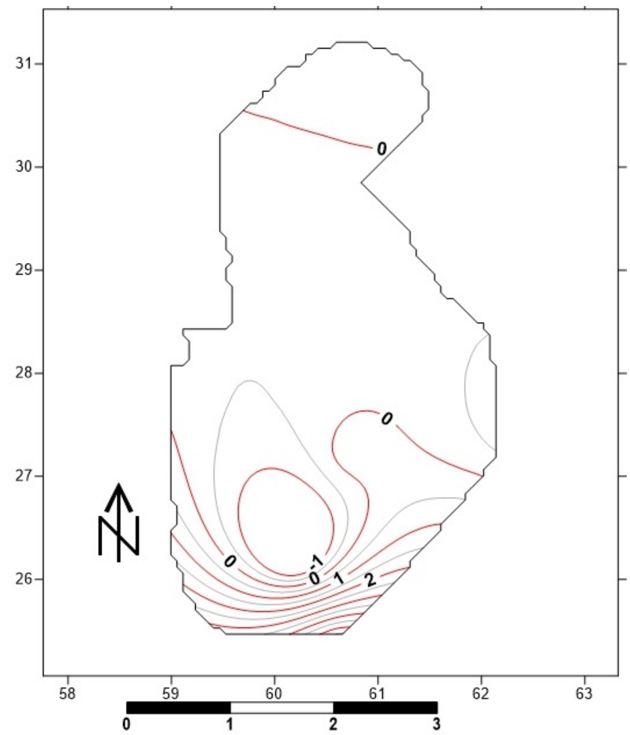

Figure 7. Spatial distribution of The Relative humidity factor in the study area

6. Winter rainfall

Since the important variables of the rainfall such as rainfall in months of February and March are in the category and have strong correlation with this factor, this factor was named winter rainfall (Table 3).

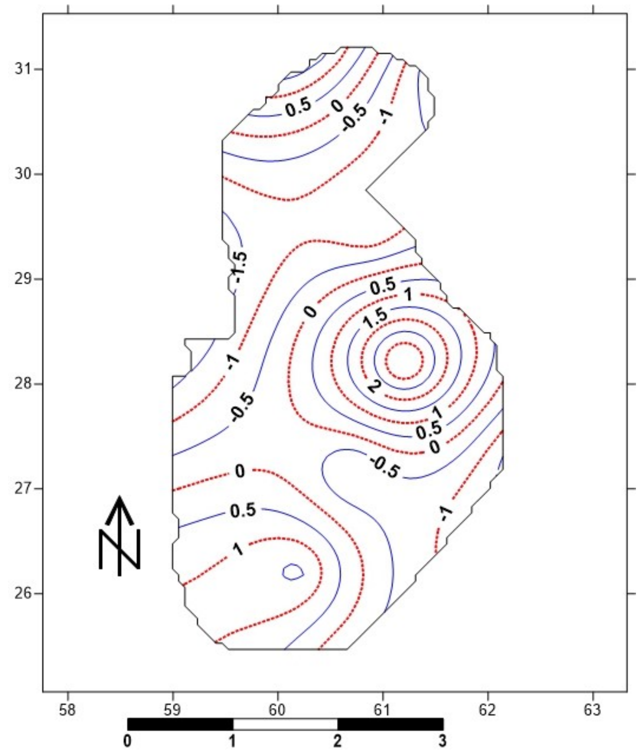

Figure 8. Spatial distribution of The Winter rainfall factor in the study area

In other parts of this province, rainfall is rare in the cold seasons of the year, Except for small areas in the northwest and southwest of the province, this is due to proximity with the adjacent provinces. That there are high elevations in the adjacent provinces with this area, and therefore these areas affected this ranges of study area (Sistan and Baluchestan province). And causes that rainfall occurs in cold seasons in these areas.

Bioclimatic classification of the study area (south east of Iran) using multivariate statistical methods

Cluster analysis is a general term to describe a variety of mathematical methods seeking similarity among a set of observations [34]. Cluster analysis has been applied in numerous meteorological studies during the past decades and has progressed significantly since 1990s. Cluster analysis involves various algorithms and methods to classify similar observations based on similarity/dissimilarity criteria. The input into these algorithms is the data required for calculating similarities [33]. Using the hierarchical cluster analysis of factor scores based on Ward's method, 7 bioclimatic zones were identified in the study area. Since factor scores show the significance of each factor, the name of each zone was determined based on the sum of factor scores within that zone. Moreover, considering the higher weight of factors 1-3 (discussed in the previous sections), these three factors were mainly used in the naming of bioclimatic zones. Finally, the south east of Iran were divided into 7 bioclimatic zones (Figure 9), which will be described in the following sections. Climatic classification of the study area was also performed using conventional methods (Figure 10, Figure 11, Figure 12 and Figure 13).

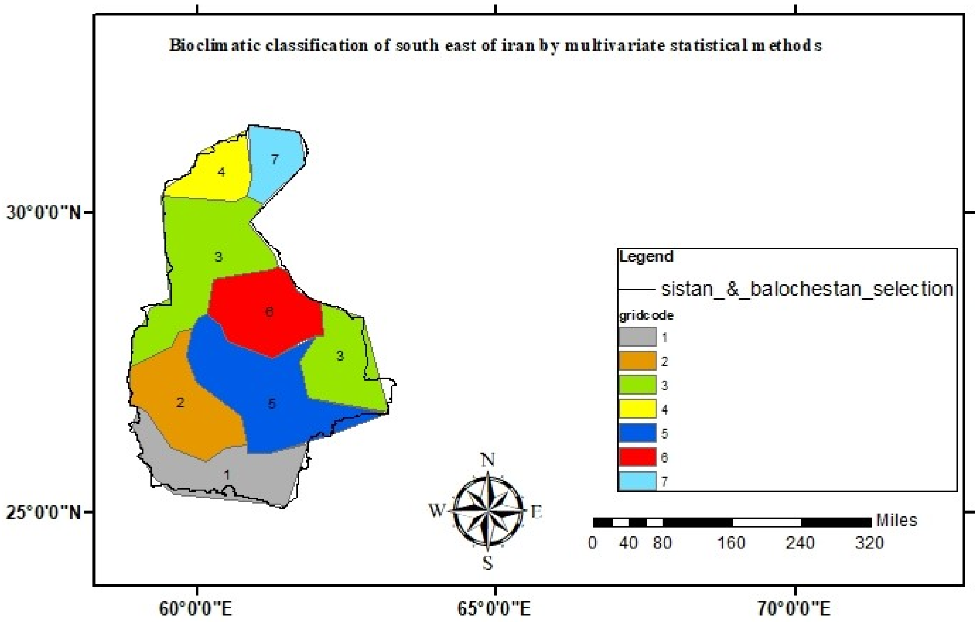

Figure 9. Bioclimatic classification of south east of Iran by Multivariate statistical methods

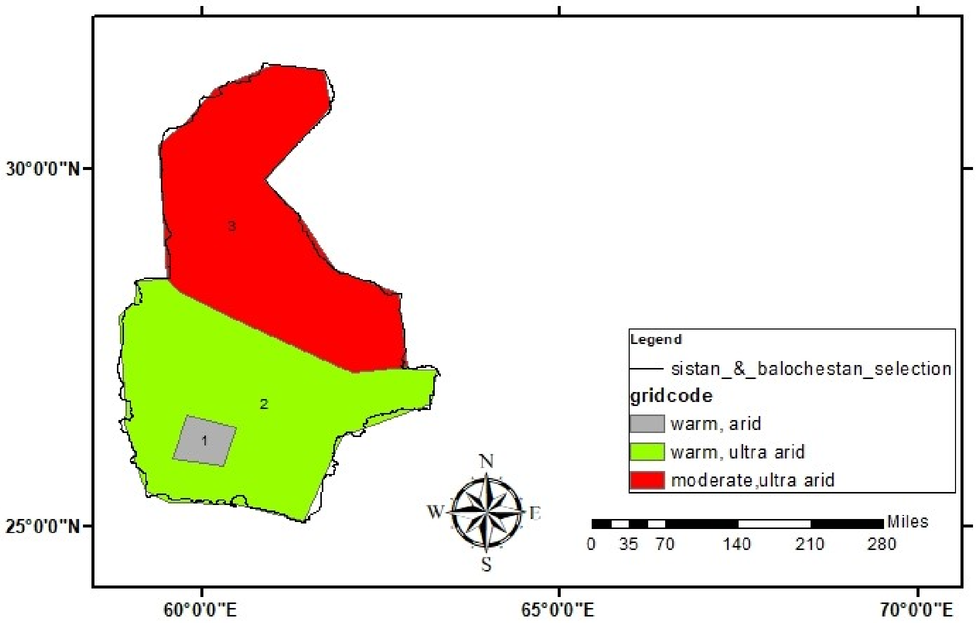

Figure 10. Bioclimatic classification of south east of Iran by De Matronne method

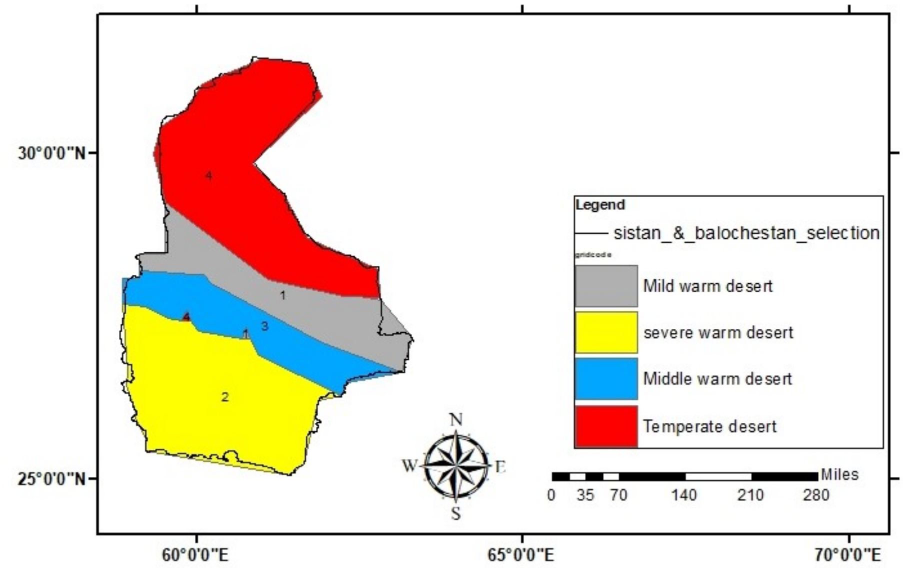

Figure 11. Bioclimatic classification of south east of Iran by Emberger method

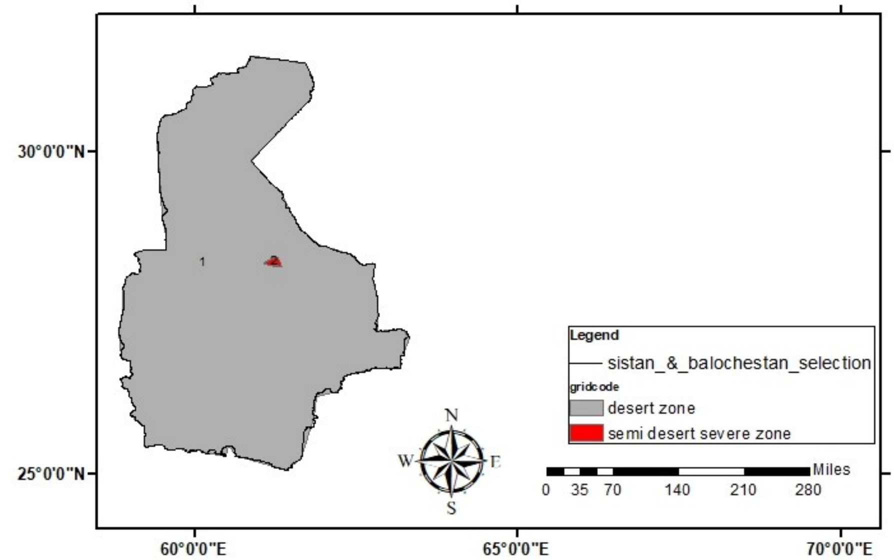

Figure 12. Bioclimatic classification of south east of Iran by Gaussan method

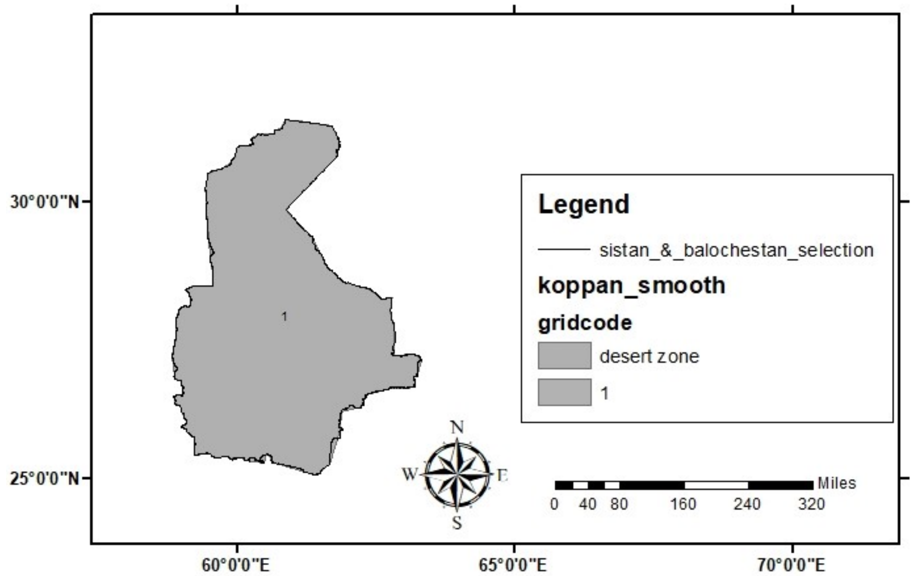

Figure 13. Bioclimatic classification of south east of Iran by koppen method

1. Semi-arid, ultra warm, very high relative humidity with summer rainfall

This area covered an area of 2186863 ha precisely located in the southern regions of Sistan and Baluchestan province (Figure 9). According to Table 5 in this zone, factor score of temperature and summer rainfall are high, the relative humidity factor is also very high. Average annual rainfall and mean annual average temperature in this area were 24/164mm and 20/27°C respectively. According to these features, this zone was named: semi-arid, ultra warm, very high relative humidity with summer rainfall

This climatic zone with characteristics such as very high relative humidity, very high temperatures, and also to consider that in the warm seasons affected by the monsoon rainfalls that comes from India to this region of Iran, it created conditions that specific plant species distributed in this area and compatible with these conditions.

Plant species such as *Taverniera glabra*, *Tephrosia sp*, *convolvulus sp*, *Gymnocarpus sp* are distributed in this climatic region .according to the percentage of high salinity in this area, the salt species such as *suaeda sp* are dominant species in this climatic zone.

According to de Martonne's classification, a small part in the north of this zone is called warm - arid and the remaining parts of this zone were categorized as the Very arid and warm. Based on Emberger's classification all of this zone was named desert and very warm. This zone had desert climate based on Gaussen's classification and Bwh climates based on Köppen's classification. (Figure 10, Figure 11, Figure 12 and Figure 13).

Table 5. Factor scores and important climatic variables in thirteen bioclimatic zones in central Iran

Variables / Bioclimatic zone	Average annual temperature	average annual relative humidity	Annual rainfall	annual number of days with dust	average annual wind speed	Winter rainfall	Spring rainfall	Summer rainfall	Autumn rainfall	Temperature and summer precipitation factor	warm season wind factor	spring dust factor	fall and spring wind factor	relative humidity factor	winter precipitation factor
I	27.20	51.31	164.24	38.92	5.96	93.67	27.72	10.57	32.28	0.81	0.13	-0.68	0.41	2.22	0.59
II	26.81	34.98	163.61	43.96	5.49	91.21	31.22	12.59	28.60	1.29	0.29	-0.74	-0.10	-0.77	0.37
III	21.15	31.05	100.84	61.15	6.05	61.99	16.30	4.27	18.28	-0.57	-0.21	-0.46	0.58	-0.31	-0.94
IV	20.27	31.81	95.86	71.95	7.07	65.73	12.72	0.79	16.61	-1.51	1.58	-0.49	-1.32	0.12	0.32
V	25.07	32.08	128.82	57.83	4.95	74.96	17.79	13.34	22.73	0.42	-0.91	0.77	-0.96	0.05	-0.30
VI	20.76	29.50	126.61	72.35	5.85	81.98	13.97	5.42	25.25	-0.79	-0.46	0.77	0.62	-0.31	1.39
VII	20.97	34.93	73.56	128.38	8.92	50.08	9.20	0.50	13.78	0.39	3.19	2.34	0.26	0.18	-1.17

Figure 14. Geographical position of plains (Dasht-e kavir&Dasht- e Lut), mountains (especially Zagros Mts), seas and study area in Iran

2. Semi - arid, ultra warm with summer rainfall

This area covers an area of 2192342 hectares, almost equal to the previous area, and located in the southwest of the study area. This zone is in the direction of the western winds of the temperate region that enter to Iran and therefore, the maximum amount of rainfall in this route will be achieved in the warm seasons.

According to Table 5 in this area, the factor scores of temperature and summer rainfall factors are very high also, since the average annual rainfall in this area is 163.61 mm, and also the average annual temperature is 26.81°C, It was called by this name.

The similarity of this zone with the previous zone is very high, and only the relative humidity factor in these two zones is the difference which is due to its remoteness from large water resources (Persian Gulf and Oman Sea) On the other hand, this area is located adjacent to the plains, therefore the relative humidity factor in this zone is negative. These characteristics in this area caused that the plant species in this area to be suitable with these climatic factors and have less diversity and richness than the previous zone. The most important plant species in this area are: *Hamada SP*, *Polygonum sp*, *Calligonum sp*, *Gymnocarpus sp*, *Convolvulus sp*. The dominant plant species in this area are shrub species, which are located in this area with very low densities, and the percentage of canopy in this area is very low.

According to de Martonne’s classification, a small part in south of this zone is named arid - warm, and the rest of the area in this method is called very dry and warm. And the remaining parts of this zone were categorized as the Very arid and warm. Based on Emberger’s classification, a very small area in the north of this zone is called temperate desert, also parts in the north of this zone called Middle temperate desert and the remaining parts in this zone are called severe warm and desert. In the Gaussen’s method, all of this area called desertic zone and according to koppen classification is called Bwh. (Figure 10, Figure 11, Figure 12, Figure 13)

3. Warm and arid with wind in cool season

The zone with 4379205 hectares is the widest zone in this study which Parts of this zone are located in the east, and parts are located in the north and northwest in study area. According to the scores of factors in this zone, only the cold season winds have a positive and high score and the rest have received negative and low score (Table 5)

According to Table 5 and scores of factors in this zone, it is seen that the temperature and rainfall of the warm seasons are negative, which is mostly due to the shortage of rainfall in the warm seasons. On the other hand, the factor of rainfall in the cold seasons also received a very high but negative (94%) score which means that in this climatic zone the rainfall of the cold seasons is also very low. Therefore and considering that the average annual rainfall in this area is 100/84 ^{mm} and the average annual temperature is 21.54°C, this zone is named "arid, warm and windy in the cold seasons”.

The dominant species plant in this climatic zone are shrub species, species such as: *Gymnocarpus sp*, *Anabasis aphylla*, *Hamada sp*, *platychaete sp*, *zygophyllum sp*.

Parts of this climatic zone are ultra-arid and warm with the de Martonne’s classification, and the parts are ultra-arid and temperate. In the Emberger’s classification, the parts that are located in the east of this zone include mild- warm desert and temperate- warm desert, Parts of this zone, which are located in the north and northwestern regions of the study area, including mild- warm desert, temperate- warm deserts, and middle-warm desert. In the Gaussen’s method, all of this area called desertic zone and according to koppen classification is called Bwh. (Figure 10, Figure 11, Figure 12, Figure 13).

4. Ultra arid, warm and windy

The zone with an area of 103724 hectares is located in the north of the study area (Figure 9). This zone is one of the driest climatic regions of Iran and the study area. This zone, along with the seven zone, has the worst conditions, but this area is better than the seven zone the atmospheric precipitation in this zone is higher due to its neighbors to South Khorasan province, and Rangeland and vegetation in this zone have better conditions due to proximity to the highlands of South Khorasan province. (Figure 14)

According to Table 5 it is seen that in this climatic zone the temperature and summer precipitation factor is high but negative score which is negative due to the low amount of atmospheric precipitation in the warm seasons. On the other hand, the average annual rainfall in this zone is 95.86 mm (Table 5). Also the factor score of the winds of the warm seasons is high in this zone, therefore this zone is named “dry, warm and windy”.

The climatic features in this zone have created conditions that the vegetation in this area is very poor and dominant and dominant species in this area are shrubs. Which the most important of these plant species are: *Artemisia sieberi, Salsola sp, Hamada sp, GymnoCarpus sp.* also according to de Martonne’s classification the total of this zone is named very arid temperate zone, in the Emberger’s classification is named temperate desert zone. In the Gaussen’s method is named desertic zone and in koppen classification is named Bwh. (Figure 10, Figure 11, Figure 12, Figure 13)

5. Semi-arid, with summer precipitation and dusty in spring seasons

The climatic zone with an area of 3242769 hectares is the second largest zone of this study area. The factor scores in this zone indicate that the temperature and summer rainfall in this zone have high scores. Also, the spring dust factor has a high score, so this zone is named (Table 5). Also, according to the Table 5 in this zone, the annual rainfall is 128/82 ^{mm} and the average annual temperature is 25.07 $^{\circ C}$ so this zone was named: semi- arid, with summer precipitation and dusty in spring seasons.

The most important plant species in this area are the following species: *Zygophyllum SP*, *Gaillonia sp*, *Astragalus sp*, *convolvulus sp*, *and Gymnocarpus sp.* In the de Martonne’s classification the most parts of this zone have ultra - arid and warm climate and just some parts in north and northeast of this zone named ultra- arid and temperate climate (Figure 10). According to the Emberger’s classification the south parts in this zone ultra – warm and desert, central parts middle-warm and desert and north of this zone mild-warm and desert climate are named (Figure 11). In the Gaussen’s method the total of this zone is named desertic zone (Figure 12) and according to Figure 13 the koppen classification is named Bwh the total of this zone.

6. Semi-arid warm, dusty in spring season with winter rainfall

The area with an area of 2033772 hectares is located in east of the study area (Figure 9). According to the data of Table 5, it is noted that in this area the temperature and summer rainfall are high but negative. On the other hand, the factor of winter rainfall in this area has a high and positive score. Also, the dust factor in the spring also received a high score. Also, according to the data in Table 5 and as regards that the average annual precipitation and the average annual temperature are 126. 61^{mm} and 20/76°C respectly in this zone, this climatic zone was named: Semi-arid warm, dusty in spring season with winter rainfall

This is due to the presence of Taftan mountain range in this zone. All of the plant species in this zone are shrubs that the dominant species of this zone are: Artemisia herba alba and Ar. Sieberi, located at Taftan heights, other species plant in this area includes: Zygophyllum sp, Gaillonia sp, pteropyrum sp, Hamada sp, Calligonum sp.

In the de Martonne's classification all of this zone named: ultra - arid and temperate climate (Figure 10). According to the Emberger's classification the south parts in this zone named mild-warm desert and remaining parts named temperate desert (Figure 11). In the Gaussen's method just some parts of this zone named semi-severe desert and another parts is named desertic zone (Figure 12) and according to Figure 13 the koppen classification is named Bwh the total of this zone.

7. Ultra arid-warm, ultra dusty and windy zone.

This zone with the 901557 ha area is in the northern part of the study area and is the smallest climatic zone (Figure 10). According to the data in Table 5 in this zone, the two factors of wind and dust have a highest factor scores in this zone Also, according to Table 5 the average annual rainfall in this area and the average annual temperature in this area are 73.56 mm and 20.97°C respectly in this zone, therefore this zone was named Ultra arid-warm, ultra dusty and windy zone.

As respect that this zone is located adjacent to areas of Afghanistan and is always exposed to heavy winds and storms, the vegetation in this zone is very poor, in this climatic zone the dominant species are bushes and shrubs species, including *Tamarix sp, Aeluropus lagopoides, Salsola sp, Anabasis setifera, Ephedra Sp.*

In the de Martonne's classification all of this zone named: ultra - arid and temperate climate (Figure 10). According to the Emberger's classification it is located in a temperate desert climate (Figure 11). In the Gaussen's method named desertic zone (Figure 12) and according to Figure 13 the koppen classification is named Bwh the total of this zone.

4. Discussion and Conclusion

According to the results obtained in this study, from among climatic factors, the following 6 factors: temperature and summer precipitation, warm season wind, spring dust, cool season wind, relative humidity and winter precipitation play a major role in the distribution of plant species habitats in south east of Iran. These factors allocate 31.70%, 19.05%, 14.50%, 12.68%, 10.65% and 9.47% of the total variance to themselves, respectively, which makes 98.06% in total.

Generally, in this study and according to the factor scoring table (Table 5), it is observed that in the study area and considering the geographical location of Sistan and Baluchestan province, which is neighbor and border with two poor countries of Afghanistan and Pakistan, temperature and summer rainfall, Winter precipitation and wind climatic factors are effective with 91.72% of 100% impact in this province of Iran. These results are quite reasonable given the geographical location of Sistan and Baluchestan province, which is located in a very dry region along the border with Afghanistan and Pakistan, which have no management of natural resources, and especially on their rangelands.

However, if the results of this research exactly interpreted, It is inferred that the temperature and summer rainfall factor have the highest percentage of variance among other factors (Table 3) And has the most impact and positive effects in the (1) and (2) climatic zones. Where these two areas are in the vicinity of the vast water sources (the Persian Gulf and the Oman Sea, Figure 14) and it seems logical. And because in these climatic zones the air is always sultry thus the vegetation also strongly affected by this climatic factor and plant species are always affected by high and very warm temperatures Also, according to the results of the research, saligheh (2006) exactly the climate zone (2) is en route to rainy systems that enter from the west and from the Zagros Mountains of Iran to this part of the Sistan and Baluchistan province and zone (2) is en route to this rainy systems and Therefore, factor (1), namely temperature and summer rainfall factor in this zone is high, so that 57.5% of the humidity is supplied from this path.

Also, according to the results of the research, saligheh [35], the second route of the rainwater system in this study area (Sistan and Baluchestan province) are the Rainfall systems that coming to Iran from the Strait of Hormuz which also yields about 33.66% of the region's moisture from this path. This Route due to passage from southern moisture sources it has been accompanied by showery rains and create short-term, but intense rainfall in this zones, therefore in this two zones the temperature and summer rainfall factor has a high score and plant species in these zones are also more affected by this climatic factor.

As regards that the northern region of the studied area is particularly susceptible to severe winds called 120-day winds of Sistan during the summer (June, July, August, and September), it affects the vegetation of this region. And in this area, (seven and four zones) vegetation cover are extremely poor, However, in these seasons (spring and summer) the amount of precipitation is insignificant, and a small amount of rainfall occurring in this area disappears with severe winds. And consequence with the wind speed severe wind erosion occurs at the surface of the rangeland soils in these zones and in these zones (4 and 7) the factor score of this factor (dust) and wind are very high, as the results of this research confirm this subject (Table 5).

The high level of these factors causes the bare soil in these two climatic zones, and thereupon the vegetation, these areas are extremely weak and poor. And only species grow and distribute under these severe climatic conditions in these zones which have long roots that can penetrate deep into the soil and obtain water and food such as: *Tamarix aphylla*, *Haloxylon persicum* and also species with juicy leaves that have been fermented to prevent the evaporation of water. Varieties of genus *salsola* and *suaeda* are from indicator and dominant species in zones 7 and 4.

However as described above, as a result of severe winds in the area, sand storms occurs in this area. So that Distribution map of dust factor confirms this subject. According to the spatial distribution map of dust factor in this research the highest amount of this factor is located in the north of the study area and consequently, there are should be a systematic management of the correction and rehabilitation of the rangelands in these areas and uses from these sever winds that occurs in this zones as an opportunity And use solar panels to generate electricity.

A considerable subject in this research is Existence Taftan mountains in the climatic zone of six, that according to data of Table 5 in this zone the factor score of winter precipitation is high and the highest amount of this factor And the highest amount of this factor in the whole study area is also seen in this area due to the fact that Taftan mountain range is located in this climate zone, And the highest amount of this factor (winter rainfall) in comparison with other climatic zones is seen in this climatic zone, because of the Taftan mountains is Existence in this climate zone. And according to the results of this research, the best climatic conditions are in this zone, and even insofar as in this zone snowfall occurs in the high altitudes of this zone in winter seasons.

And plant species of this altitudes are cushioned that one of the most important genus of plant species is *Astragalus sp*, Also forest species such as *Amygdalus scoparia* and *pistatia atlantica* are seen at the altitudes of this climatic zone, which are the indicator species of this zone.

It can be concluded that in climatic zone of six the role of winter rainfall factor in distribution of plant species is much more important than other factors. And also in climatic zones of seven and four the role of wind and dust factors is much more important than other climatic factors in distribution of plants species in rangelands. Generally, when the climatic zoning results using multivariate statistical methods in this study are considered, it turns out that has been done an accurate climate zonation And accordance with the climatic and ecological conditions in each of climatic zones.

So that every scientist in the first reprise, by hearing the name of the climate zone, finds a Very detailed and comprehensive view of the climate in each zone. And this benefits from a multivariate statistical method that is very accurate and complete and have a high ability to differentiate of climatic zones, whereas traditional climatic methods (koppen, Gaussen's, Emberger's and DE martens) compared to multivariate statistical methods, indicative that inability of these methods to differentiate the climatic regions. For example, 1 and 2 Zones have relatively high relative humidity due to their proximity to vast water resources (Persian Gulf and Oman Sea). And the temperature in these zones is warm and sultry, and thereupon, vegetation in these areas is affected by this climatic factor.

The influence of these factors (relative temperature and relative humidity) on vegetation in these zones is shown only by multivariate statistical methods, while by traditional methods (koppen, Gaussen's, Emberger's and DE martens) this phenomenon is not shown.

For this reason the zones one and two respectively are named: semi-arid, ultra warm with very relative humidity and semi-arid, ultra warm.

Also, according to Figure 14, since Zone 3 is located adjacent to the Loot Plain, and the temperature of the Loot Plain affects this area, and as a result, this zone was named "arid-warm". and also the seven zone is located in north of the study area at the zero point border with Afghanistan, the focus of the crisis and wind erosion are all over the world, and as a result of the sandstorms that enter this area into seven zones, with the negative impact on life Live creatures include vegetation in the seven zone And affect all of the climatic features in seven Zone, And, on the other hand, the high wind speed in this zone causes that the low rainfall that occurs in in this area in the warm seasons is immediately dried out after precipitation And very low rainfall Penetrate in the rangelands soils in this zone (7) For that reason, This zone was named: ultra-arid, very windy and very dusty that This subject is only mentioned in multivariate statistical methods, and traditional methods of assessing climatic zone are incapable of expressing these facts.

As we know, mountains, plains, deserts (topography) and water resources are effective in creation of climate and bioclimatic maps. Therefore, according to the results of this study, all of seven climatic zones were identified and named according to the climatic and ecological conditions in each area.

On the other hand, traditional methods that are most used in this field are incapable and only based on the proposed formula in each region determining of climatic zone and do not have a very careful in the Separation of bioclimatic maps.

While the climate is a set of elements and climatic factors in each region and this resultant set of factors and climatic elements in each region is referred to only in multivariate statistical methods. And traditional methods only determine bioclimatic maps in each zone based on one or two element of each region. This makes the precision in the demarcation of the climatic zones very low, and as a result, the real climate of each region is far from the reality with what is achieved by these methods.

And traditional clustering methods that are most commonly used (koppen, Gaussen's, Emberger's, and Demartons) Are unable in this subject and do not have a high accuracy in the Separation of bioclimatic classification. For example, in this research and according to the figure of 14, in the koppen method, total of study area (. /.100 percent of the area under study, the entire Sistan and Baluchestan province) has been named as the Desert Climate (Bwh) Whereas this is far from reality And there are areas in the province of Sistan and Baluchestan that have a better climatic conditions than the desertic climate.

Also, based on the koppen method, the range that by this method named Bwh is divided into seven different climates according to the multivariate statistical methods. In each of these seven different climates, one factor or several factors have a higher performance For example, in south of the studied area, which is located in the vicinity of large water resources (Persian Gulf and Oman Sea) the two factors of relative humidity and temperature have a higher performance And since the average annual rainfall in these zones is about 164 mm (Table 5) Generally these zones named: semi-arid, ultra warm with high relative humidity whereas in koppen classification does not refer to these factors at all.

Or, for example, the zone (6), which has a relatively better climate than other areas, has a Taftan mountain range, and Taftan Mountains are located in this area, which has a high performance in this zone of winter rainfall (+ 1.39 in Table 5) and this subject is mentioned only in multivariate statistical methods, while the koppen method has not been mentioned at all.

Also, in zones 4 and 7, where two factors of wind and dust storm in this zones have a higher performance than other zones (Table 5) should be named on the basis of these factors, which in multivariate statistical methods these factors are mentioned precisely And in naming these two zones, these factors have been used And this means the precise divided and separation of each climatic zone over other areas that This subject only done in multivariate statistical methods And, as it was said the koppen method is unable to express these facts.

According to Figure 12, and according to the Gaussen's method, approximately all of the studied area is named as desertic climate. And this method, like the koppen method, has named the entire study area as one climate called a desertic climate and only a very small area that includes Taftan Mountains is called "severe semi-desertic climate" (Figure 12). And all the errors mentioned in the koppen Method are also true here, and this method also has many weaknesses in relation to the bioclimatic classification Compared with multivariate statistical methods.

Also, in the Demarton classification, the entire study area is divided into 3 zones (Figure 10) which has a lot of weaknesses. For example, approximately 50 percent of the total of the studied area in this method is Belongs to the "ultra-arid and moderate" zone which extends from the center to the north of the study area (Figure 10), whereas according to the Figure 9 in the multivariate statistical methods this range is divided into five separate climatic zones (arid warm with winds of cold seasons, ultra-arid warm and windy, semi-arid ultra-warm with summer precipitation and dusty, semi-arid warm with rainfall in winter and dusty in spring season, ultra-arid warm ultra-windy and dusty) As it is seen, this area that according to the Demarton classification named it "temperate desert" In multivariate statistical methods, different regions have been created which is distinguished by very high accuracy And in the naming of each zone, the appearance or percentage of each factor is included, so that separated of precipitation in to "arid and ultra-arid", from temperature to "warm and ultra-warm", from season rainfall to "rainfall in cool and warm seasons" also from factors as wind and dust storm separated to" ultra-windy and windy", "ultra-dusty and dusty" Whiles in the demarton method none of the above factors has been mentioned, and only one common name, called "temperate desert" has been used. at the same time, according to the demarton method, 50% of the study area, Which extends from the center to the south of the range, is divided into 2 general zones, called warm arid and warm ultra-arid, That's 50 percent of the study area in statistical methods were divided into four zones (ultra warm semi-arid with high relative humidity and summer rainfall, ultra-warm semi-arid with summer rainfall, warm arid with winds in cold seasons and semi-arid ultra-warm with summer rainfall and dusty in spring season).

As can be seen (as shown in Figure 10), in the De marton method approximately half of the total study area was allocated to two climatic zones, but in multivariate statistical methods, the same 50% of its range was classified into more accurate bio climates zone (4 climatic zones) And in the naming of these four zones, from factors such as high relative humidity, dust storm in warm seasons, wind speeds in warm and cold seasons were used in the end, a precise climatic zoning without any error or weakness will be achieved in this area. While these subjects is not included in the Demarton method, and only based on temperature and rainfall was named climatic zones in this method, and from other factors such as wind speed, dust storm, relative humidity, rainfall in warm and cold seasons not used in naming of climatic zones and this subject is from weaknesses in demarton method. In Emberger's classification similar to the three traditional methods mentioned above included a lot of weaknesses, so that in this method, the name of the climatic zone has been separated only on the basis of rainfall and temperature. According to the map of Figure 11, the whole range of the study area is divided into four climatic zones. As seen, approximately 35% of the study area has been allocated to ultra-warm desertic climate which this 35% range, located in the South side of the study area, and this range in multivariate statistical methods is divided into three distinct zones (semi-arid ultra-warm with high relative humidity and rainfall in summer season, semi-arid ultra-warm and rainfall in summer season, semi-arid ultra-warm and rainfall in summer season with dust storm in spring season). This area is not desertic zone, because the desert range is referred to as an annual rainfall of 50 mm, while the annual rainfall of this zone (of the total pixels contained in this range) is 152.22 mm and the range with this rainfall is not considered desert at all, and this is the main and significant weakness of this method. While in multivariate statistical methods based on rainfall, this region is divided into three distinct zones, which have been called semi-arid in perspective of precipitation and also in the area of this region, which is indicated and called zone 1 by multivariate statistical methods (figure9) Based on the fact that the relative humidity factor is very high and also in this region (zone 1) the temperature factor and summer precipitation has a high degree of appearance (Table 5) this climatic zone named semi-arid ultra-warm with high relative humidity and summer rainfall.

Also the part of this range that in multivariate statistical method called Zone 2 Based on the fact that relative humidity appearance factor in this area (Table 5) was low, but another factors was similar to factors in zone(1), therefore this zone was named semi-arid ultra-warm with summer rainfall**.** The next zone, which has been named as a separate zone in multivariate statistical methods, is the southern part of the zone 5 (Figure 9), which in Emberger's method is called ultra desertic climate, As it is seen according to Figure 9 the southern parts of the zone 5 in multivariate statistical methods include, on average, about 128 mm of rainfall, which This amount of rainfall is not referred to the desert, because the desert is referred to as an area with fewer than 50 mm rainfall also in this area, the amount of temperature and summer precipitation factor is + 0/42 and the spring dust storm factor is +0/77, Therefore the abovementioned factors should be considered in the designation of this zone. That only the multivariate statistical methods do this subject and therefore according to this methods this zone named “semi-arid ultra-warm, with summer rainfall and dusty in spring seasons” wiles in Emberger’s method none of the factors of summer rainfall, dust and relative humidity were not mentioned and this is due to the weakness of Emberger’s method.

Also according to Emberger’s method, about 35% of the area in this study, which is located in the northern part of the range, is named the temperate desert that as shown in the multivariate statistical method (Figure 9), this region is not a moderate region, rather It is also a warm zone because the average annual temperature in this range is approximately 21 ° C, which is not considered a moderate temperature. On the other hand, the average of relative humidity factor in this range is also -0.08, which this amount of relative humidity is also relatively very low and this area with these specification of temperature and relative humidity cannot be considered moderate range, but it is considered to be warm. Simultaneously, according to the Emberger’s method this area from viewpoint of precipitation is named desert area, while the average annual rainfall in this range is exactly 130 mm (based on the average pixels of this range and the rainfall level of each pixel) that it ever should not be named as a desert, because the desert refers to an area with an average annual rainfall is equal to or less than 50 mm, while in this range it is 130 mm and this subject is from weakness points of this method Which has named this range "desert and temperate". Whereas this range based on the multivariate statistical method is divided into 4 distinct zones which in the north of the boundaries are named the two zones of 4 and 7 and in the center and south of this range, named the two zones of 3 and 6 (figure of Map 9) that in the north of this range and according to the data of Table 5 in the four zone the factor of cold season winds, has a high factor score (+1.85). And also due to other characteristics of the climatic factors in this area, this zone was named in the “ultra-arid warm and windy”. Also in the 7 zone in the north of study area and in vicinity of 4 zone the factor of cold season winds with factor score of +3.19 and factor of spring dust with factor score of +2.13 and other characteristics of the climatic factors, this zone are named “ultra-arid warm ultra-windy ultra-dusty”. And as can be seen, these cases have not been regarded in the Emberger’s method, and there's just one general name on these zones while in multivariate statistical method, every field and every region exactly based on the effective climatic factors in each zone are named. Meanwhile, the two zones of 3 and 6 that in multivariate statistical methods are also segregated into separate zones in Emberger’s method these two zones together and with the name of "temperate desert" climate are named which the average annual rainfall of these ranges (zones 3 and 6 in multivariate statistical methods), which in Emberger’s method are named as "desert climate", are approximately 114 millimeters per year (based on average annual precipitation of the pixels included in this range) also the average relative humidity factor in this range is -0.3, that with considering the average annual temperature of these ranges which is 95.2°C, these ranges cannot be named temperate zones Rather, these ranges with these specifications are considered the warm zone, and this case is from weaknesses of this method and this weaknesses are corrected in the multivariate statistical methods and this areas are named exactly based on climatic factors existing in these areas, namely, in the third zone the factor score of the cold season’s winds are high and, as a result, this factor has been used in naming this zone, also, in the six zone, factors of spring dust, cold season winds and winter rainfall have a high factor scores and are very important Therefore, in naming in this area, these factors have been used. and while in Emberger’s method has not been indicated, none of the above mentioned factors and in the naming of the zones have not been used from these factors, About 30% of the study area is in the Emberger’s method, which is dependent into two zones of moderately warm desert and mild warm desert areas located in the center of the study area that of temperature factor the average annual temperature of the pixels covering these areas is 23 ° C, Also the average annual rainfall of these pixels containing these ranges is 122 mm, according to this characteristics this ranges should not be named "desert". However, since these two areas (About 30% of the study area) are named moderately warm and mild warm areas by the Emberger’s method, this subject is near to reality but it does not reflect the real climate of these two areas Because in these two areas factors such as warm season rainfall, the cold season winds and spring dust storm have a very high factor scores, and these three factors must be included in the naming of these zones Unfortunately, this has not been done in the Emberger’s method on the other hand Fortunately, this is done in the multivariate statistical methods And this is also a weakness of these methods(common classifications).

In general, this research shows the ever-greater efficiency of multivariate statistical methods in determining the magnitude of each climatic factor in the distribution and dispersion of plant species and in determining different climatic zones in south east of Iran (including the Sistan and baluchestan province) in comparison to conventional and traditional climatic classification methods. Moreover, in the climatic classification of Saudi Arabia, using multivariate statistical methods, factor analysis, and cluster analysis; and comparing it with classical climatic classification methods such as Gaussen’s and De Matron, Ahmed, too, came to the conclusion that multivariate statistical methods have divided this country into nine different climatic zones. However, the classical methods have divided the whole country of Saudi Arabia into 2 or 3 regions. In addition, he finally concluded that the diversity of climatic variables used in multivariate statistical methods makes this climatic classification method seem much more useful than classical and traditional methods [36]. In the present study, a climate-vegetation classification was conducted on a large scale in south east of Iran, which only considered the effect of the macroclimate on the vegetation. In the end, it is suggested that more factors such as topography and soil are considered in the study of the climatic regions of vegetation distribution in order to improve the results of the bioclimatic classification. Nevertheless, this study paves the way for the next bioclimatic studies.

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