

Climatic Zoning of Precipitation and Temperature in Chaharmahal and Bakhtiari Province Using Geographic Information System (GIS)

¹Ali Khalaj and ²Seyyed Mehdi Mortazavi

¹Department of Climatology, Payame Noor University, Fars Province, Iran

²Department of Climatology, University of Esfahan, Esfahan, Iran

Abstract: In this study, data from 13 meteorological stations has been used to zoning of precipitation and temperature in Chaharmahal and Bakhtiari province where in the meantime, there are 8 climatological stations and 6 synoptic stations. After data preparation, in Excel and Notepad++ by GIS software, we produced zoning maps of temperature and precipitation. It can be stated through maps that rainfall in the North, North East and North West where are higher than other points in Chaharmahal and Bakhtiari, enjoys greater intensity. In the meantime, Koohrang station has the most rainfall among other parts of the province. More precipitation in the cold season (winter and fall) that is more severe in winter in contrast in the warm months, rainfall is the lowest. Annual precipitation charts which have been prepared from 1958-2010, represent a trend of increasing rainfall from the past to the present. On the other hand, the maps of temperature zoning show that in winter the temperature reaches below 0°C and a large part of the province experience the temperature below zero. The temperature changes in the province fluctuated from -6°C in January to 33° in July. In general, Chaharmahal and Bakhtiari located in the Western parts of the country enjoy blessing of winter precipitation in the West of the country where are due to the low-pressure air masses from the Mediterranean. In contrast, low rainfall and high temperatures in warm seasons are due to the rule of the Azores high pressure on the climate of Iran. It seems that in the province there is a positive correlation between precipitation and elevation so that at the higher places such as Koohrang, rainfall is more intense.

Key words: Climatic zoning, temperature, precipitation, Chaharmahal and Bakhtiari, GIS

INTRODUCTION

Implementation of sustainable development requires careful planning based on talents and resources constraints and climate of each region is the most important determinants of the location development (Alijani, 1997). Scientists have presented different models for managing resources and access to the highest continuous production, since there must be essential basic information to choose a model. Climate classification can meet basic needs of society policymakers to make a logical decision (Rasouli *et al.*, 2013). Iran is a country where the average rainfall is about 1-third of the global average precipitation and water resources are severely constrained. On the other hand, the major use of water resources is in the agricultural sector. Therefore, to optimal use, it is essential to help save water and improve irrigation efficiency to preserve limited resources. Choosing compatible products with the climate and limited need of water and resistant to dehydration, especially in drought conditions are some factors to optimize agricultural water consumption pattern

(Asakareh, 2012). Climatic classification is a set of rules that by using them, we can separate areas where have climate points and we can categorize them. Human need to identify possible environment for planning and optimal utilization of resources increases the range of his knowledge in the field of various climates and subsequently, the climatic classification for effective use of this information is essential. Generally, identifying the natural characteristics of each region, particularly in the weather can play a major role in planning and preparing that land. Climatic zoning (identification of the zones which has identical climate) is essential to achieve comprehensive development in various spatiotemporal aspects (Oji, 2006). In this regard, environmental, economic, agricultural and industrial potencies (oil, gas and petrochemical projects) in the province and optimized operation of them and also prediction of natural disasters, such as floods, etc. (Lashnizand, 2011) the necessity of the proper recognition of environmental conditions and characteristics of different climatic zones and finally climatic zoning of the province, especially for planners have been revealed.

Research purposes: Climate zoning of the province and providing climate maps and graphs and the impact of topography on the climate of the province using the software functionality of Arc map (Gis)

Detailed objectives:

- Complete and systematic knowledge of climatic conditions of Chaharmahal Bakhtiari and achievement of a suitable climatic zonation
- Preparation of maps and diagrams climate of the province
- Attention to the factor of topography and recognition of its effects on climate of the province using GIS capabilities

Problem statement: Understanding the natural features of each region, especially the weather can play a major role in planning and preparing (Soltani *et al.*, 2011). A variety of climatic zoning are presented by scientists and researchers that many of them are only compatible in certain areas. On the other hand, using these methods to zoning is versatility. The most important use of them is regional cropping pattern, similarity of climatic zones, drought, water sources, etc., Each system of climate classification is a set of rules that by using them, we can separate the areas where certain features are common points of view and areas with common characteristics together are put in one place. The criteria applied in different sciences are not the same and they are different. As from the perspective of a geographer, climatic zoning is to organize and group climatic zones so that each district may have similar climatic characteristics (Samadi and Mohammadi, 2010). From an agricultural perspective, climatic zoning is to designate areas where in terms of cultivation and production have the similarity of climate and in studying methods of pest, weeds, the use of agricultural machinery, research and other farming operations are part of a class. From the viewpoint of experts of natural resources, climatic zoning is to determine forest, grassland and vegetation types in each area and finally in terms of hydrology, climatic zoning is to classify different regions in terms of water harvesting from surface and subsurface resources (Tavousi and Delara, 2010). The two issues should take into climate classification: to determine essential criteria for classification; to determine the boundary between two groups or two climatic regions. The most important uses of climatic zoning, we can mention helping project planners and strategic planning with regard to the type of climate and dominant elements, establishing industries with regard to climate conditions, building design, producing energy using local natural conditions, etc (Masoudian, 2006). Today, on behalf of scientists, different models for climate classification are presented which the result of the calculation of each of

these categories provides basic information from the area and help policy and decision makers in each community to have better and clearer understanding on the part of the regional issues which are based on the climate and weather and the accuracy of their choice is increased by using the results presented. Today, the use of Geographic Information Systems (GIS) has provided many facilities in climatic zoning and using statistical methods, especially geostatistical have led to enjoy the accuracy of estimates for zoning of heavier scientific support. Having a zoning map of each region is a complete guide from economic realities, agriculture, water resources, climate and tourism and so on. In particular, this zoning is more in tune with the proposed methods.

Range of study: Chaharmahal and Bakhtiari province is one of mountainous areas of the central plateau of Iran and it is located between 31° and 9 min to 32° and 38 min of North latitude and 49° and 30 min to 51° and 26 min of east longitude of Greenwich. This province is limited on the North and East to the province of Isfahan, on the West to the province of Khuzestan, on the South to Kohgiluyeh and Boyer-Ahmad province and on the north-west to the province of Lorestan. Chaharmahal and Bakhtiari natural shape is based on central highlands of the Zagros Mountains and it is regarded as one of the country's mountainous regions. The capital of the province, Shahrkord, with a height of 2,150 meters among the cities of Iran is the highest of the city in the country. That's why, it is known as the roof of Iran. Zagros Mountains in this area are prolonged in bands from the North West to the South East and famous mountain of Zard Kooch Bakhtiari with an altitude of 4,548 m is located in this province. Much snow in the highlands of the province has caused that the most popular South Western and central Iran perennial rivers, the Karoon River and Dez emanate from these highlands. Having high mountains and placing in the path of Mediterranean atmospheric flows have caused that this area enjoys a good condition in the annual rainfall. Atmospheric fallout begins in October and ends in January to the highest level (Movahhedi *et al.*, 2012). The rains reduce in May little by little. Because of the mountainous atmosphere of the province and given that the temperature of the height is different in every region of the province there are several thermal climates in the province. Therefore, the climate is temperate in the winter cold and summer in the province. Also due to being young orogenic period, in this area, natural calamities such as floods, earthquakes, landslides can be seen in many places.

Chaharmahal and Bakhtiari province is considered one of mountainous areas of the central plateau of Iran where in the central part of the Zagros mountain range is located between the mountains of the interior of

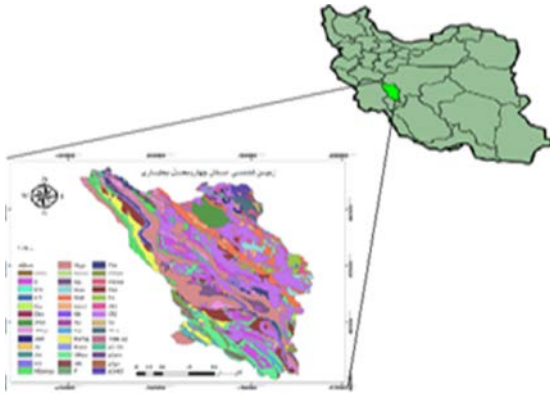


Fig.1: Location of khaharmahal and bakhtiari

the province. Due to being young orogenic Mountain-building period and conditions of specific faults in this area, many natural calamities such as floods, earthquakes and landslides in many parts are visible. Chaharmahal and Bakhtiari province has 16 highest mountains with a height of $>3000-500\text{ m}^2$. The mountains are prolonged on the North West province to South East and whatever we go ahead on the West to the east and Isfahan province, the heights are reduced and finally, we get to the relatively wide plains such as Lar, Faradonbeh, Kiar and Gandoman. The plains include a total of close to 24% of the province and its store of sediments brought them fertile ground for agriculture. “Zard Kooh Bakhtiari” where it is the second highest Zagros mountain range (after Mount Dena) is located in this province. Because of high mountains which it is located in the path of wet winds of the Mediterranean systems and lead to climbing and unloading of these systems, the province has been relatively good rainfall to the extent that this area despite having only one per cent of Iran, ten percent of the country’s water resources is at its disposal. Atmospheric fallout and snow and rain in the mountains of the province are the most popular origin of the permanent rivers in SouthWestern and central Iran, the Karoon and Zayandehrood and include aquifers of two rivers with 2720 and 13,800 km^2 , respectively. There are also various streams in the province where in addition to the tourist attractions and natural beauty, they have provided fertile grounds for the creation of mineral water factories Fig. 1.

MATERIALS AND METHODS

In this study, we will address methods and processes used to prepare the data and software such as Excell, GIS, Notepad ++ are used Fig. 2.

Process

Sorting data

Primary sorting: For climatic zoning of Chaharmahal and Bakhtiari need climate data that first all data of weather

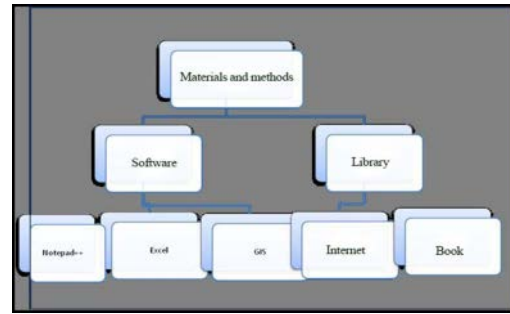


Fig. 2: Materials and method of research

stations including synoptic and climatology was received from the National Weather Service and to sort the data and separate information needed including temperature and precipitation of the province during the period it is transferred to Excel and all synoptic and climatology stations are restructured separately.

Removing asterisks, changing months into numbers, separating data of temperature and precipitation and jointing; to remove asterisks available and to change months into numbers, we will transfer it into Notepad++ and after separating, we will return to Excel. In the next stage, since we intend to sort temperature and precipitation data based on the length of period, we change it into dbf and we have made an idcode since 1951-2010 separately and joint it in GIS together.

Restructuring data: In Excel, to compensate the loss of data, first, we will separately sort all data on precipitation and temperature of synoptic and climatological stations together and according to formula Gaussian = if (B2 = 0, f; b2, we will consider temperature formulas, data temperature on average monthly and precipitation data as the sum of monthly. After converting data from daily to monthly, according to the nearest station which this means that the station that has the highest data is in priority and we will put the rest into the nearest station. To interpolate, first the station which is the highest data, we will fill by the next station and then, according to the closest station via the first station, the rest will also be interpolated in chain. To do this, we will consider the correlation of two adjacent stations and if the value of the correlation is >0.5 , we will data storage for the station having the loss of data. In this case, this show a good correlation for data of temperature but the correlation has been below 0.5 for rainfall which reach the correlation >0.5 by eliminating numbers deviated. In this province, the highest data belongs to Zaman Khan Bridge station both in the data of rainfall and temperature data which for completing temperature data of Zaman Khan Bridge station are used only from stations of Boroijen, Saman,

Table 1: Specifications of synoptic stations of the province of Chaharmahal and Bakhtiari

Station name	Height	Longitude	Latitude
Boroojen	2197	51/30	31/95
Farokh	2065	50/93	32/30
Koohrang	2285	50/12	32/43
Lordegan	1580	50/82	31/52
Saman	2057	50/93	32/45
Sharkord	2061	50/39	32/34

Table 2: Specifications of climatological stations of the province of Chaharmahal and Bakhtiari

Station name	Height	longitude	latitude
Adalator	2410	50/95	31/90
Adldozan	2054	50/95	32/08
Boldagi	2231	51/05	31/92
Emam	2285	51/30	31/73
Farsan	2059	50/55	32/25
Malkhlie	1762	51/25	31/28
Pol-zaman	1883	50/88	32/48
Sharkord	2061	50/39	32/34

Shahrkord and Farrokh and for data of rainfall are used from stations including Boroojen, Farokh, Adalator and Koohrang, in the following monthly data are changed to annually and for each station, mean, standard deviation and coefficient of variation are taken and from each station was obtained chart and correlation separately which in chapter four will be analyzed. Also, monthly data of precipitation and temperature on average have been changed from 1952-2010 and stored into text to be used in GIS for climate zoning. In the next stage, in GIS we will zone the province based on the average monthly temperature and precipitation that for each one is produced about twelve maps monthly from March to February and also the map of monthly change rate of the whole province and a graphical map for March to February and it is classified and with it the area is extracted and from it an output is taken which in GIS layers such as DEM of the province, the map of the whole province and monthly average is used which is appeared on the map in spot. Temperature formula: if (B2 = 0; "F"; b2). Rainfall formula: if (B2 > 0; "F"; b2).

Table 1 and 2 represent the characteristics of synoptic weather stations and climatological stations of Chaharmahal and Bakhtiari province, respectively. Among the synoptic stations, Koohrang station with the height 2285 is regarded as the highest station and Lordegan with the height 1580 is regarded as the lowest station, also in the climatological meteorological stations, Adalator with the height 2410 m is considered the highest station and Malkhlie with the height 1762 m is considered the lowest station. In total among all stations, Adalator with the height 2410m is the highest station and Lordegan with the height 1580 is the lowest station.

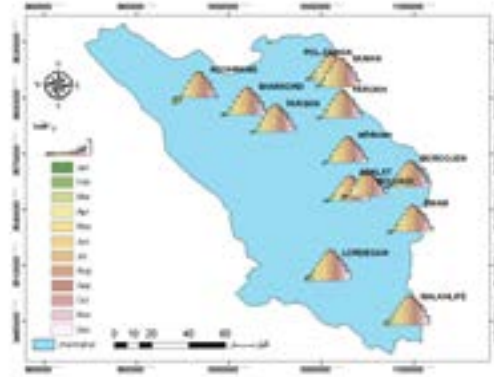


Fig. 3: Diagram map of temperature of weather stations in Chaharmahal and Bakhtiari

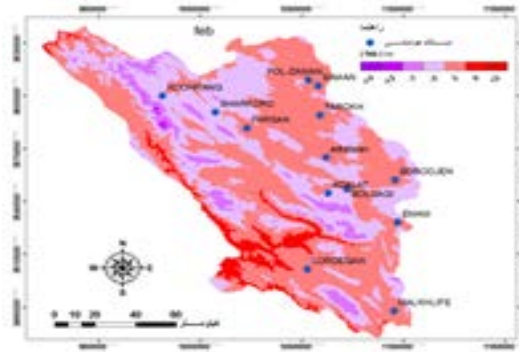


Fig. 4: Map of zoning temperature January in Chaharmahal and Bakhtiari province

RESULTS AND DISCUSSION

According to Fig. 3 and 4, it is specified that in several stations including FAROKH, FARSAN, BOROOJEN and other stations, sub-zero temperatures is sub-scale in the winter. In contrast, In contrast, maximum temperature is in the station in May to September when the temperature is between 25-30°. It seems that temperatures in parts of northern and northwestern province are lower than other parts in the province due to the high altitude areas where sub-zero temperatures in these stations are evidence on this. Certainly, the height is a factor for reducing the temperature in different parts of the province.

According to Fig. 4 and Table 3, it is determined that January temperatures in the whole province at least 17° C and maximum 10° C. Accordingly, the maximum area of the province is covered in the range of 0° C to 6° C with area 61.9%, while the lowest area of temperature is specified between -17-12° C with 0.74. In general, January is the coldest month, with most of the area of the province is covering the sub-zero temperatures.

Table 3: Descriptive statistics of zoning temperature in January of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/9	-13	-12	-17	0/74	11981
1/5	-8	-6	-12	10/07	163990
1/6	-2	0	-6	61/90	1007890
1/5	2	6	0	25/00	406960
1/1	7	10	6	2/29	37333

Table 4: Descriptive statistics of zoning temperature in January of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/5	-13	-12	-15	0/13	2082
1/5	-8	-6	-12	5/58	90887
1/5	-2	0	-6	36/18	589116
1/7	2	6	0	52/69	857902
¼	8	12	6	5/40	87909
0/0	12	12	12	0/02	259

Table 5: Descriptive statistics of zoning temperature in march of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/3	-6	-5	-6	0/04	674
½	-1	0	-5	3/82	62143
1/3	3	5	0	25/68	418078
1/3	7	10	5	58/87	958536
½	12	15	10	11/07	180180
0/4	16	17	15	0/52	8535

Table 6: Descriptive statistics of zoning temperature in April of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/5	-1	0	-3	0/22	3657
½	3	5	0	5/69	92647
1/3	8	10	5	35/38	575961
1/3	12	15	10	51/34	835830
1/3	16	20	15	7/35	119595
0/2	21	21	20	0/03	464

According to Fig. 5 and Table 4, it is determined that January temperatures in the whole province at least -15° C and maximum 12° C. Accordingly, the maximum area of the province is covered in the range of 0° C-6° C with area 52.69%, while the lowest area of temperature is specified 12° C with 0.02 area of the whole province.

According to Fig. 6 and Table 5, it is determined that March temperatures in the whole province at least -6° C and maximum 17° C. Accordingly, the maximum area of the province is covered in the range of 5° C-10° C with area 58%, while the lowest area of temperature is specified -6° C with 0.04 area of the whole province.

According to Fig. 7 and Table 6, it is determined that April temperatures in the whole province at least -3° C and maximum 21° C. Accordingly, the maximum area of the province is covered in the range of 10° C-15° C with area 51%, while the lowest area of temperature is specified 21° C with 0.03 area of the whole province.

According to Fig. 8 and Table 7, it is determined that May temperatures in the whole province at least 6° C and maximum 25° C. Accordingly, the maximum area of the province is covered in the range of 15° C-20° C with area

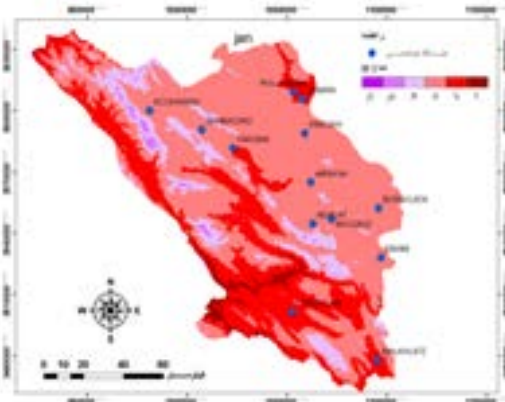


Fig. 5: Zoning map of January temperature in Chaharmahal and Bakhtiari province

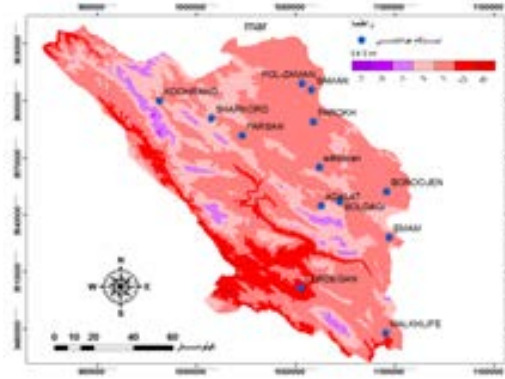


Fig. 6: Zoning map of March temperature in Chaharmahal and Bakhtiari province

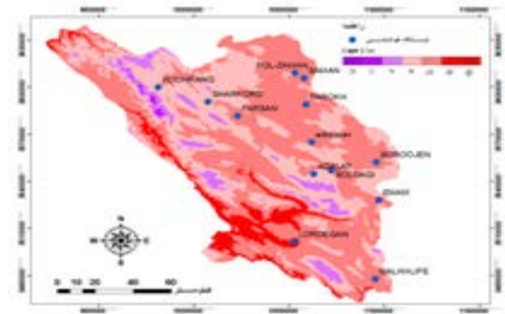


Fig. 7: Zoning map of April temperature in Chaharmahal and Bakhtiari province

66%, while the lowest area of temperature is specified 25° C with 0.02 area of the whole province. According to Fig. 9 and Table 8, it is determined that June temperatures in the whole province at least 10° C and maximum 30° C.

Table 7: Descriptive statistics of zoning temperature in May of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/9	9	10	6	2/07	33742
1/3	13	15	10	22/78	370973
1/3	17	20	15	66/58	1084070
½	22	25	20	8/54	138991
0/1	25	25	25	0/02	367

Table 8: Descriptive statistics of zoning temperature in June of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/9	14	15	10	2/27	37011
1/3	18	20	15	26/77	435859
½	22	25	20	62/95	1025000
½	26	30	25	7/98	129991
0/0	30	30	30	0/02	289

Table 9: Descriptive statistics of zoning temperature in July of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/7	15	16	12	0/77	12531
1/0	19	20	16	7/37	120020
1/1	23	24	20	44/70	727739
1/1	26	28	24	41/46	675078
1/0	29	32	28	5/49	89388
0/2	32	33	32	0/21	3400

Table 10: Descriptive statistics of zoning temperature in August of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0 0/8	15	16	12	1/45	23639
1/1	19	20	16	12/65	206037
1/1	22	24	20	58/99	960489
1/0	26	28	24	23/72	386127
0/9	29	32	28	3/18	51822

Accordingly, the maximum area of the province is covered in the range of 20° C-25° C with area 62%, while the lowest area of temperature is specified 30°C with 0.02 area of the whole province.

According to Fig. 10 and Table 9, it is determined that July temperatures in the whole province at least 12°C and maximum 33° C. Accordingly, the maximum area of the province is covered in the range of 20° C-24° C with area 44%, while the lowest area of temperature is specified 33° C with 0.21 area of the whole province.

According to Fig. 11 and Table 10, it is determined that August temperatures in the whole province at least 12° C and maximum 29° C. Accordingly, the maximum area of the province is covered in the range of 20° C-24° C with area 58%, while the lowest area of temperature is specified 15° C with 1.45 area of the whole province.

According to Fig. 12 and Table 11, it is determined that September temperatures in the whole province at least 8°C and maximum 25° C. Accordingly, the maximum area of the province is covered in the range of 16° C-20° C with area 52%, while the lowest area of temperature is specified 11° C with 1.35 area of the whole province.

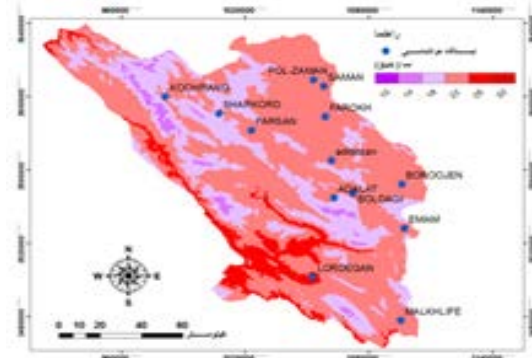


Fig. 8: Zoning map of May temperature in Chaharmahal and Bakhtiari province

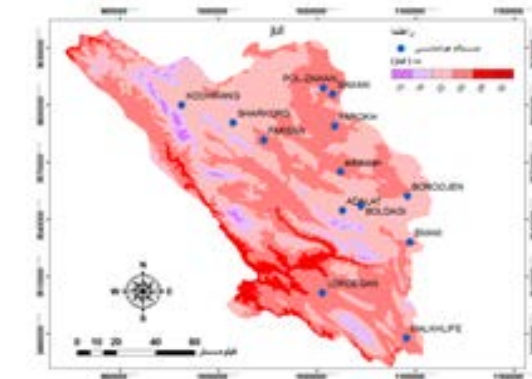


Fig. 9: Zoning map of June temperature in Chaharmahal and Bakhtiari province

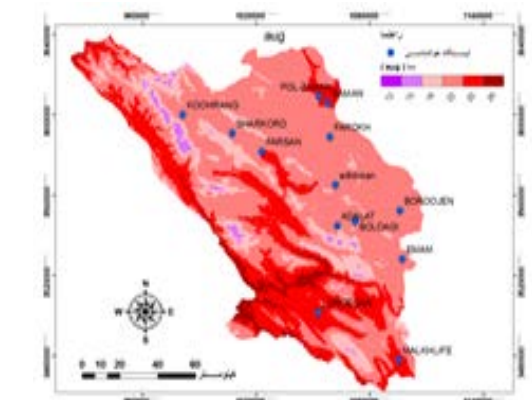


Fig. 10: Zoning map of July temperature in Chaharmahal and Bakhtiari province

According to Fig. 13 and Table 12, it is determined that October temperatures in the whole province at least 5° C and maximum 25° C. Accordingly, the maximum area of

Table 12: Descriptive statistics of zoning temperature in October of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/6	7	8	5	0/40	6559
1/1	11	12	8	6/78	110410
1/1	14	16	12	34/60	563407
1/1	17	20	16	50/35	819764
1/0	21	24	20	7/59	123504
0/2	24	25	24	0/28	4512

Table 13: Descriptive statistics of zoning temperature in November of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/8	-1	0	-4	0/49	7982
1/5	4	6	0	13/08	212958
¼	9	12	6	66/86	1088530
¼	14	18	12	19/05	310147
0/4	19	20	18	0/52	8535

Table 14: Descriptive statistics of zoning temperature in December of Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/8	-6	-5	-9	0/73	11966
1/3	-2	0	-5	9/28	151068
1/3	3	5	0	53/51	871213
1/3	7	10	5	32/97	536836
1/1	11	15	10	3/51	57072

Table 15: Descriptive statistics of zoning precipitation of January in Chaharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
4/6	33	40	23	3/10	51225
10/8	62	80	40	30/60	506250
7/8	93	120	80	49/04	811350
11/9	140	160	120	6/87	113650
11/7	180	200	160	8/20	135700
2/9	205	211	200	2/20	36400

the province is covered in the range of 16° C-20° C with area 50%, while the lowest area of temperature is specified 24° C with 0.28 area of the whole province.

According to Fig. 14 and Table 13, it is determined that November temperatures in the whole province at least-4° C and maximum 20° C. Accordingly, the maximum area of the province is covered in the range of 6° C-12° C with area 66%, while the lowest area of temperature is specified-1° C with 0.49 area of the whole province.

According to Fig. 15 and Table 14, it is determined that December temperatures in the whole province at least-9° C and maximum 15° C. Accordingly, the maximum area of the province is covered in the range of 0° C-5° C with area 53%, while the lowest area of temperature is specified-6° C with 0.73 area of the whole province.

Climatic zoning of precipitation in Chaharmahal and Bakhtiari province:

According to Fig. 16 it becomes clear that in several stations including Koohrang, Farokh, Farsan, Emam and other stations, precipitation is more appropriate than other stations. In the meantime, most precipitation among other stations is in Koohrang, according to the rainfall diagram of stations in

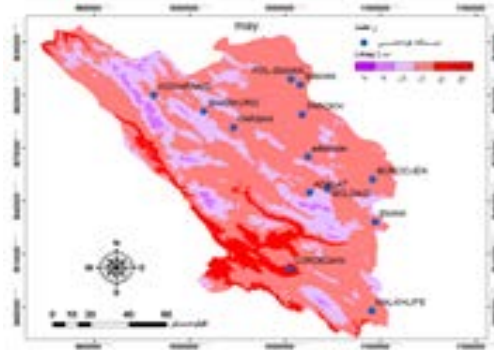


Fig. 11: Zoning map of August temperature in Chaharmahal and Bakhtiari province

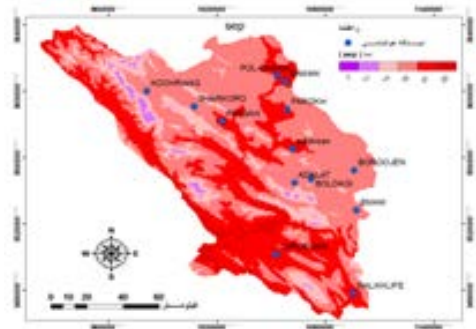


Fig. 12: Zoning map of September temperature in Chaharmahal and Bakhtiari province

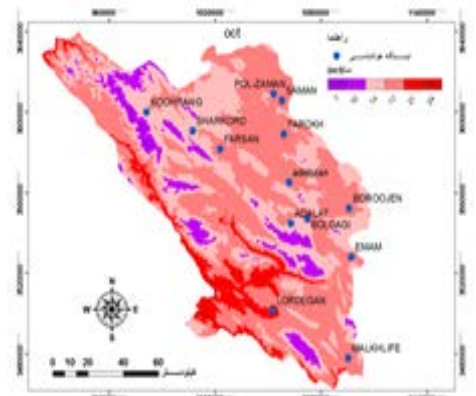


Fig. 13: Zoning map of October temperature in Chaharmahal and Bakhtiari province

the province mostly occurs in Winter (January to April; October-December). It seems that precipitation in the Northern parts of the province is more than other parts throughout the province due to the highest height which there is less rainfall. It can be said that precipitation

Table 16: Descriptive statistics of zoning precipitation of February in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
5/9	32	40	18	5/43	89825
11/5	66	80	40	52/65	871125
9/7	91	120	80	26/37	436325
11/8	141	160	120	7/21	119275
11/1	180	199	160	8/34	138025

Table 17: Descriptive statistics of zoning precipitation of March in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
4/0	34	40	25	2/65	43825
10/7	62	80	40	29/06	480800
8/0	92	120	80	50/44	834600
11/6	139	160	120	6/38	105525
11/4	180	200	160	7/50	124175
5/3	209	220	200	3/97	65650

Table 18: Descriptive statistics of zoning precipitation of April in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
5/4	28	35	15	6/19	102500
9/7	58	70	35	62/64	1036470
9/9	80	105	70	16/80	277925
10/0	124	140	105	7/91	130875
6/9	152	165	140	6/45	106800

of the province, where is located in the west is due to the intrusion of the Mediterranean Sea in winter which most is found in heights.

According to Fig. 17 and Table 15, it is determined that the minimum and maximum precipitation of January across the province is 33 mm and 205 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 80-120 mm with 49.04% of the province's total area, while the lowest area of rainfall is determined between 200-210 mm of 2.20%. In general, January is one of rainy months in the year including about 80 mm of much of the area of the province.

According to Fig. 18 and Table 16, it is determined that the minimum and maximum precipitation of February across the province is 18 mm and 199 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 40-80 mm with 52% of the province's total area, while the lowest area of rainfall is determined between 18-40 mm of 5.43%. In general, February is one of rainy months in the year including about 40-80 mm of much of the area of the province.

According to Fig. 19 and Table 17, it is determined that the minimum and maximum precipitation of March across the province is 25 mm and 220 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 80 mm with 50% of the province's total area, while the lowest area of rainfall is determined between 34 mm of 2.64%. In general, March is one of rainy months in the year including about 80-120mm of much of the area of the province.

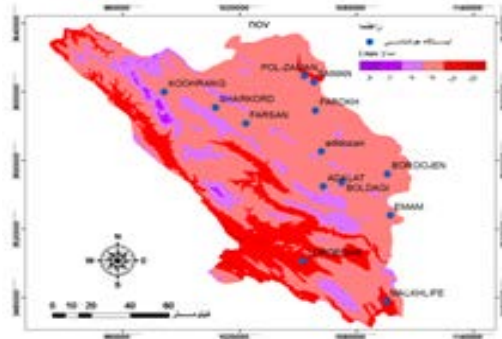


Fig. 14: Zoning map of November temperature in Chaharmahal and Bakhtiari province

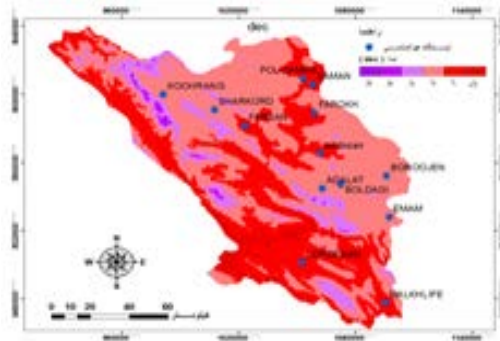


Fig. 15: Zoning map of December temperature in Chaharmahal and Bakhtiari province

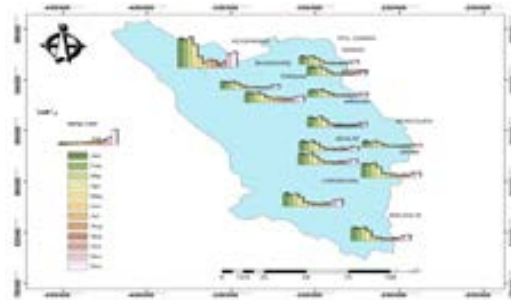


Fig. 16: A diagram map of precipitation of weather stations in Chaharmahal and Bakhtiari

According to Fig. 20 and Table 18, it is determined that the minimum and maximum precipitation of April across the province is 15 mm and 165 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 35-70 mm with 62% of the province's total area, while the lowest area of rainfall is determined between 28 mm of 6.19%. In general, precipitation in this month enjoys appropriate conditions

Table 19: Descriptive statistics of zoning precipitation of May in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
4/0	14	20	5	10/59	175200
4/4	30	40	20	69/95	1157400
6/0	50	60	40	10/17	168200
4/7	68	77	60	9/29	153775

Table 20: Descriptive statistics of zoning precipitation of June in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
1/5	5	7	1	8/32	137725
2/0	10	14	7	18/93	313175
1/9	19	21	14	31/79	525975
1/8	23	28	21	34/28	567200
½	30	32	28	6/68	110500

Table 21: Descriptive statistics of zoning precipitation of July in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
2/4	7	10	0	13/37	221250
2/5	15	20	10	51/39	850275
2/4	24	30	20	19/54	323375
3/0	35	40	30	6/59	109025
2/9	45	50	40	7/87	130275
0/6	51	52	50	1/23	20375

Table 22: Descriptive statistics of zoning precipitation of August in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
¼	3	5	0	5/55	91750
¼	8	10	5	12/98	214750
2/4	16	20	10	49/60	820625
2/5	24	30	20	17/69	292750
2/9	35	40	30	7/49	124000
2/2	44	48	40	6/47	107125

so that precipitation between 35-70 mm has included most area of the province. According to Fig. 21 and Table 19, it is determined that the minimum and maximum precipitation of May across the province is 5 mm and 77 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 20-40 mm with 69.9% of the province's total area, while the lowest area of rainfall is determined between 68 mm of 9.29%. Precipitation in this month is a little and most precipitation is created in the heights of Koohrang where as we approach the warmer months of the year the rainfall intensity is reduced.

According to Fig. 22 and Table 20, it is determined that the minimum and maximum precipitation of June across the province is 1 mm and 32 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 21-28 mm with 34% of the province's total area, while the lowest area of rainfall is determined between 30 mm of 6.68%. Precipitation in this month is a little and most precipitation is created in the heights of Koohrang where this month is considered one of the months raining a little. According to Fig. 23 and Table 21, it is determined

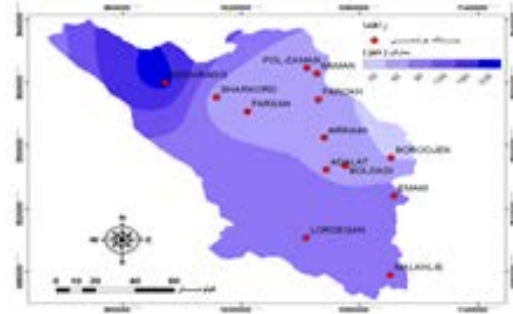


Fig. 17: Map of zoning precipitation of January in Chharmahal and Bakhtiari province

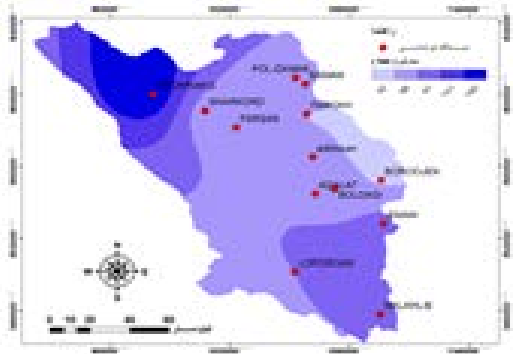


Fig. 18: Map of zoning precipitation of February in Chharmahal and Bakhtiari province



Fig. 19: Map of zoning precipitation of March in Chharmahal and Bakhtiari province

that the minimum and maximum precipitation of July across the province is 0 mm and 10 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 10-20 mm with 51% of the province's total area, while the lowest area of rainfall is determined between 51 mm of 1.23%. Precipitation in this month is a

Table 23: Descriptive statistics of zoning precipitation of September in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
0/9	4	5	1	5/80	96000
1/3	7	10	5	16/14	267100
1/5	12	15	10	9/11	150725
1/3	18	20	15	27/94	462350
0/9	22	23	20	41/00	678400

Table 24: Descriptive statistics of zoning precipitation of October in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
¼	6	8	3	8/32	137600
2/3	12	16	8	23/42	387475
1/7	20	24	16	52/46	868050
2/4	28	32	24	8/73	144375
1/6	35	38	32	7/08	117075

Table 25: Descriptive statistics of zoning precipitation of November in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
4/2	15	20	4	10/11	167200
5/9	33	40	20	65/15	1077900
6/0	48	60	40	10/53	174175
5/7	71	80	60	7/58	125425
4/4	88	96	80	6/64	109875

Table 26: Descriptive statistics of zoning precipitation of December in Chharmahal and Bakhtiari province

SD	Mean	Maximum	Minimum	Area (%)	Area (ha)
3/2	15	20	8	5/35	88525
5/4	32	40	20	33/65	556750
3/8	46	60	40	43/58	721075
5/9	70	80	60	6/61	109375
5/8	90	100	80	7/45	123325
2/4	104	109	100	3/36	55525

little and most precipitation is created in the heights of Koohrang where this month is considered one of the months raining a little.

According to Fig. 24 and Table 22, it is determined that the minimum and maximum precipitation of August across the province is 0 mm and 48 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 10-20 mm with 49% of the province's total area, while the lowest area of rainfall is determined 5 mm of 5.55%. Precipitation in this month is a little and most precipitation is created in the heights of Koohrang where this month is considered one of the months raining a little. According to Fig. 25 and Table 23, it is determined that the minimum and maximum precipitation of September across the province is 1 mm and 23 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 20-23 mm with 41% of the province's total area, while the lowest area of rainfall is determined 4 mm of 5.80%. Precipitation in this month is a little and most precipitation is created in the heights of Koohrang where this month is considered one of the months raining a little. According to Fig. 26 and Table 24, it is determined that the minimum and maximum precipitation of October

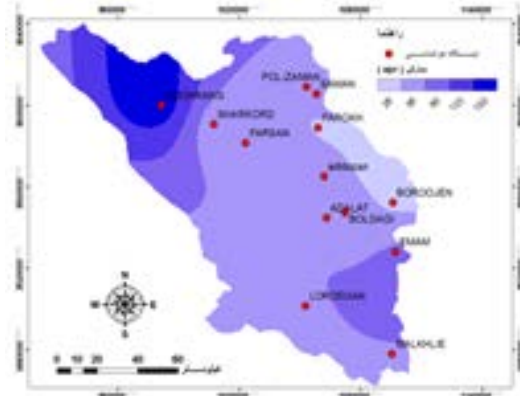


Fig. 20: Map of zoning precipitation of April in Chharmahal and Bakhtiari province

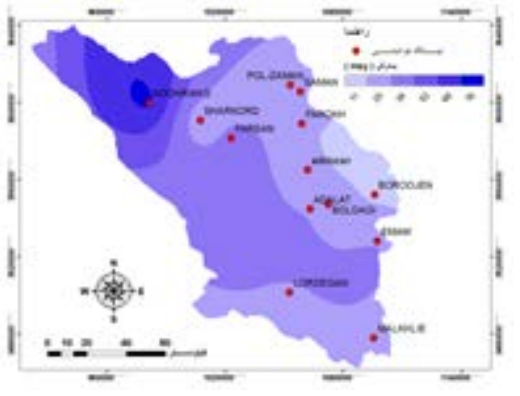


Fig. 21: Map of zoning precipitation of May in Chharmahal and Bakhtiari province

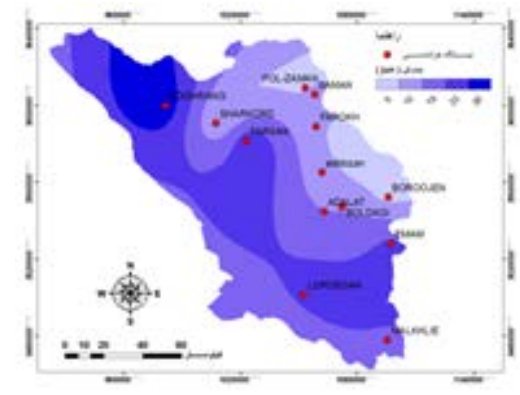


Fig. 22: Map of zoning precipitation of June in Chharmahal and Bakhtiari province

across the province is 3 mm and 38 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 16-24 mm with 52% of the province's total

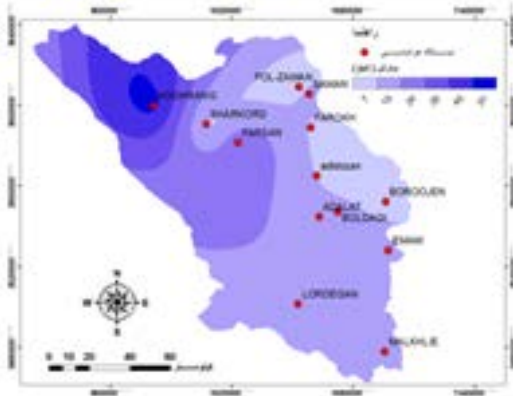


Fig. 23: Map of zoning precipitation of July in Chharmahal and Bakhtiari province



Fig. 26: Map of zoning precipitation of October in Chharmahal and Bakhtiari province

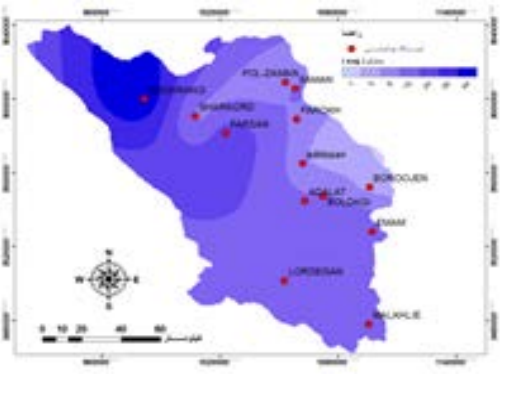


Fig. 24: Map of zoning precipitation of August in Chharmahal and Bakhtiari province



Fig. 27: Map of zoning precipitation of November in Chharmahal and Bakhtiari province

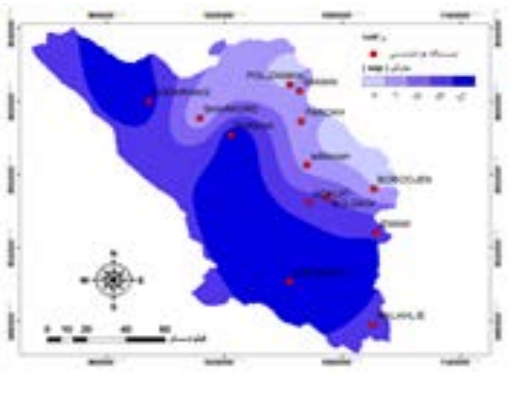


Fig. 25: Map of zoning precipitation of September in Chharmahal and Bakhtiari province

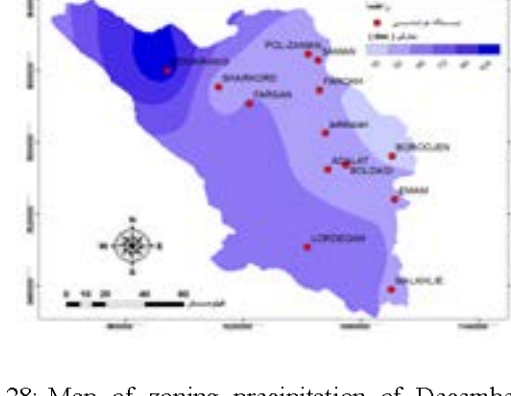


Fig. 28: Map of zoning precipitation of December in Chharmahal and Bakhtiari province

area, while the lowest area of rainfall is determined 35 mm of 7.08%. Precipitation in this month is a little and most precipitation is created in the heights of Koohrang where

this month is considered one of the months raining a little. According to Fig. 27 and Table 25, it is determined that the minimum and maximum precipitation of November across the province is 4 mm and 65 mm, respectively.

Accordingly, the maximum area of the province is covered in the range of 20-40 mm with 65% of the province's total area, while the lowest area of rainfall is determined 88 mm of 6.64%. Precipitation in this month enjoys appropriate conditions.

According to Fig. 28 and Table 26, it is determined that the minimum and maximum precipitation of December across the province is 8 mm and 109 mm, respectively. Accordingly, the maximum area of the province is covered in the range of 40-60 mm with 43% of the province's total area, while the lowest area of rainfall is determined 104 mm of 6.64%. Precipitation in this month enjoys appropriate conditions.

CONCLUSION

Monthly charts of rainfall in weather stations of Chaharmahal and Bakhtiari Province show a general trend of rainfall throughout the year that precipitation in winter has been more than other seasons and in the meantime, winter is dedicated to the highest precipitation. Winter rainfall in the province is more than the Mediterranean Sea air masses that in cold seasons lead to rainfall in this area and this is the same proof of rainy and cold seasons in the province. In contrast, we will observe a dramatic reduction of rainfall in Iran and this province in the warm season due to the prevailing climate of subtropical high pressure on Iran and preventing intrusion-air, also by studying annual rainfall charts, it can be said about the various stations that annual precipitation charts show a course of increasing precipitation from 1958-2010 indicating wet at the moment and this can result in increasing agricultural production, horticultural crops, rising waters and groundwater in the province. Relationship between precipitation and the height has been a low correlation that does not indicate precipitation increase with height in all regions of the province.

Monthly charts of temperature in weather stations of Chaharmahal and Bakhtiari province show the air temperature during the year that they reach the lowest value in winter so that the air temperature may reach $<-12^{\circ}\text{C}$ in January to its smallest point which is due to the rule of cold air of mountainous areas in the surrounding areas. In examining the relationship between temperature and altitude, high negative correlation between temperature and height can be seen so that solidarity in 13 meteorological stations in the province were on average >-0.75 indicating temperature decreases with increasing height.

In reviewing maps of zoning precipitation in the province and considering percent and area of each zone, it can be concluded that rainfall in the northwestern province of Chaharmahal and Bakhtiari and Koohrang heights is more than other regions of the province. It seems that precipitation and elevation in this area are related to each other. The greatest amount of precipitation is in the cold months (January, February, March, November and December). Maps of zoning temperature of the province show the cold weather in winter and their prevalence in the province so that temperature of a large part of the province in Winter is below zero.

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