EÖTVÖS LORÁND UNIVERSITY

FACULTY OF INFORMATICS

DEPARTMENT OF CARTOGRAPHY AND GEOINFORMATICS

CLIMATE REGIONALIZATION OF ARDABIL AND EAST AZERBAIJAN PROVINCES, IRAN

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DECLARATION

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DEDICATION

I dedicate this dissertation to my parents and siblings

ACKNOWLEDGEMENT

I wish to offer my gratitude to Eötvös Loránd University for offering me the opportunity to study the course in the institution. I also offer my sincere thanks to my supervisor Dr Varga Zsofia for guiding me though out all the stages of writing the dissertation.

Abstract:

The climate of different regions of Iran is changing in recent years. As regards the climate of each region affecting all economic, social, cultural, etc. activities, it is necessary to study climate change. In this study, using ArcGIS software, we determine the climate of East Azerbaijan and Ardabil provinces. For this goal, the De martonne method drought index and meteorological data bought from the Iranian meteorological site for these two provinces from 2011 to 2017 are used. Three stations were used for Ardabil province (Moshiran, Niyar, and Neour) and six stations for East Azerbaijan province (Maragheh, Jangle Arassbaran, Dryland Agricultural Research Institute, Tasooj, KhodaAfarin (Tatar), Khoja). The results show that the drought index of these two provinces during these years is less than 10, in other words, it is in the arid classification.

Then the trend of changes in the maximum monthly average temperature of meteorological stations in Ardabil and East Azerbaijan provinces increases respectively, except for Maragheh station, and also the trend of changes in the maximum monthly average rainfall of Ardabil and East Azerbaijan stations decreases, respectively. According to the rainfall-time chart for different years of these two provinces, the maximum average monthly rainfall in different years is not specific to one station.

Keywords Climate. East Azerbaijan and Ardabil provinces. Climate. De martonne method. ArcGIS

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CHAPTER 1 Introduction

1.1. Introduction

In this chapter, we will present the background of the study and then a Statement of the problem and Research questions will be stated. The aims and hypothesis of the study are stated below. Finally, we look at the scope of the study and the limitations of the study.

1.2. Background of the study

Climatic conditions of a geographical area such as temperature, heat, atmospheric pressure, and other meteorological characteristics over a relatively long period of time (Wikipedia.org). The climate of each province affects all economic, social, agricultural, and industrial activities, etc. (hobbs 1981). Climate is different in different regions of Iran, in recent years due to population growth, greenhouse gases in some climates of Iran's provinces have changed (Salehi Komroudi and Shakeri Bostanabad 2019), for environmental planning requires geographical studies and even advanced Predicts the trend of future climate change. For planning and activities, it is necessary to know the climate of that area. So far, many researchers have studied the climate of Iran's provinces using different methods and models, but less climatic research has been done in Ardabil and East Azerbaijan provinces.

In this study, the climate change of East Azerbaijan and Ardabil provinces in recent years will be studied using GIS software. Also, the trend of temperature change and the average rainfall of the stations during 7 years will be examined and the maximum average monthly temperature and the average monthly rainfall of the stations during this period will be determined.

1.3. Statement of the problem

The Reduction of rain and increase of heat in East Azerbaijan and Ardabil provinces have led to climate change in these two provinces. Given that climate change in each province affects all agricultural and economic activities, it is necessary to study climate change. It is also necessary to study the trend of changes in average monthly temperature and average monthly rainfall to predict climate change. Therefore, in this research, using meteorological data purchased, the climate determination of the two provinces of East Azerbaijan and Ardabil in the years 2011 to 2017 will be studied. Then the graph of changes in average monthly temperature and average monthly rainfall during these years is drawn for all stations in these two provinces.

1.4. Research questions

- What is the climate of Ardabil and East Azerbaijan provinces from 2011 to 2017?
- What is the trend of changes in average monthly temperature and average monthly rainfall in Ardabil and East Azerbaijan?
- What is the trend of changes in the average monthly average temperature and average monthly rainfall of stations in East Azerbaijan and Ardabil provinces?

1.5. Objectives of the study

- To determine the climate of Ardabil and East Azerbaijan provinces in the years 2011 to 2017 using the De martonne method.
- To determine the trend of changes in average monthly rainfall in Ardabil and East Azerbaijan provinces.
- To determine the trend of average monthly temperature changes in Ardabil and East Azerbaijan.

1.6. Hypothesis

- Use of meteorological data of East Azerbaijan and Ardabil provinces from 2011 to 2017
- Using the De martonne method to determine the climate and GIS software
- Use of monthly average temperature parameters and average monthly rainfall

1.7. Scope of the study

In this study, meteorological data of Ardabil and East Azerbaijan provinces from 2011 to 2017 were purchased from the meteorological site in Iran. The purchased data include three stations for Ardabil province and seven stations for East Azerbaijan province and the parameters of average monthly rainfall and average monthly temperature.

Then, using the De martonne method and ArcGIS software, the climate of Ardabil and East Azerbaijan provinces is determined. Then, by drawing temperature-time and precipitation-time diagrams, the trend of monthly precipitation and average temperature changes during these years was determined. Also, the maximum rainfall of the provinces was compared during these years. The diagram of the research steps is shown in Figure (1).

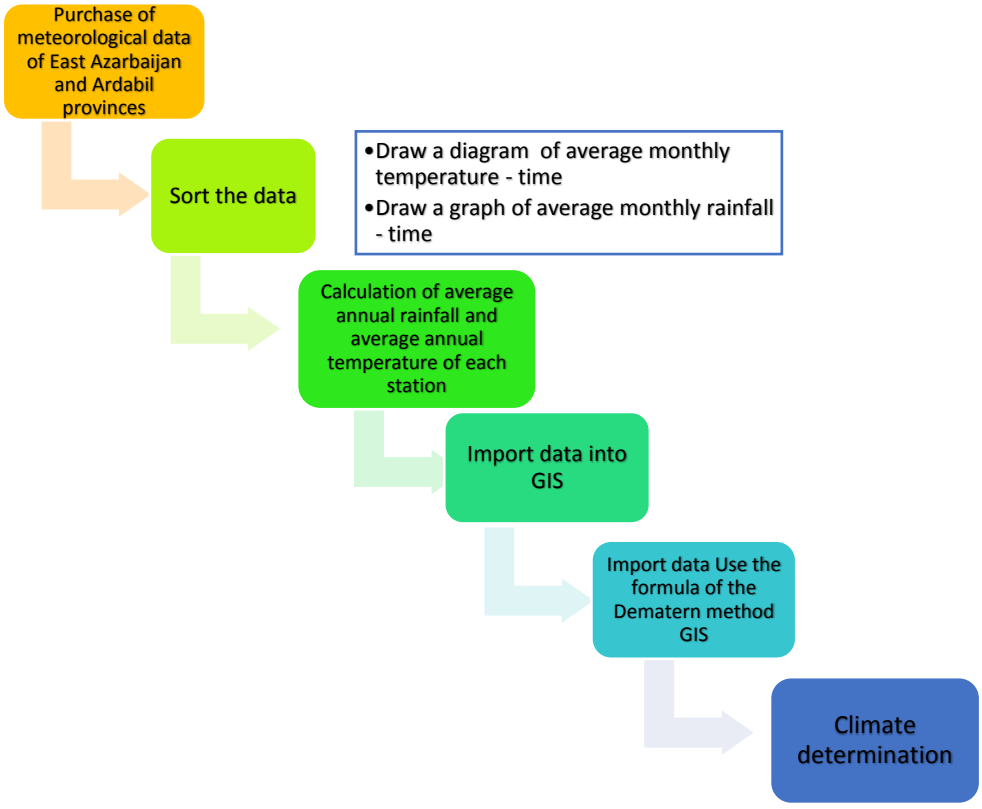


Figure 1: The diagram of the research steps.

1.8. Limitations of the study

During doing this research, we encountered limitations, including purchasing meteorological data from the Iran meteorological site, all meteorological stations in the provinces of Ardabil and East Azerbaijan were ordered from 2010 to 2020, but after purchasing, only data from 2011 to 2017 were provided. Meteorological data were not provided in full, and data for some months were not provided for some stations. It should be noted that the evaporation parameter that was ordered did not provide its data.

CHAPTER 2 Literature review

2.1. Introduction

In this chapter, we review the literature and then examine the study area.

2.2. Literature review

In recent years, many researchers have studied the determination and change of climate change and the impact of these changes in different regions of Iran, and in the following, we will review some of these articles:

MOMENI and ZIBAEI (2013) studied the impact of climate change in Fars province on the agricultural sector. Their results showed that reducing rainfall without changing the temperature leads to a 1.5 percent reduction in community welfare. Hosseinzad, Farnam et al. (2014) Hosseinzad, Farnam et al. (2014) also examined the impact of climate change in the Khozeh catchment area of the Ajabshir region of Urmia province and showed that the emergence of drought in this region, it led to a 2.6 percent decrease in annual income of farmers.

Some researchers examined the impact of climate change on tourism. For example: In 2011, the comfort climate of several Iranian tourist cities was studied by (Esmaili, Gandomkar et al.) Using a phonologically equivalent temperature index.

Baratian and Rezaei (2013) analyzed the impact of climate on tourism in Ilam province and Safari (2013) analyzed the impact of climate on tourism acceptance in East Azerbaijan province. Toosi, Doulabian et al. (2020) examined the impact of climate change on flood risk in Khorasan Razavi province

Among the researchers of East Azerbaijan and Ardabil such as Zarghami, Abdi et al. (2011) by examining the climate change of East Azerbaijan and its effect on runoff showed that the climate of this province has become semi-arid to arid and has led to a significant reduction in water flow. Sobhani, GhafariGilandeh et al. (2015) Using SEPI fuzzy index, the drought trend in Ardabil province is on the rise. In 2020, (Amininia, Abad et al.) Studied the climate of Ardabil province and his results showed that every month of the year, which station attracts the most tourists and also realized that it has an important role in the health and attraction of tourism. Then Amininia, Safarianzengir et al. (2021) analyzes the drought in Ardabil province and forecasts using the climate model and the forecast results show that the temperature will increase in the coming years.

2.3. Study area

In this study, we investigate climate change in the two provinces of East Azerbaijan and Ardabil, which are located in the northwest of Iran (Figure 2). East Azerbaijan province has a cold montane climate and the whole area of the province is made up of mountains and heights. East Azerbaijan province covers an area of 45,491 square kilometers and occupies about 2.8% of the total area of Iran.

Ardabil province is located in the northwest of Iran with an area of 17881 square kilometers and 1.1 percent of the total area forms the country (Ghorbani, Mahmoud Alilou et al. 2021). This province is east of the plateau it is located in Azerbaijan, about 75% of which has a mountainous texture with a large difference in altitude, and the rest of the regions are smooth and low.

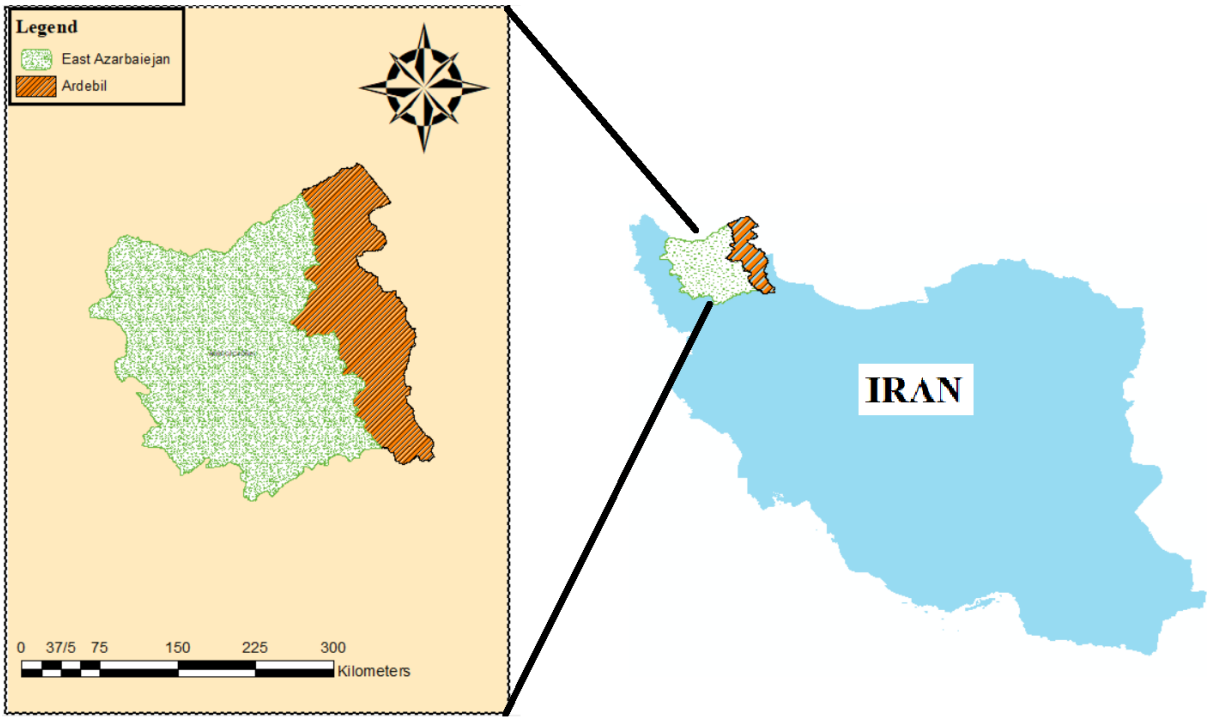


Figure 2: Location of East Azerbaijan and Ardabil provinces in Iran.

As shown in Figure 3 and Figure 4 below, East Azerbaijan and Ardabil provinces are located in zones 39 and 38, respectively.

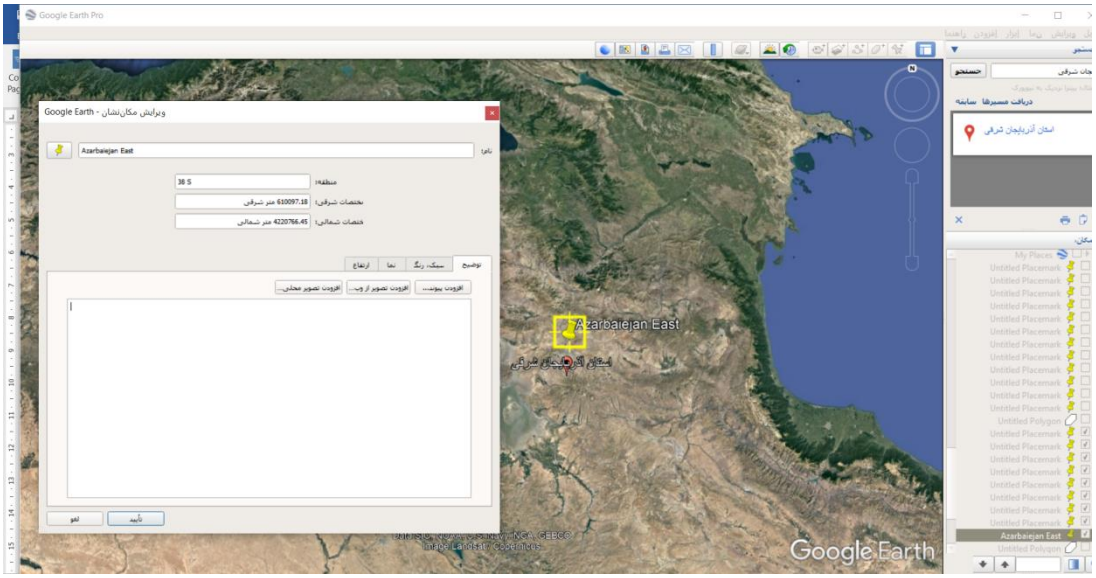


Figure 3: East Azerbaijan Province Zone in Google Earth.

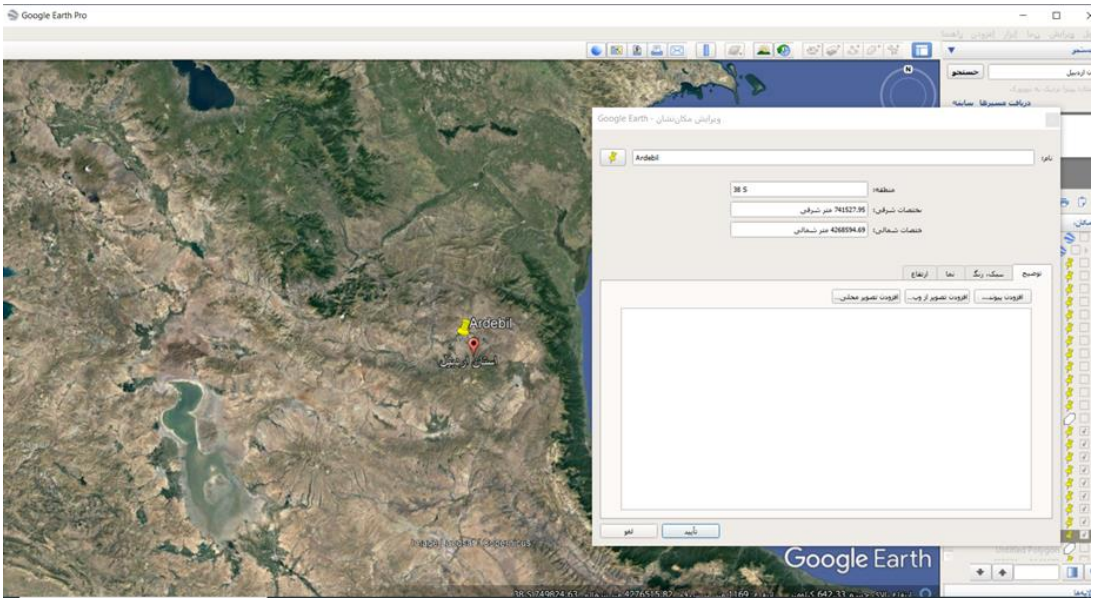


Figure 4: Ardabil province zone in Google Earth.

CHAPTER 3 Research methodology

3.1. Introduction

In this chapter, we review the literature and then examine the study area. In this chapter, we describe the research method, in which the data we used in this research are introduced, and then we describe the climate determination method.

3.2. Research Methodology:

3.2.1. Data

Synoptic meteorological data of Ardabil and East Azerbaijan provinces from 2011 to 2017 have been purchased from Iranian meteorological sites in fig5 (https://data.irimo.ir/). At the time of ordering the data, all stations of East Azerbaijan and Ardabil provinces and meteorological parameters such as average monthly temperature, average monthly rainfall, number of monthly rainfall days, and average monthly evaporation were selected, but at the time of purchase, data from some stations were delivered.

In this study, we use meteorological data from 2011 to 2017 to determine climate and its changes. Purchased data includes data of 7 stations for East Azerbaijan province (Maragheh, Jangle Arassbaran, Dryland Agricultural Research Institute, Tasooj, KhodaAfarin (Tatar), Khoja) and 3 stations for Ardabil province (Moshiran, Niyar, Neour) is shown in Table 1.

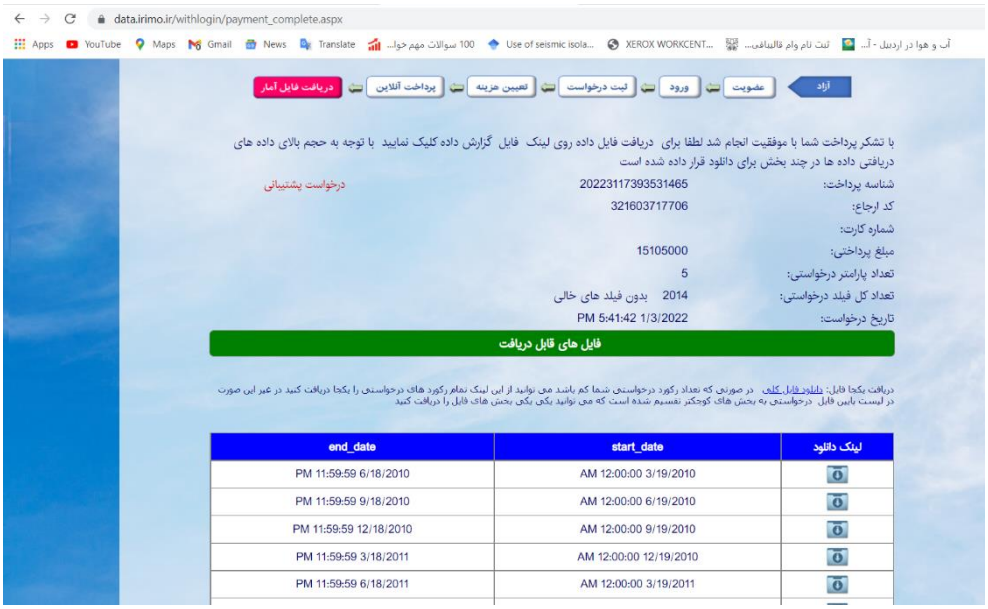


Figure 5: Meteorological data acquisition: Iran Meteorological Organization

Ardabil	**Station**						**Variables**
		Moshiran	**Neour**	**Niyar**			
	latitude	38/68	38/01	38/233			**tm_m**
	longitude	47/53	48/56	48/3			**rr24**
East Azerbaijan	**Station**						**tm_m**
		Dryland Agricultural Research Institute	**Jangle Arassbaran**	**Khoda Afarin(Tatar)**	**Maragheh**	**Tasooj**	**Khoja_***
	latitude	37/28	38/05	39/02	37/4	38/32	38/1494
	longitude	46/45	46/45	46/83	46/27	45/35	46/5831

Table 1:Name, latitude and longitude of stations in Ardabil and East Azerbaijan provinces and variables used

It should be noted that the data purchased in some stations or months is not provided due to errors in recording or measuring data. Researchers use a variety of methods to recover lost data, such as arithmetic mean, weighted mean, and correlation lines. In this study, the arithmetic means method was used to reconstruct the data.

In the arithmetic mean method, at least three adjacent stations with complete statistics are required. Also, in the long run, the difference between the average rainfall at nearby stations should be less than 10%.

3.2.2. Climate determination method

From the past to the present, many scientists have proposed different methods for determining the type of climate. Among these methods are the De martonne method, Coupon, Ivanov, Amberge, etc. Based on the research of Ghorbanizadeh Kharazi and Mojdeh Cheleh Mal Dezfulnejad (2014), the De martonne method is the best method for classifying the climate in Iran (endotn article). The relationship between the De martonne methods is as follows (Relationship 1):

$$I = \frac{P}{T + 10} \qquad (1)$$

In Equation 1, I = drought coefficient T = average annual temperature, P = Average annual rainfall (mm). According to the numerical value I, the type of climate is determined as in Table 2.

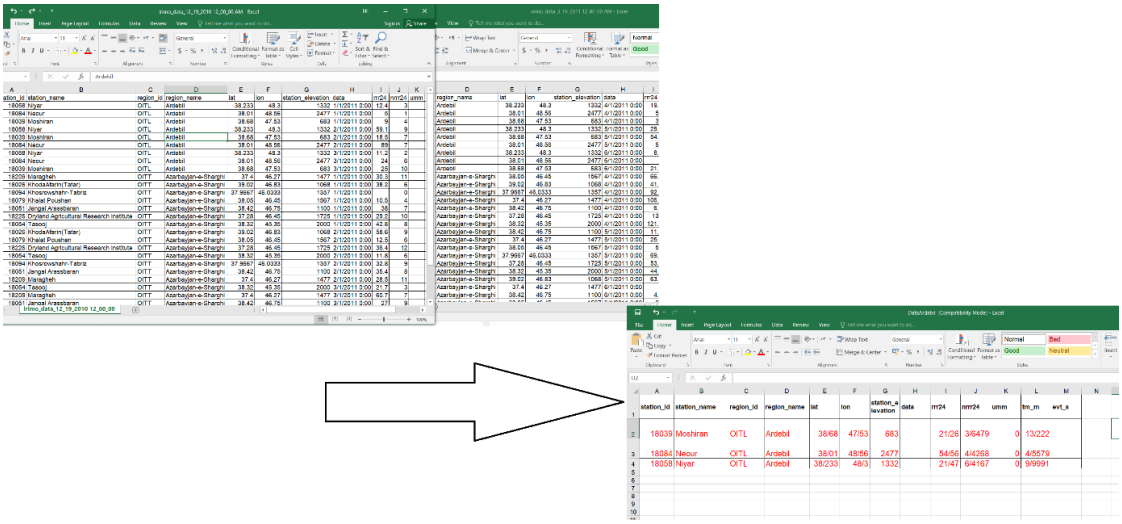
Types of Climate	**Values of Ia_{DM}**
Arid	<10
Semi- arid	10-19.9
Mediterranean	20-23.9
Semi-humid	24-27.9
Very humid	28- 34.9
Extremely humid	35<

Table 2:Demarten drought coefficient range

3.2.3. Climate determination using ArcGIS software

ArcGIS software is one of the complete and complex software with various tools that are used in various sciences for data processing and analysis. In this research, this software is used to determine climate change.

First, we put the purchased data of a province in an Excel and calculate the average annual rainfall and the average temperature of each station as in Figures 6 and 7, respectively, for the provinces of Ardabil and East Azerbaijan, and then add the Excel in GIS software.



. Figure 6: Calculation of average annual rainfall and average temperature of Ardabil province

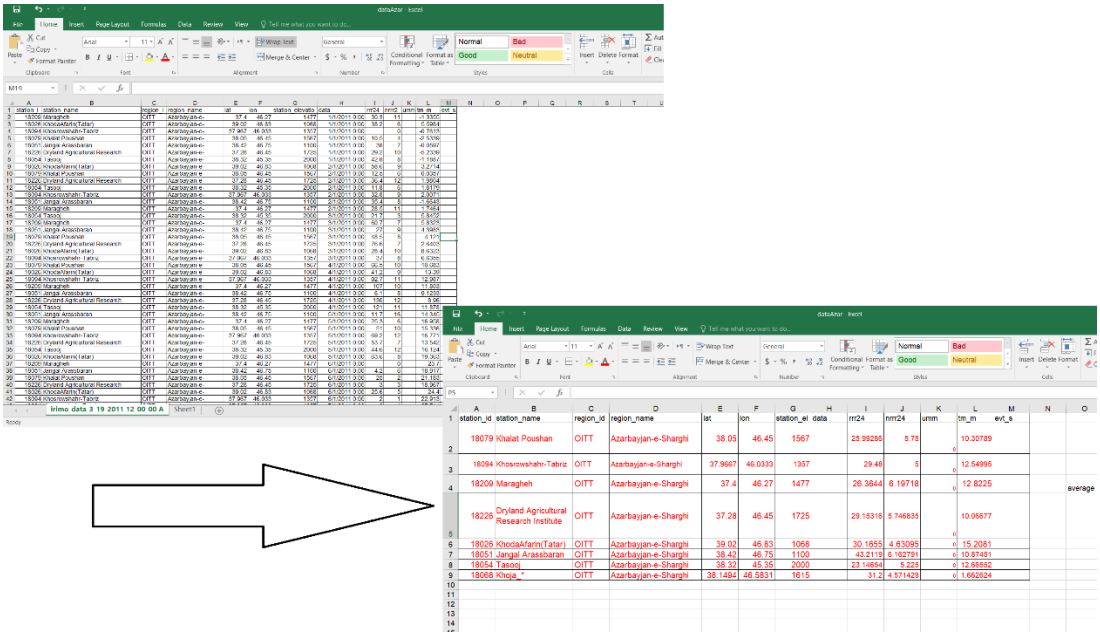
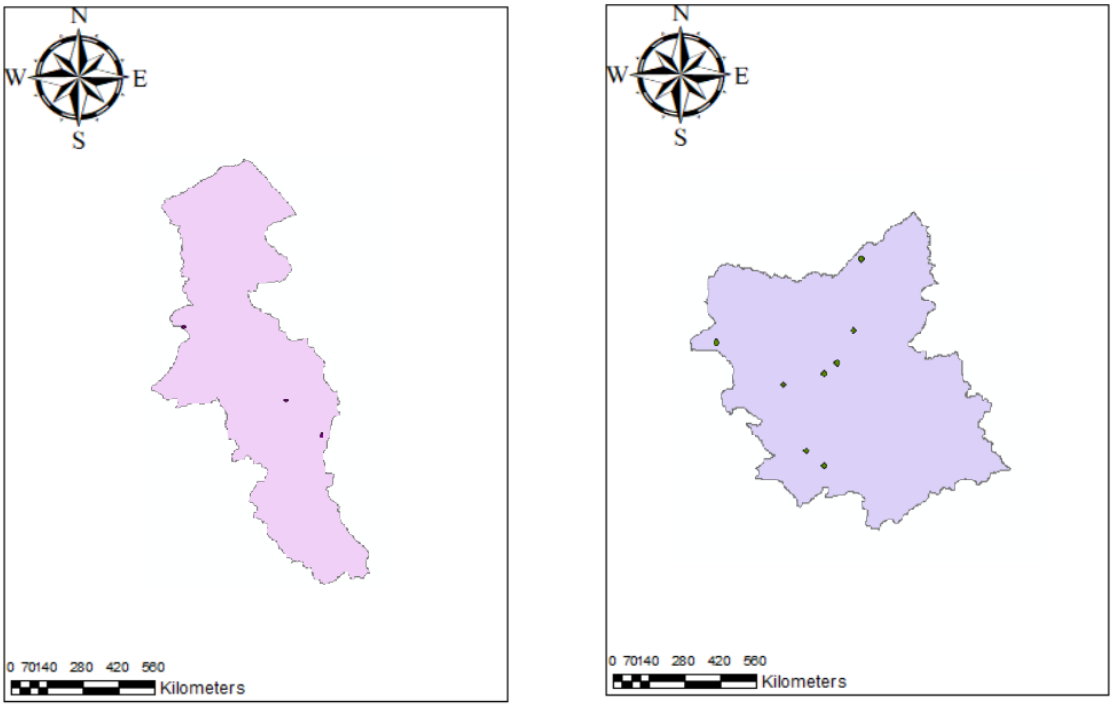


Figure 7: Calculation of average annual rainfall and average temperature of East Azerbaijan province

After entering the data, the data must be coordinated in GIS (WGS1984). Then we convert the data to a shape file. Then we add the border of each province as a ship file and it is displayed in Figure 8.



a) The border of Ardabil province and three meteorological stations

b) The border of East Azerbaijan province and three meteorological stations

Figure 8: Border of Ardabil and East Azerbaijan provinces with meteorological stations

CHAPTER 4 Results and Discussion

4.1. Introduction

In this chapter, we discuss the results of zoning the average monthly temperature and average monthly rainfall and determining the climate of the two provinces of East Azerbaijan and Ardabil. Then, the trend of monthly rainfall changes in the stations of both provinces and the trend of changes in the average monthly temperature of the stations are also examined. In the following, the maximum and minimum changes in the average monthly temperature and monthly precipitation are discussed.

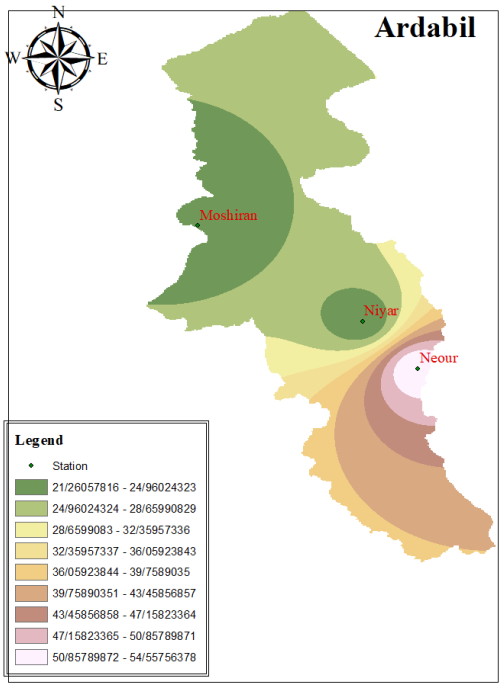
4.2. Results:

4.2.1. Zoning map of average annual rainfall and average annual temperature

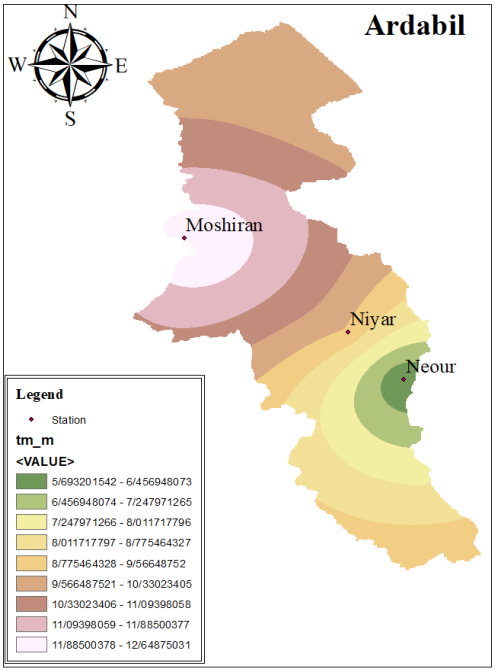
The average annual rainfall (mm) and the average annual temperature (° C) for the stations of these two provinces, which are used in the De martonne method, are called in ArcGIS software. Then, by inserting kriging in GIS, the zoning map of the average annual rainfall and average annual temperature parameters of Ardabil and East Azerbaijan provinces is shown in Figure 8.

As in Figure 9, the lighter the color of the images, the higher the rainfall and temperature of those stations. According to Figure 9 in Ardabil province, the highest average temperature and highest average rainfall were in 2011 to 2017 in Moshiran and Neour stations, respectively, and in these years, Neour station had the lowest average temperature whereas the lowest average annual rainfall was experienced in Moshiran and Niyar stations.

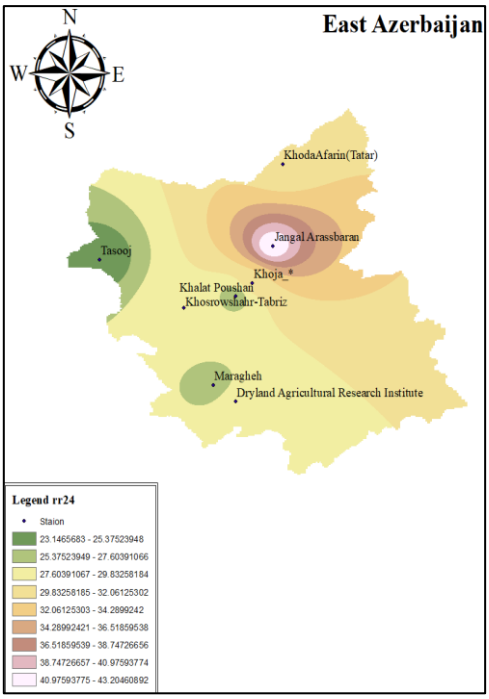
Also in East Azerbaijan province from 2011 to 2017, the highest average annual temperature occurred in KhodaAfarin stations and the highest annual rainfall occurred in KhodaAfarin stations, and the lowest average annual temperature and lowest average annual rainfall occurred in Khoja and Tasooj stations.



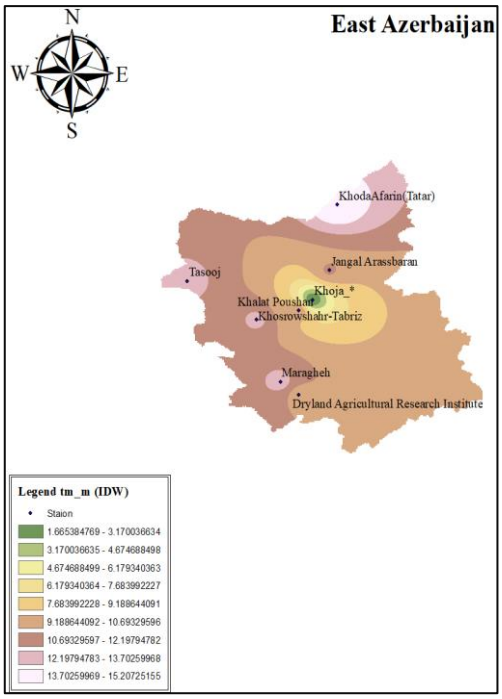
Zonation map of average annual rainfall (rr24 (mm)) in Ardabil



Zonation map of average temperature (tm_m (°C)) in Ardabil



Zonation map of average annual rainfall (rr24 (mm)) in East Azerbaijan



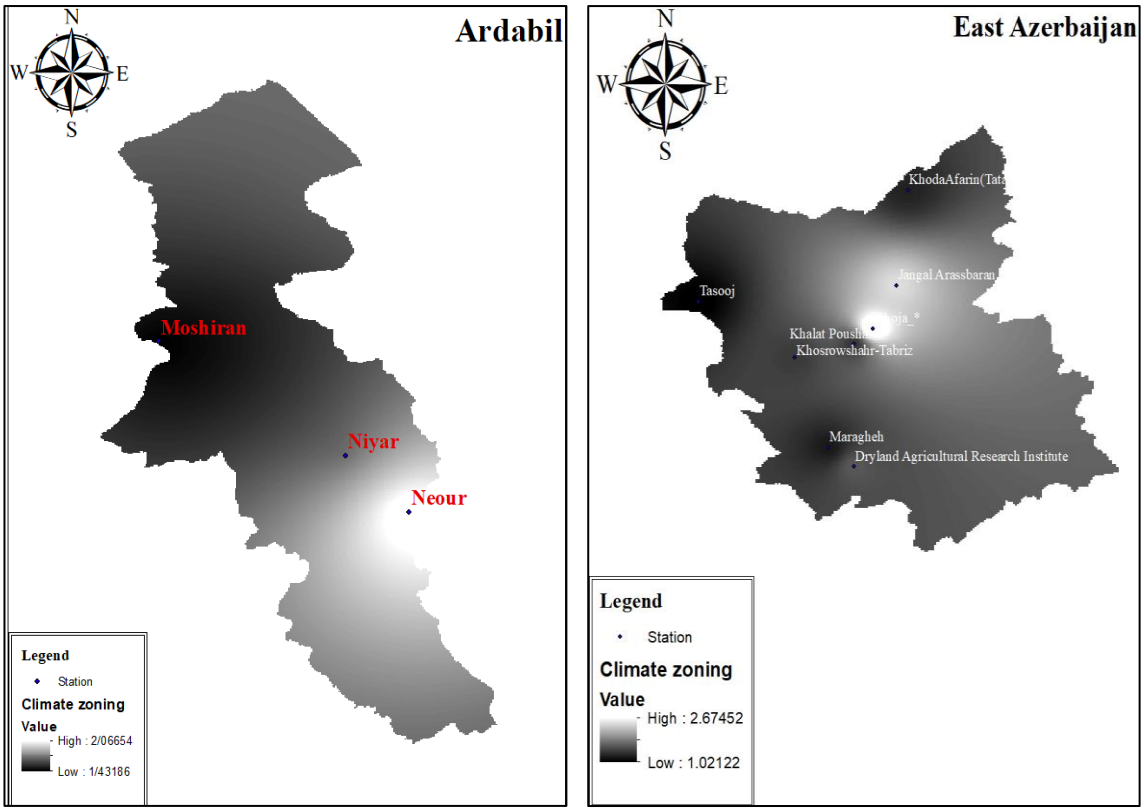
Zonation map of average temperature (tm_m (°C)) in East Azerbaijan

Figure 9: Zonation map of average annual rainfall and average temperature of Ardabil and East Azerbaijan provinces

4.2.2 Climate zoning

After drawing the zoning maps of average annual temperature and average annual rainfall, to calculate the final raster, we enter the De martonne relation in GIS software and the climate zoning map of Ardabil and East Azerbaijan provinces was drawn as in Figure 10.

According to Figure 10, the drought index in the temperature method of Ardabil and East Azerbaijan provinces is in the range of (0.94 – 3.48) and (1.02-2.675), respectively.



Climate zoning map of Ardabil province *Climate zoning map of East Azerbaijan province*

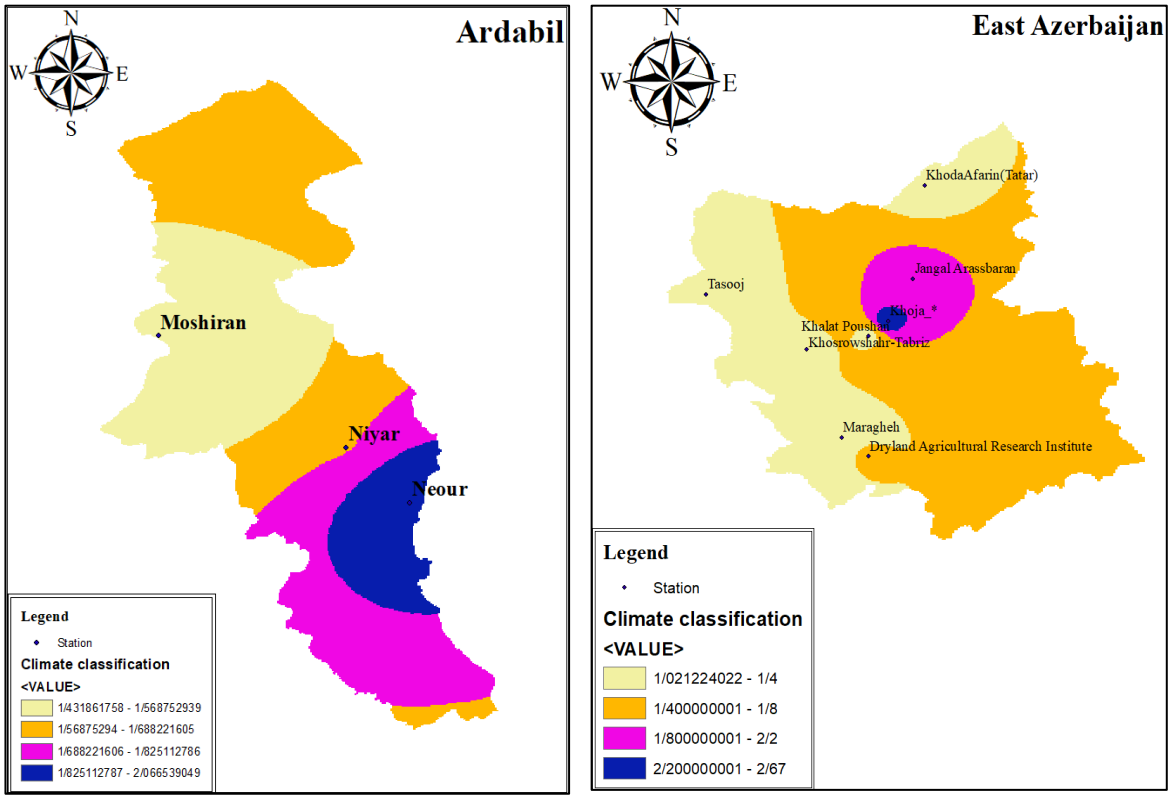
Figure 10: Climate zonation map of Ardabil and East Azerbaijan provinces

4.2.3 Climate classification of East Azerbaijan and Ardabil provinces

After drawing the climate zoning map in GIS software, it is necessary to classify to better understand the climatic range of each station. Figure 11 shows the climatic classification of East Azerbaijan and Ardabil provinces.

According to Figure 11, in Ardabil province, Moshiran station has the lowest drought coefficient. In other words, the climate of this station is very dry and Noor station has the highest drought coefficient. In other words, drought has a lower climatic coefficient than other stations.

Also, according to Figure 11, in Azerbaijan province, Tasooj and KhodaAfarin and Maragheh stations have the lowest dry coefficient, i.e. the dry climate of this station is more than other stations, and Khoja station has the highest dry coefficient, i.e. the dry climate of this station. It is less than other stations.



Climate classification map of Ardabil province

Climate classification map of East Azerbaijan province

Figure 11: Climate classification *map of Ardabil and East Azerbaijan provinces*

4.2.4 Changes in average temperature and monthly rainfall

Figures 12 and 13 show the trend of changes in average monthly rainfall and average monthly temperature in different stations of East Azerbaijan province (Maragheh, Jangle Arassbaran, Dryland Agricultural Research Institute, Tasooj, KhodaAfarin (Tatar), Khoja) in the period 2011 to 2017, respectively. According to the diagrams in Figure 11, the amount of rainfall at a station varies in different years. In different years, the maximum rainfall in a particular month varied between different stations.

Also, according to the diagrams in Figure 13, the trend of changes in the average monthly temperature diagrams in different years is similar. In other words, the temperature trend starts from the bottom and then increases and then decreases, but it cannot be said that in different years the chart is the maximum for one station.

The diagrams in Figure 14 show the trend of changes in the average monthly rainfall of stations (Neour, Moshiran & Niyar) in Ardabil province from 2011 to 2017. According to Figure 13, changes in different graphs of average rainfall do not have a specific trend.

Figure 15 shows the trend of average monthly changes of stations (Neour, Moshiran & Niyar) in Ardabil province from the years 2011 to 2017. The trend of average monthly temperature changes in Ardabil province, as shown in Figure 15, the whole station has a similar trend, in other words, the trend of temperature changes starts from low, reaches a maximum, and then decreases. It should be noted that in different years, the maximum temperature is not for a particular station.

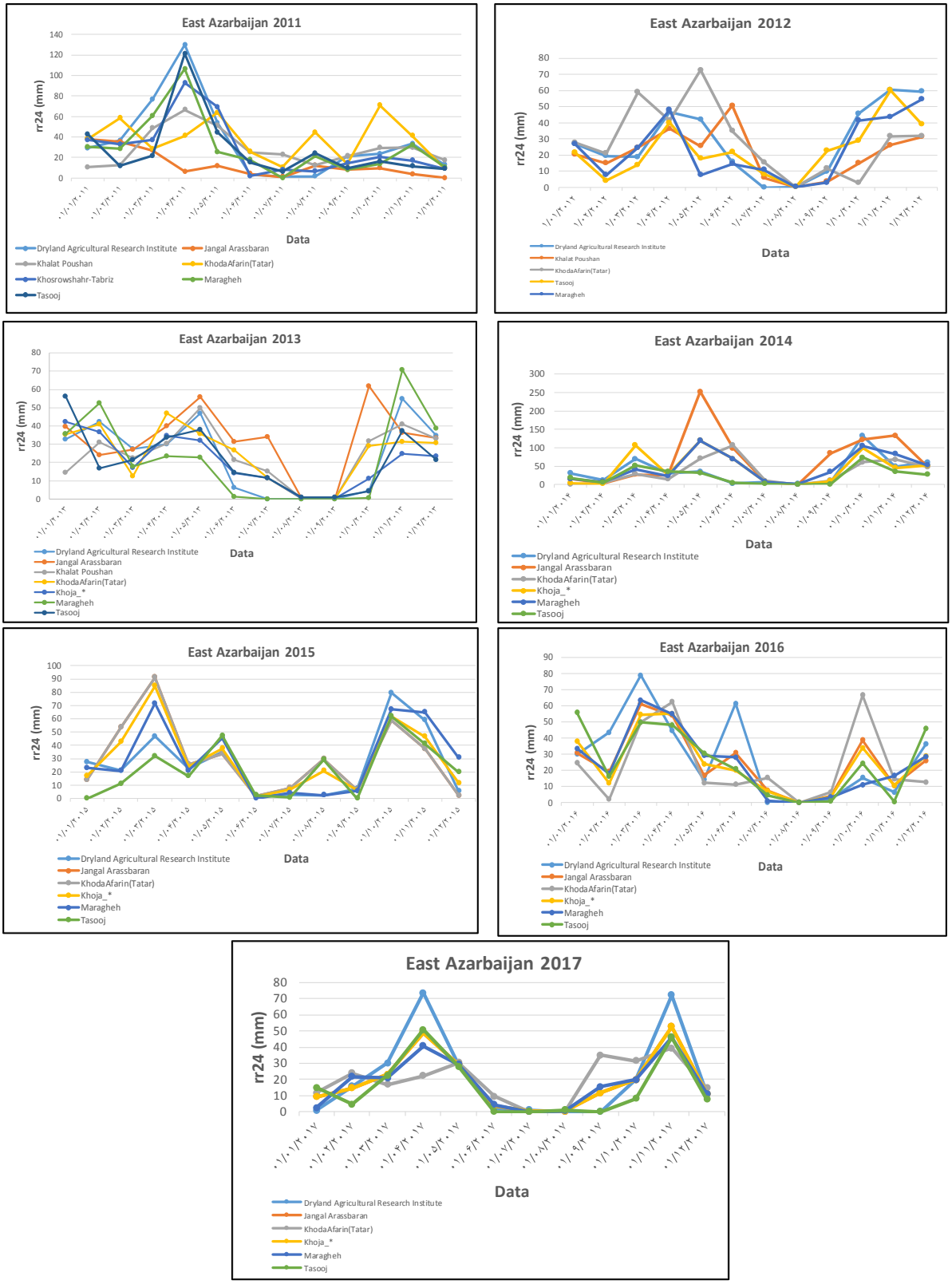


Figure 12: The trend of changes in the average monthly rainfall in different stations of East Azerbaijan province from 2011-2017

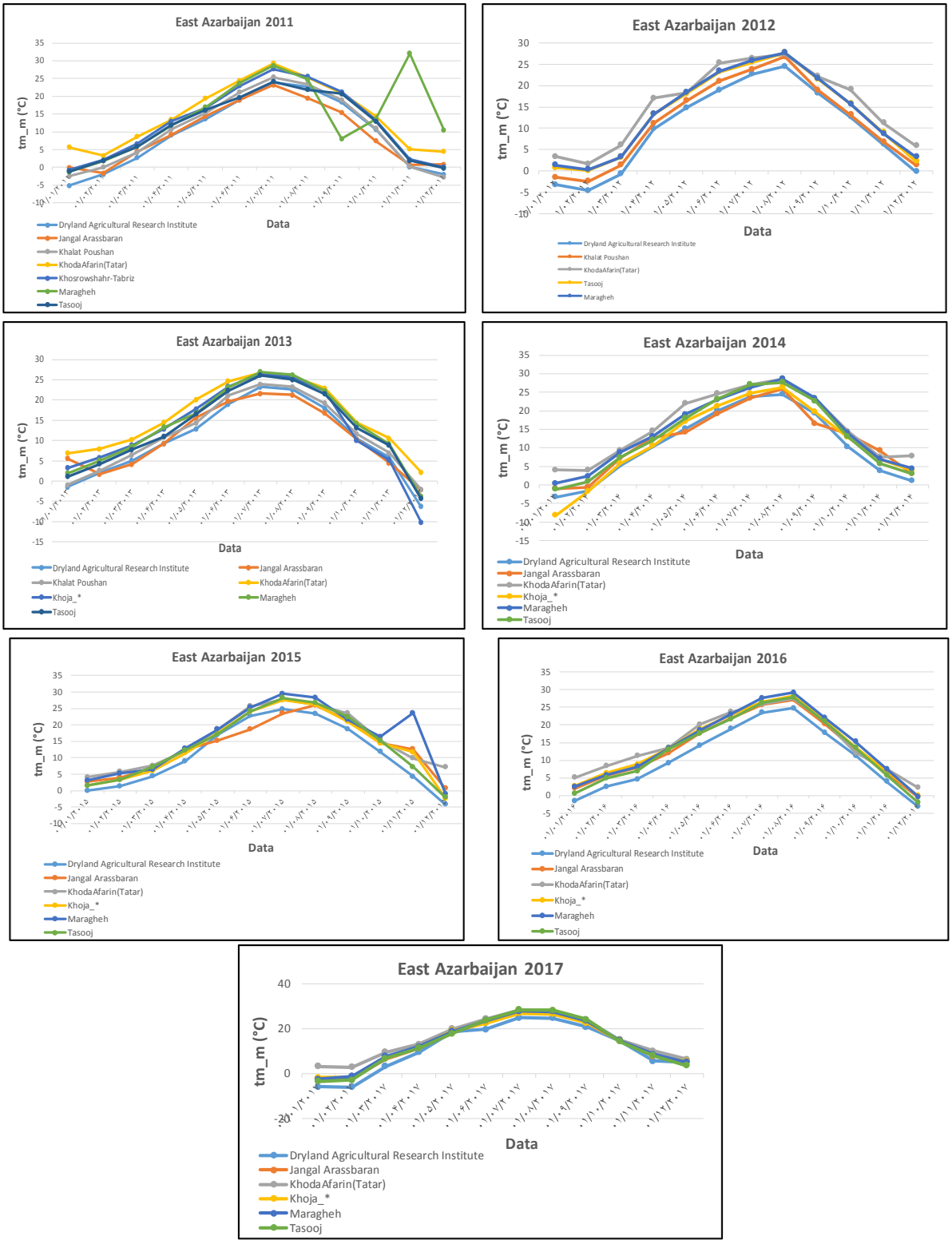


Figure 13: The trend of average monthly temperature changes in different stations of East Azerbaijan province from 2011-2017

Figure 14: Trend of changes in the average monthly rainfall in different stations of Ardabil province from (2011-2017)

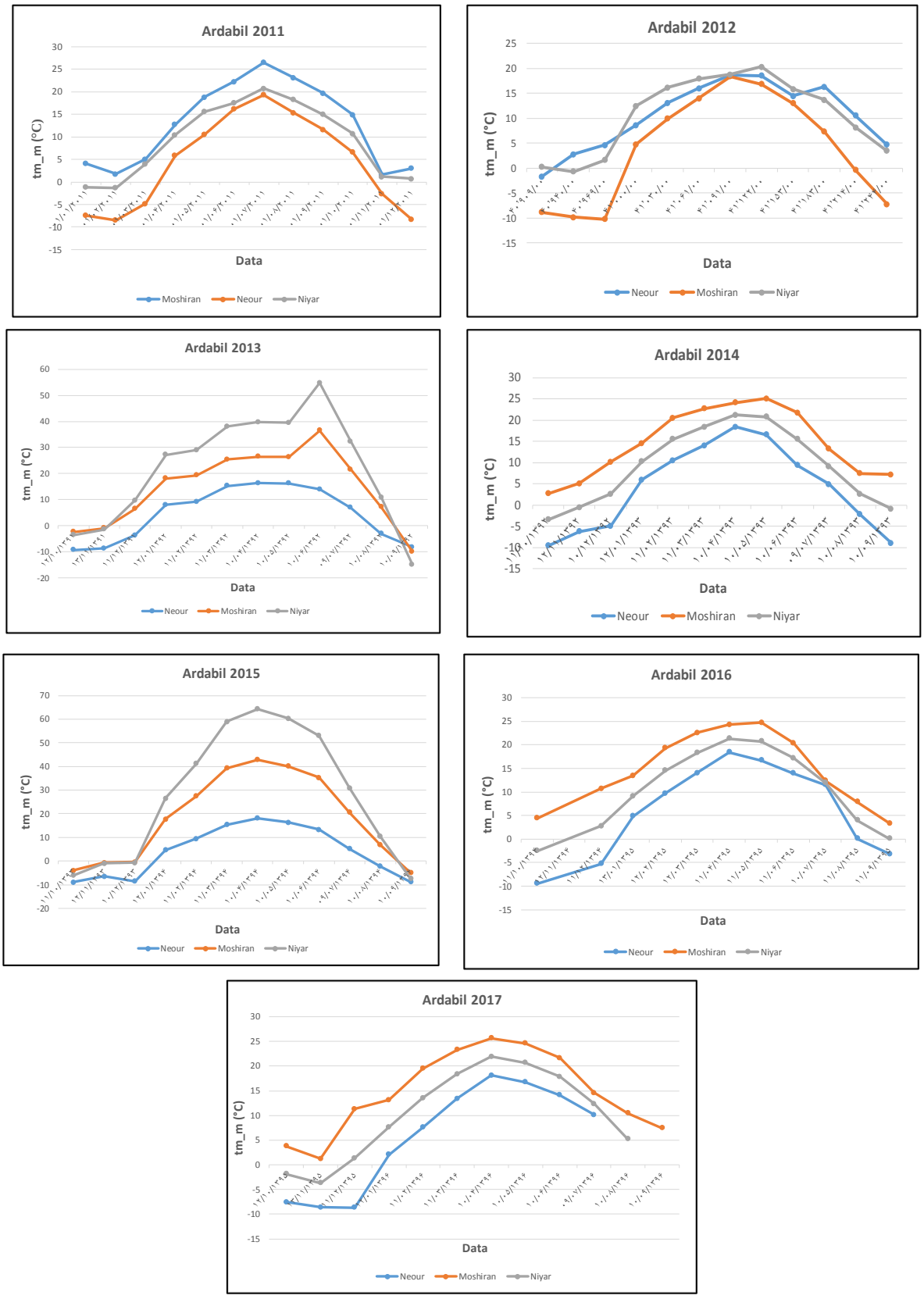


Figure 15 :The trend of average monthly temperature changes in different stations of Ardabil province from (2011-2017)

4.2.5 Changes in average temperature and monthly rainfall

Tables 3 below shows the maximum and minimum average monthly rainfall in the stations of East Azerbaijan province (Maragheh, Jangle Arassbaran, Dryland Agricultural Research Institute, Tasooj, KhodaAfarin (Tatar), Khoja) from 2011 to 2017. According to Table 3, all stations had a downward trend from 2011 to 2013, then in 2014, the maximum rainfall increased by one jump and, again from 2015 to 2017 decreased. Also, according to Table 3, the minimum monthly rainfall values of the stations do not have a special trend.

rr24	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	1/2	0/2	8/866666667	0/2	6/277778		
maxx	130	38	70/9	106/5	121/1		2011
rrr24	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	0		0/35	0/3	0/35		
max	60/3		72/6	54/5	60/11		2012
rrr24	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	0	0/266666667	0/266666667	0	0/8	0/266667	
max	54/9	61/8	46/8	70/9	56/3	42/4	2013
rrr24	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	2	0	0	0/666666667	0	0/2	
max	131/7	252	107	119/2333333	72/9	119/2333	2014
rrr24	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	1/6	1/8	1/8	0	0	1/2	
max	79/6	91/2	91/2	71/46666667	62	84/62222	2015
rrr24	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	0	0	0	0	0	0	
max	79	61/15555556	66/64	63/6	55/8	55/16667	2016
rrr24	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	0	0/333333333	0	0/111111111	0	0/333333	
max	73/6	52/56666667	39/4	46/02222222	50/7	52/56667	2017

Table3: The trend of changes in the average monthly rainfall in different stations of East Azerbaijan province from 2011-2017

Tables 4 below shows the maximum and minimum average temperatures in the stations of East Azerbaijan province (Maragheh, Jangle Arassbaran, Dryland Agricultural Research Institute, Tasooj, KhodaAfarin (Tatar), Khoja) from 2011 to 2017. According to Table 4, in general, the monthly temperature has decreased in all stations from 2011 to 2013, and from 2014 to 2017, in general, the average monthly temperature of the stations has increased. The average monthly changes of the stations are not a special trend.

tm_m	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	-5/23387	-1/66429	3/27143	-1/33548	-1/18871		
maxx	23/9145	23/1645	29/2419	32/1	24/1446		2011
tm_m	Dryland Agricultural Research Institute		KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	-4/66296		1/6	0/327586	0/075862		
max	24/5016		27/3516	27/7419	27/7677		2012
tm_m	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	-6/24677	-2/20484	2/15333	-3/81935	-4/32581	-10/1258	
max	23/2516	21/6323	26/7452	26/9032	26/0968	26/58173	2013
tm_m	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	-3/23276	-0/980645	3/99259	0/471429	-1/20968	-8/20806	
max	24/4839	25/9533	28/5935	28/5677	27/6613	26/34357	2014
tm_m	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	-4/19516	0/641992	4/03548	-0/972414	-2/04839	-2/40532	
max	24/7871	25/99003333	27/7419	29/4258	28/2161	27/47633	2015
tm_m	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	-3/215	-0/483493333	2/20323	-0/43871	-2/03548	-0/09032	
max	24/7597	27/14676667	27/4774	29/2032	27/8258	28/1688	2016
tm_m	Dryland Agricultural	Jangal Arassbaran	KhodaAfarin(Tatar)	Maragheh	Tasooj	Khoja_*	
min	-6/10179	-2/075286667	2/82593	-2/42581	-3/41774	-1/73584	
max	24/85	27/1871	28/2484	27/96613333	28/4629	27/02151	2017

Table 4:The trend of average monthly temperature changes in different stations of East Azerbaijan province from 2011-2017

Figure 16 below shows the maximum changes in the average monthly rainfall of East Azerbaijan Province from 2011 to 2017.

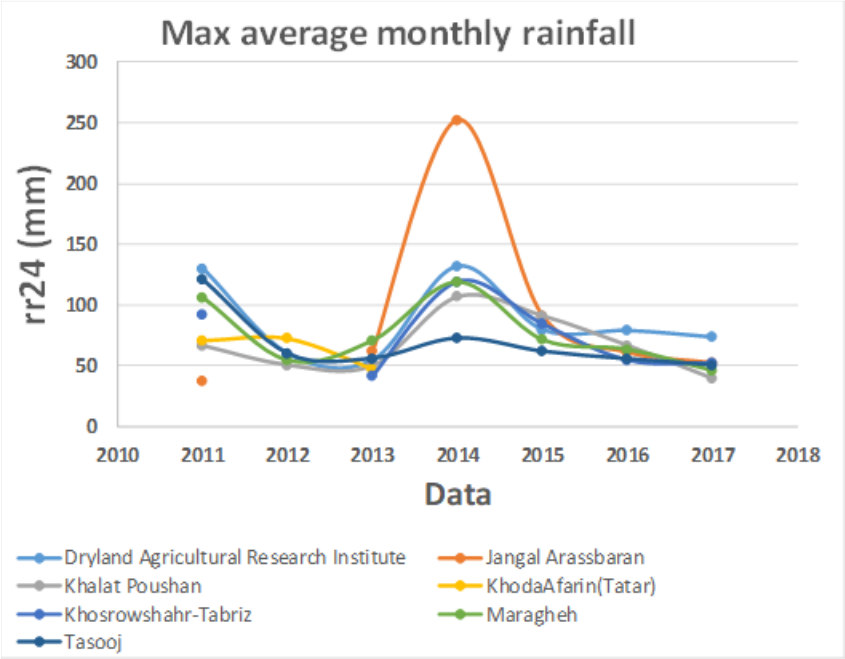


Figure 16 :The trend of max average monthly rainfall changes in different stations of East Azerbaijan province from (2011-2017)

Figure 17 shows the maximum changes in the average monthly temperature of East Azerbaijan Province from 2011 to 2017.

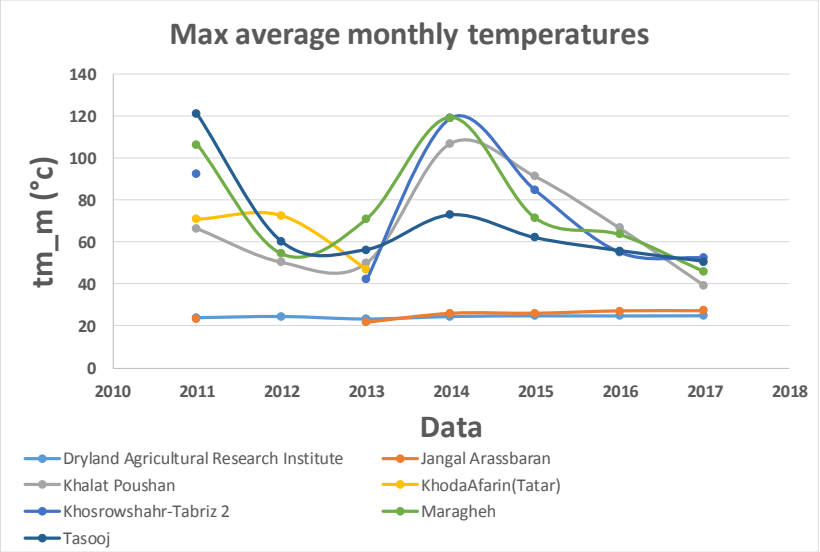


Figure 17 :The trend of maximum average monthly temperature changes in different stations of East Azerbaijan province from (2011-2017)

The maximum and minimum average monthly rainfall of three stations (Neour, Moshiran & Niyar) in Ardabil province are shown in Table 5. According to Table 5, the changes in the maximum average monthly rainfall do not have a specific trend, but I can compare the first years with the last years and find that the maximum amount in previous years is very high and the lower the maximum values from 2011 to 2017. Regarding the trend of changes in the minimum average monthly rainfall of three stations in Ardabil province, no specific opinion can be given.

Table 5:Minimum and maximum average monthly rainfall of Ardabil stations in the years (2011-2017)

rr24	Neour	Moshiran	Niyar	
min	0	0	2/6	
max	99/5	54/5	59/1	2011
rr24	Neour	Moshiran	Niyar	
min	0/75	0	0/8	
max	120/35	216	72/5	2012
rr24	Neour	Moshiran	Niyar	
min	0	0	0	
max	159	60	90/375	2013
rr24	Neour	Moshiran	Niyar	
min	0	0	0	
max	117	93	92	2014
rr24	Neour	Moshiran	Niyar	
min	0	0	6/75	
max	136	57	93	2015
rr24	Neour	Moshiran	Niyar	
min	0	1/5	0/75	
max	13	49	28	2016
rr24	Neour	Moshiran	Niyar	
min	-8/64655	1/23214	-3/69643	
max	18/1467	25/6661	21/9064	2017

Figure 18 shows the maximum changes in the average monthly rainfall of Ardabil Province from 2011 to 2017.

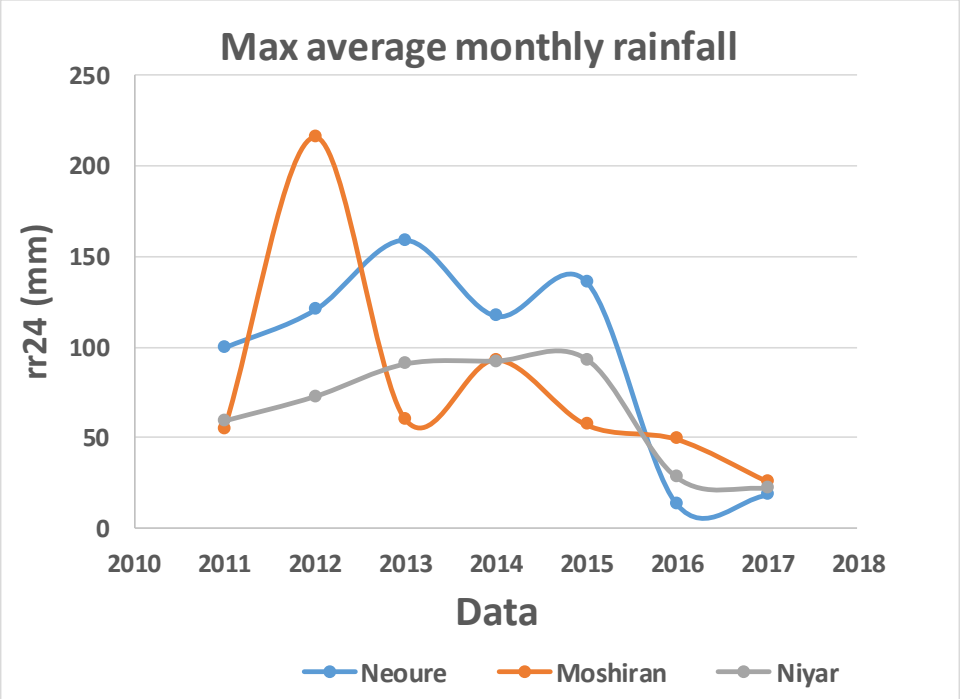


Figure 18: The trend of max average monthly rainfall changes in different stations of Ardabil province from (2011-2017)

The maximum and minimum average monthly temperatures of three stations (Neour, Moshiran & Niyar) in Ardabil province are shown in Table 6.

According to Table 6, the maximum monthly average temperature of Ardabil stations decreased from 2011 to 2013, then in 2012, the maximum average monthly temperature of stations increased, and then until 2017 decreased.

tm-m	Neour	Moshiran	Niyar	
min	-8/46607	1/58167	-1/29286	
max	19/3645	26/5484	20/7581	2011
tm-m	Neour	Moshiran	Niyar	
min	-1/66613	-10/2065	-0/6931	
max	18/62635	18/4333	20/3032	2012
tm-m	Neour	Moshiran	Niyar	
min	-9/3871	-1/7	-4/9742	
max	16/371	22/5783	18/2558	2013
tm-m	Neour	Moshiran	Niyar	
min	-9/615	2/71774	-3/44863	
max	18/3968	25/0433	21/2468	2014
tm-m	Neour	Moshiran	Niyar	
min	-8/94194	3/88387	-2/50162	
max	18/1145	24/7919	21/4532	2015
tm-m	Neour	Moshiran	Niyar	
min	-9/42742	3/28871	-2/51774	
max	18/3839	24/6935	21/3363	2016
tm-m	Neour	Moshiran	Niyar	
min	-8/64655	1/23214	-3/69643	
max	18/1467	25/6661	21/9064	2017

Table 6: Minimum and maximum average monthly temperature of stations in Ardabil province in 2011-2017)

Figure 19 shows the maximum changes in the average monthly temperature of Ardabil Province from 2011 to 2017.

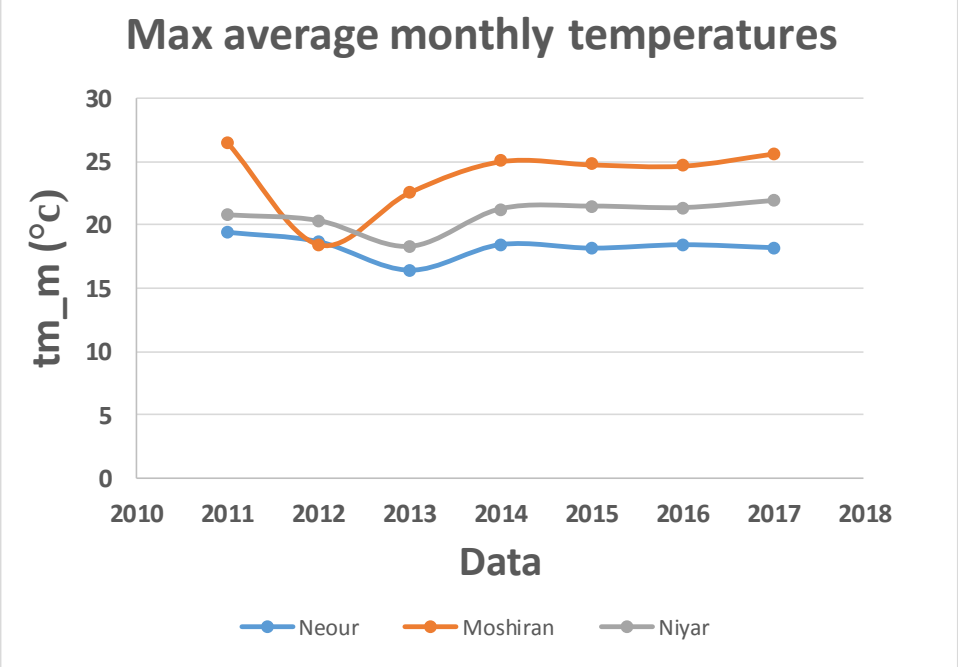


Figure 19: The trend of max average monthly temperature changes in different stations of East Azerbaijan province from (2011-2017).

CHAPTER 5 Conclusions

5. Conclusions

East Azerbaijan and Ardabil provinces are two neighboring provinces. The climate of these two provinces is in the dry climate range using the De martonne method and ArcGIS software. In general, the trend of changes in the maximum average monthly rainfall of East Azerbaijan stations (Maragheh, Jangle Arassbaran, Dryland Agricultural Research Institute, Tasooj, KhodaAfarin (Tatar), Khoja) from 2011 to 2017 has been decreasing, but in Ardabil stations (Neour, Moshiran & Niyar), the changes in the maximum average monthly rainfall during these years, there is no particular trend.

Also, the trend of average monthly temperature changes in East Azerbaijan stations, from 2011 to 2013, has been decreasing, and then in 2014, the maximum average temperature has increased, and then until 2017, this trend has been increasing. The trend of average monthly temperature changes in stations of Ardabil province has been decreasing from 2011 to 2013 and then increasing from 2014 to 2017.

During these seven years in the two provinces of East Azerbaijan and Ardabil, the maximum average monthly rainfall of the stations has not been specific to one station and, also the maximum average monthly temperature during these years in these two provinces has not been specific to one province.

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