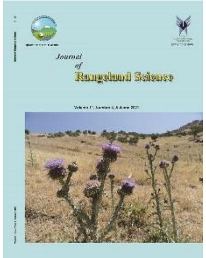

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Research and Full Length Article:

Influence of Climatic Factors on Forage Production and Vegetation Cover of Iran's Upland Rangeland (Jashloobar Rangeland, Semnan Province)

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Abstract. Annual climate fluctuations cause changes in production, condition, trends and grazing capacity of rangelands. The present study investigated effect of climatic factors on the vegetation dynamics in Jashloobar, summer rangeland of Semnan province, Iran, in two vegetation types: *Festuca rubra* in Margesar and *Stipa lessingiana* in Sefiddasht during 2011–2015. Climatic parameters included temperature (mean daily, absolute maximum, absolute minimum, monthly maximum and minimum), monthly humidity (absolute maximum, absolute minimum and average) and monthly precipitation. These factors were determined by Inverse Distance Weighted method using 19 meteorological stations in Semnan province due to an absence of climatological and synoptic stations on this site. Vegetation cover percent and production were measured within two 400m transects and 20 plots ($1×1m^2$) along transects. Means comparisons were made between the years in terms of vegetation production and canopy cover using Duncan test, and the relationship between climatic factors with vegetation parameters which were determined using linear regression. Results show that production varies significantly over years ($P<0.05$). The lowest production rates in Margesar and Sefiddasht were observed in 2013-2014 with 254 and 213.3 kg/ha respectively. Although the precipitation significantly decreased from 293 mm in 2011-2012 to 173 mm in 2013-2014($P<0.05$), but stepwise regression indicated that finally in Margesar, absolute maximum temperature and absolute minimum humidity in December and in Sefiddasht, absolute maximum temperature in June and absolute minimum temperature in August were entered in production forecasting model. This indicates that forage production is highly sensitive to absolute mentioned climatic parameters in addition to rainfall. Also, due to short period of growing season in these years, grazing period should also be limited; therefore, ranchers and the government should optimize rangeland management and reduce the length of the grazing period, decreasing grazing capacity or alternative livelihoods such as ecotourism, beekeeping and exploitation of medicinal plants.

Key words: Meteorological parameters, Forage, Summer rangelands

Introduction

Iran's rangelands are important not only for an environmental perspective but also for the forage production view. According to the latest census in Iran, nomadic tribes have more than 24 million animal units that are about 28% of light livestock and 4% of the country's heavy livestock population. Lightweight livestock forms a major part of the nomad's livestock (86.4%) which about 70% of their nutrition depends on rangeland (Iran Statistical Center, 2017). In addition to other benefits of rangeland ecosystems, these statistics emphasize on their value in our country.

Changes in temporal and spatial patterns of precipitation, air and soil temperature, humidity, and soil water content lead to changes in the functioning of natural ecosystems such as rangelands. As these changes occur constantly, they have affected resources at the regional and global level.

As well, temporal and spatial differences of forage yield can be fully explained by conjoining these key factors: temperature, amount and timing of rainfall, soil characteristics, topography (Liu *et al*., 2019) and management. The lack of accurate and timely decisions will accelerate the destruction of these resources especially in arid and semi-arid regions such as Iran.

Iran will experience an increase of 2.6ºC in mean temperatures and a 35% decline in precipitation in the next decades (Mansouri Daneshvar *et al*., 2019). So, predicting the changes in climatic parameters and its impact on vegetation can help us make timely management decisions.

Various studies have been carried out in different countries on the effect of climatic factors on vegetation. In a research, impact of forecasted changes in precipitation patterns on California rangeland production was modeled. Researchers found that some regions will become wetter and others will become drier so that suitable areas for cattle grazing would be lower due to climate change (Shaw *et al*., 2011). Ren *et al*., (2012) suggested that during six years, vegetation dynamics and species co-existence were more affected by temporal variability in rainfall and temperature rather than grazing that determines in a grazed steppe ecosystems.

Munkhtsetseg *et al*., (2007) reported that sometimes, the frequency and length of dry periods affect plant growth without a significant decline in the seasonal rainfall. Zhang *et al*., (2005) investigated the rangeland production variation due to high temperatures and precipitation. They showed there is a significant difference between the production in drier and moisture years. They noted that the air temperature stress-degree-day had a prevailingly negative effect on vegetation growth in northeastern Mongolia. Le Barbé and Lebel (1997) pointed out that lasting drought is linked with an increase in dry-spell events, rather than with a reduction in the mean event precipitation. Chaplin-Kramer and George (2013) showed how simulated temperature and precipitation in the San Francisco will lead to changes in forage production in future. In their study, temperature is the main constraint to productivity. They said precipitation and evapotranspiration drove a simple model to determine growing season length, and temperature and growing season length drove the model for annual forage production. Askarizadeh and Arzani (2018) in a research on ecological effects of climate factors on summer rangeland vegetation in Iran showed that minimum temperature was the most effective variable that may influence the vegetation cover. Karabulut (2003) pointed out extreme climatic events such as droughts and abundant moisture conditions can have a strong impact on vegetation development and can be identified by utilizing vegetation indices. He found that the previous two months' precipitations have a stronger impact on vegetation development.

Analyses of precipitation and temperature are common in the assessment of the variation of the climatic parameter on rangeland vegetation whereas there have been few studies on climatic extreme events such as absolute maximum and absolute minimum temperature or humidity and their effects on vegetation (In addition to varying precipitation in monthly, Bi-monthly, seasonal cumulative and yearly periods). Despite these known links between the influences of temperature and rainfall in rangelands, there are a few studies about the relation between climatic extremes and its effects on the Iran rangeland, yet.

Research has also shown that even short-term weather statistics are effective in managing rangeland risk. McKeon *et al*., (2009) suggested that a risk-averse approach to rangeland management based on the 'best estimate' projections in combination with appropriate responses to short-term (1–5 years) climate variability would reduce the risk of resource degradation. Therefore, a four-year (2011–2015) experiment was conducted to examine how variability of climatic parameters such as precipitation, mean and extreme of temperature and moisture in the Jashloobar rangeland affects vegetation, as reflected by changes in the forage production and canopy cover of rangeland plants

Materials and methods

Jashloobar summer rangeland is located at 50 km north of Semnan city in Iran. It is a part of Talar watershed between 53° 07′ to 53° 12′ eastern longitude and 35° 45′ to 35° 48′ northern latitude with 2400-2600 m elevation above sea level and on the southern slope of Alborz mountains (Kargar *et al*., 2016) (Fig. 1). In Jashloobar, about 80% of the total watershed area (2500 ha) is covered by rangelands. The most important plant species of this site are: *Stipa lessingiana, Festuca rubra, Bromus tomentellus, Psathyrosyachys fragilis, Onobrychis cornuta, Acantholimon erinaceum, Artemisia sieberi*, and *Artemisia Aucheri.* The exploitation of rangelands is nomadic system. Grazing period starts from the second half of June and continues until the first half of October (Naseri *et al*., 2018). This study was carried out in two vegetation types: *Festuca rubra* in Margesar and *Stipa lessingiana* in Sefiddasht. The Specification of each type is presented in Table 1.

Study area

Some of the most important associated plant species in Margesar respectively are *Ajuga chamaecistus, Scariola orientalis, Astragalus gossypinus, Noaea mucronata, Stipa lessingiana, Cousinia nekarmanica, Bromus tomentellus, Psathyrosyachys fragilis, Onobrychis cornuta, Acantholimon erinaceum* and in Sefid Dasht are *Polygonum afghanicum, Bromes tomentellus, Cousinia nekarmanica, Astragalus gossypinus, Astragalus efinasal, Ajuga chamaecistus, Onobrychis cornuta, Noaea mucronata, Festuca rubra, Stipa lessingiana*. Annual grass and annual forbs can also be seen in both locations.

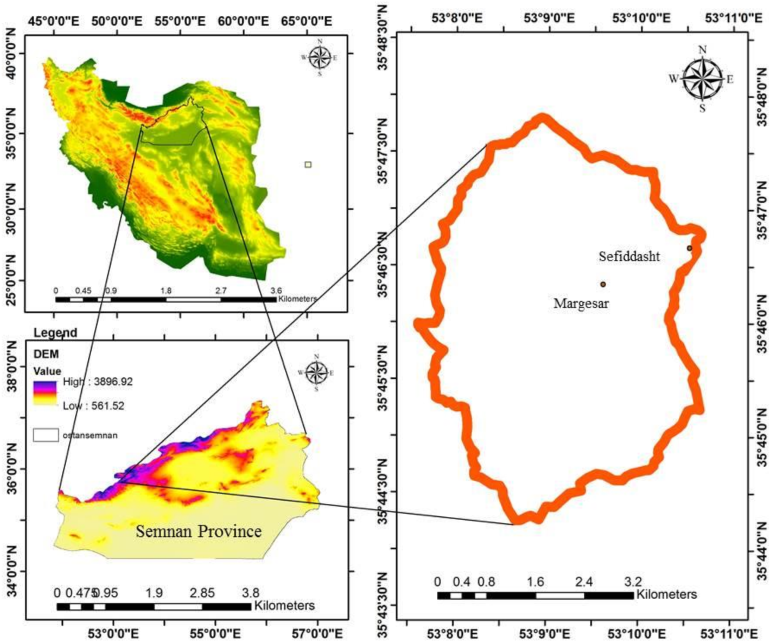


Fig. 1. Site location in Iran, Semnan province and Jashloobar watershed

Table 1. Rangeland specification and vegetation covers of study location in Jashloobar rangelands (2011-2015)

Rangeland Specification	Location 1: Sefid Dasht	Location 2: Margesar
Type of geological formation	Marl and Marl Lime	Marl and Marl Lime
Soil texture (surface layer: 0-20 cm)	Silt-loam	Silt-loam
Soil Taxonomy	Inceptisols- Ustepts- Typic Calciustepts	Inceptisols- Ustepts- Typic Calciustepts
Slope (%)	7- 8 ºC	8- 10 ºC
Aspect	South	North
Elevation range (m)	2400-2600	2400-2600
Climate	Cold Semi-steppe with temperate summer	Cold Semi-steppe with temperate summer
The average of annual temperature (ºC)	12	12
The average of annual precipitation (mm)	300	300
Vegetation types	*Stipa lessingiana*	*Festuca rubra*
Range trend (based on trend balance method)	Score 0= Stable	Score 1= improving
Rangeland condition class (Four Factor Method)	Score 32= fair	Score 38=good
Soil%	42	37
Rock%	22	13
Litter%	7	9
Cover%	28	42

Climatic data

Data of two study sites were obtained from Iran Meteorological Organization and Iran Ministry of Energy. Raster layer for each parameter/ month/ years was created using IDW method in GIS environment. By interpolating lines of each factor for each month, a vector layer output was exported and clipped for the study area, the means of data were extracted and considered as the information of the same month (Fig. 2A).

These parameters included the temperature (mean daily, absolute maximum, absolute minimum, monthly maximum and minimum), monthly humidity (absolute maximum, absolute minimum and average) and monthly precipitation. The climatic data used in this article were based on the region's crop year i.e. previous-year mid-September to current year mid-September instead of using annual calendar (January to December).

Data Analysis

In order to define the relationship of vegetation dynamics and climatic parameters, forage production and canopy cover have been modeled as a dependent variable (Y) versus single predictive variables (X) of precipitation, temperature and humidity as independent variable using simple linear regression analysis. The normality of variables was tested using Kolmogorov-Smirnov. To evaluate the difference between the years in terms of vegetation production, and canopy cover, Duncan test was used. The significance of regression coefficient was tested by F-test (Vittinghoff *et al*., 2011). Finally in order to determine the relationship between Y (production, canopy cover) and many climatic variables such as X1, X2, X3 and…, the stepwise regression was used. All data were analyzed by SPSS16.

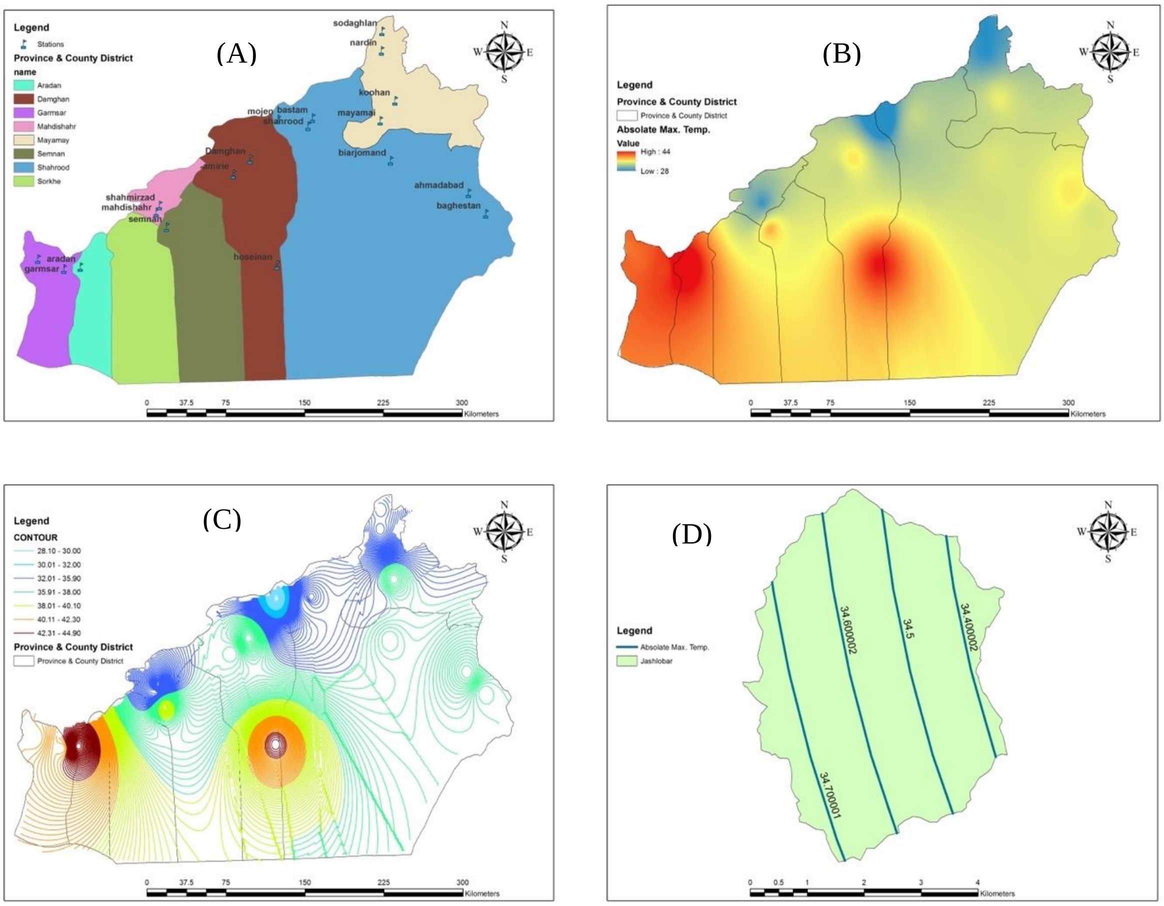


Fig. 2. Steps of data extraction (for an example absolute maximum temperature) of Jashloobar rangelands (A: Climatological and Synoptic Stations of Semnan province, B: Raster map of absolute maximum temperature in August, Semnan province, C: Vector map of absolute maximum temperature in August, Semnan province, D: Interpolating lines for Absolute maximum temperature in August for Jashloobar)

Result

Estimated climatic data

The results showed that there were two distinct periods of increase and decrease in temperature each year. This increase began almost in late April and continued until September. Conversely, from the beginning of October, a decrease in temperature was observed. The average of mean daily temperature (T_{md}) was 1.87° C for 2011-2015 crop years. There was no significant difference between years in term of this factor. 2013-2014 had the lowest (8.46°C) and 2014-2015 with 12.12°C had the highest T_{md}.

Significant differences were found between years in terms of plant production at two locations. In both study locations, the lowest production was recorded in 2013-2014. Comparison showed that in 2011-2012 and 2012-2013, Margesar canopy cover was significantly more than 2014-

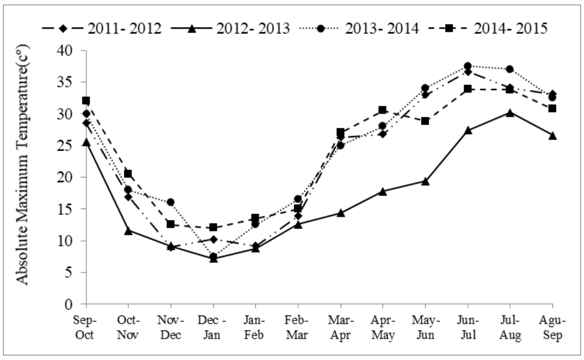
2015 with lowest cover percent. However, in Sefiddasht, there was no significant difference between years in term of canopy cover (Table 2). It is worth noting that comparison of means data for parameters with minimum and maximum (or absolute maximum and absolute minimum) is not logically correct because these values occur once in the statistical period.

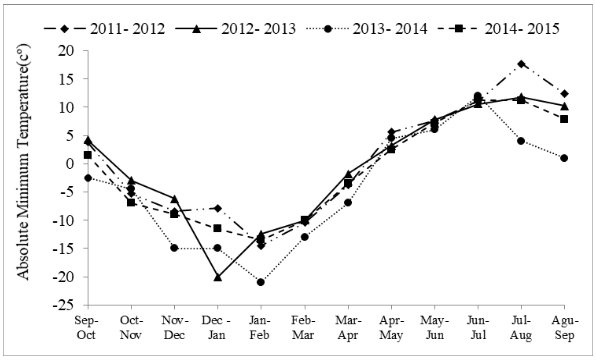
Table 2. Duncan mean comparison of the years in terms of mean daily temperature, mean humidity, annual precipitation, production and canopy cover in two study locations.

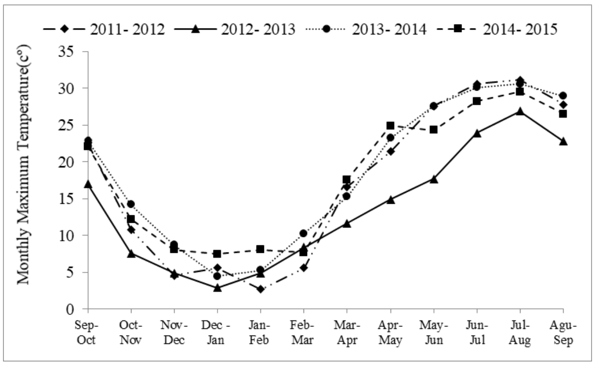
Parameter	Location	2011-2012	2012-2013	2013-2014	2014-2015
Mean relative humidity (%)	Both site	50.55^{b} ± 4.69	64.33^{a} ±2.55	59.08 ^{a} ±0.26	56.18^{ab} ±1.67
Mean daily temperature(ºc)	Both site	11.85^{a} ±2.77	11.63^{a} ±2.45	8.46^{a} ±2.33	12.12 ^{a} ±2.21
Annual precipitation (mm)	Both site	293.0 ^{a} ±0.00	225.0 ^{ab} ±0.00	173.0 ^{bc} ±0.00	156.0 ^{c} ±0.00
Canopy cover (%)	Margesar	47.97 ^{a} ±4.85	47.88 ^{a} ±4.35	36.72 ^{ab} ±2.92	33.94^{b} ±3.01
	Sefiddasht	28.41 ^{a} ±2.2	29.20 ^{a} ±2.07	29.93 ^{a} ±3.10	24.63 ^{a} ±2.46
Production (kg/ha)	Margesar	479.0 ^{a} ±49.10	583.0 ^{a} ±57.57	254.0 ^{b} ±21.43	569 ^{a} ±57.85
	Sefiddasht	326.3 ^{a} ±34.54	263.7 ^{ab} ±34.41	213.3 ^{b} ±35.6	276 ^{ab} ±37.12

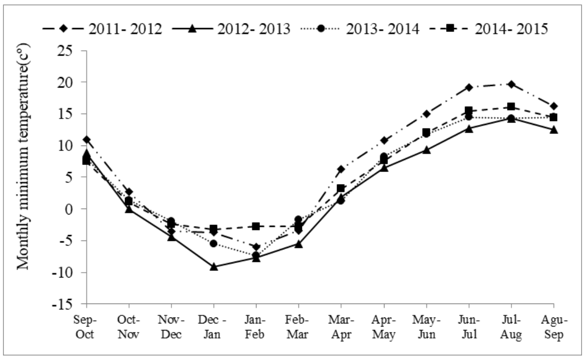
Means ± standard error, Means of each row with the same letter are not significantly different (P<0.05).

The highest absolute maximum temperature ($T_{a.\ max}$) was 37.5° C in July 2014 and the lowest absolute minimum temperature ($T_{a.min}$) was -21°C which occurred in February 2014, too. In the first and third years of research, $T_{a.\ max}$ was more than 20°C from April to October (7 months). In the second year, the $T_{a.\ max}$ was above 20° C from July to October (4 months) and in the fourth year, it occurred from April to November (8 months) (Figs. 3 and 5).









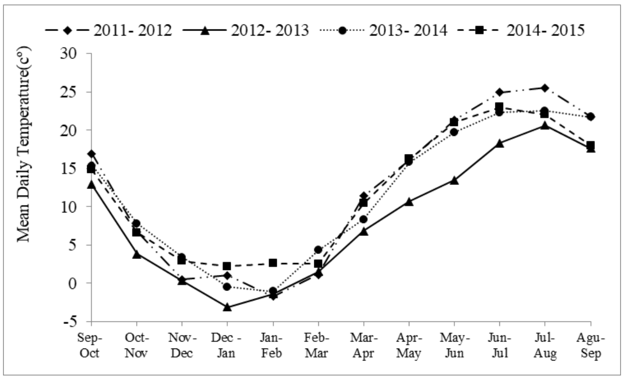


Fig. 3. Temperature trend diagram during (2011-2015)

The highest mean monthly humidity ($H_{m.m}$) was in 2012-2013 with 64.33% and the lowest was in 2011-2012 with 50.55% and this difference was statistically significant (Table 2). The highest $H_{m.m}$ occurred in November with 64.37%. July with 26.73% was the driest month during these years. The lowest of absolute minimum humidity ($H_{a.\ min}$) was 8.2% in June- July 2012 and the highest absolute maximum humidity ($H_{a.\ max}$) was 99.4% in October- November 2011. $H_{a.\ max}$ in 7 month of 2011-2012 was upper than 90% (September 2011 to April 2013) (Fig.4).

Results showed that there was a significant difference between years in terms of precipitation. Accordingly, 2011-2012 and 2014-2015 had the highest and lowest precipitation with 293 and 156 mm, respectively (Table 2).

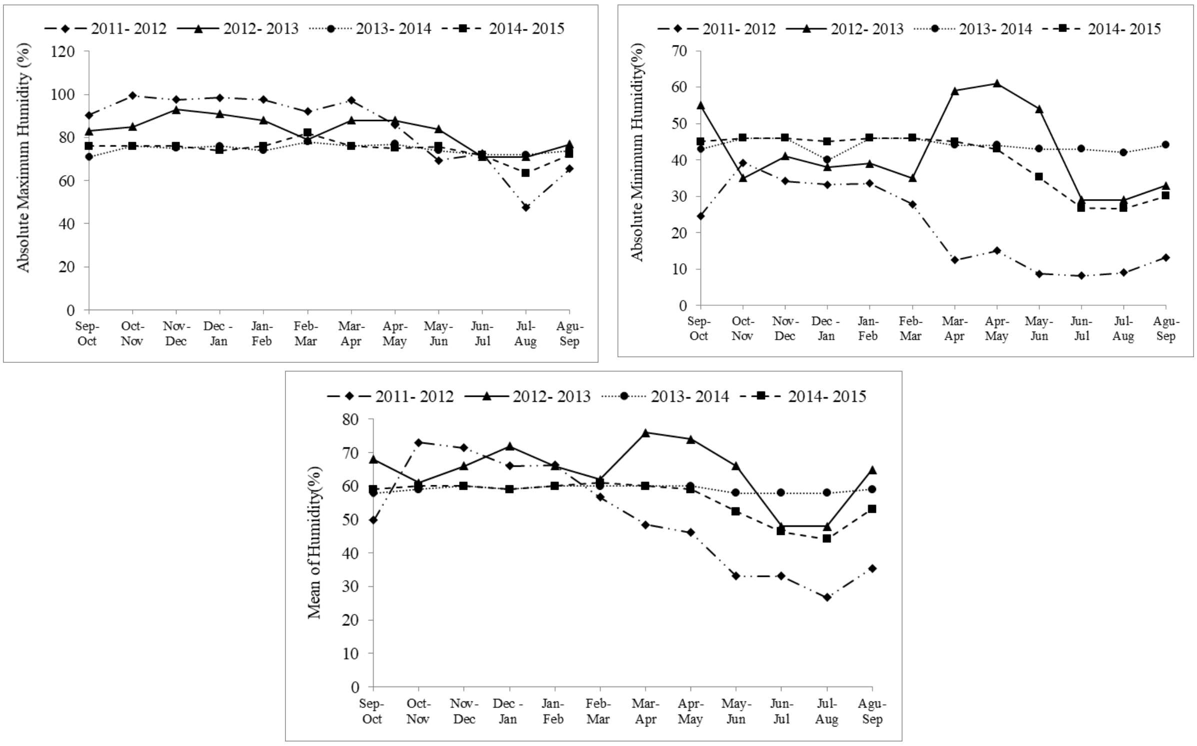


Fig. 4. Humidity trend diagram during (2011-2015)

Ombrothermic Curve

Ombrothermic diagrams indicated that in 2011-2012 and 2012-2013, the wet and dry periods were 7 and 5 months. The precipitation trend in 2012-2013 showed less fluctuation than last year (Fig. 5). April and June of 2013 had the lowest precipitation compared to the same period of other three years. In 2013-2014, dry period was longer compared with two years ago (7 months) and wet period was 5 months. In 2014-2015 with the minimum of precipitation, dry period started earlier and continued further. The wet period started in late January and continued until mid-April (almost 2.5 months).

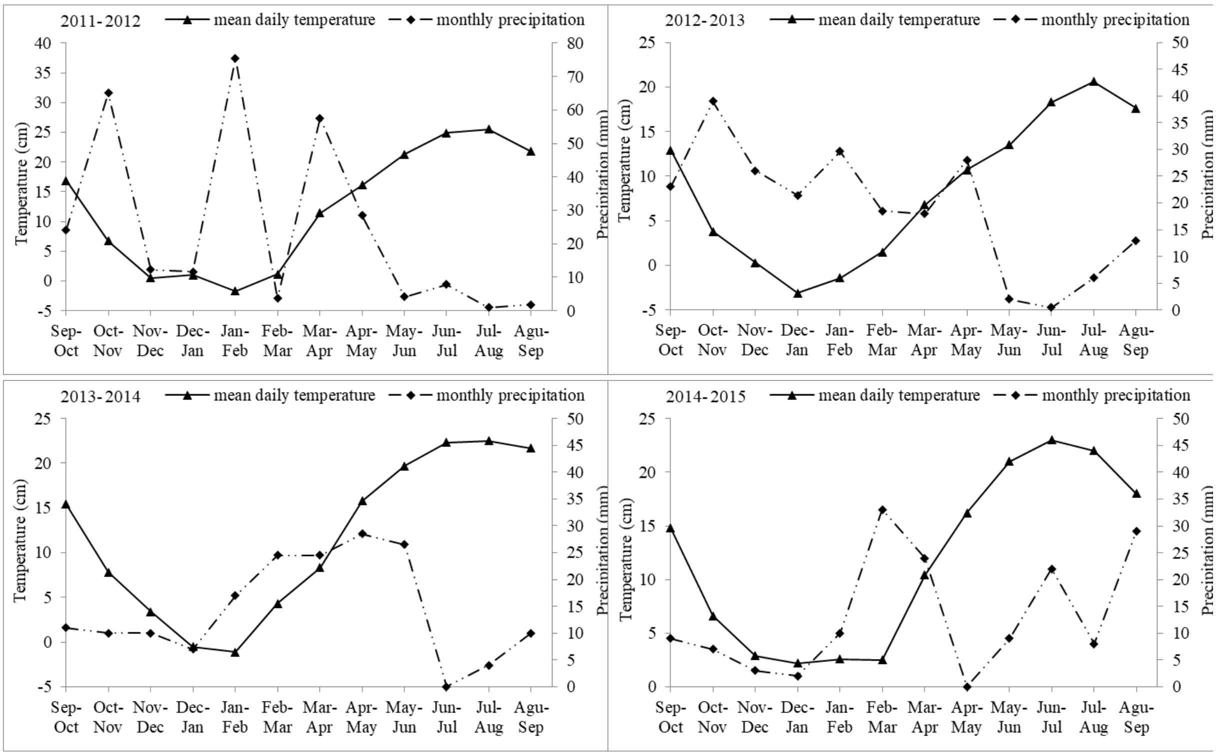


Fig. 5. The ombrothermic diagram of climate in the Jashloobar site

Simple Regression Analysis

Simple linear regressions between climate factors as an independent variable (X) and response variables such as production (kg/ha) and cover percent(Y) are given in Tables 3 and 4. These tables shows only equations that were statistically significant.

Production vs. Climatic factors

According to the results, the forage production in Margesar was significantly affected by March plus growing season rainfall (March -June). In this site, there were significant regression relations between productions with $T_{a.\ max}$ in August and $T_{a.min}$ in February, March, April, June and July. In addition, $H_{a.\ min}$ in January was important for estimating production in Margesar.

In Sefiddasht, there was no significant relation between production and precipitation but it was significantly predicted based on the $T_{m.max,}$ $T_{m.min}$ and $T_{a.min}$ in March, April and August, respectively. In addition, $H_{m.m}$ of July and August had significant effects on forecasting Sefiddasht production. $H_{a.\ min}$ in July, August and September were important for estimating production in this site, too.

Production had no significant relationship with T_{md} in both locations. The remarkable point was that minimum, maximum and absolute climatic factors had a significant relationship with production than T_{md} and precipitation (Table 3).

Table 3. The summary of simple regression analysis between climatic parameters and production and canopy cover in two study locations

Climatic factor	Location	Month	Dependent variable=production	R	Sig
Precipitation = p	Margesar	Mar.-Jun	Production=-7.13p+1060.5	0.95	*
Monthly Max temperature =$T_{m. max}$ (ºC)	Sefiddasht	Mar.	Production=-23.88$T_{m.max}$+460.89	0.99	**
Monthly Min temperature =$T_{m. min}$ (ºC)	Sefiddasht	Apr.	Production=19.49$T_{m.min}$+207.96	0.95	*
Absolute Max temperature= $T_{a. max}$(ºC)	Margesar	Aug.	Production=-47.22$T_{a.max}$+2033.3	0.96	*
	Sefiddasht	Aug.	Production=28.15$T_{a.min}$+176.7	0.99	**
Absolute Min temperature= $T_{a. min}$ (ºC)	Margesar	Feb.	Production=38.98$T_{a.min}$+1069.6	0.99	**
		Mar.	Production=1593.9$T_{a.min}$+103.47	0.98	*
		Apr.	Production=67.15$T_{a.min}$+741.54	0.96	*
		Jun.	Production=160.46$T_{a.min}$-711.27	0.96	*
		Jul.	Production=-236.95$T_{a.min}$+3100.4	0.99	**
	Sefiddasht	Aug.	Production=176.72$T_{a.min}$+8.154	0.99	**
Mean monthly humidity= $H_{m.m}$ (%)	Sefiddasht	Jul.	Production=-4.51$H_{m.m}$+477	0.99	**
		Aug.	Production=-3.5$H_{m.m}$+422.83	0.99	**
Absolute Min humidity= $H_{a. min}$(%)	Margesar	Jan.	Production=8.24$H_{a.min}$+223.66	0.97	**
	Sefiddasht	Jul.	Production=-3.22$H_{a.min}$+354.0	0.98	**
		Aug.	Production=-3.39$H_{a.min}$+358.44	0.99	**
		Sep.	Production=-3.6$H_{a.min}$+376.28	0.97	**

Pro = Production, Cov= Cover, Sig= Significance level, * and ** = significance at 1% and 5% probability level, respectively

Canopy Cover vs. Climatic factors

For vegetation cover in Margesar, rainfall of October to December and January to March was the most effective indices and T_{md} of December and winter (January to March) had a significant relationship with cover percent. In this site, canopy cover was significantly predictable by $T_{m.max}$ in December, $T_{a. max}$ in February, $T_{a.min}$ in June and September. In addition, $H_{m.m}$ in February, $H_{a. max}$ in December, January, April, May and $H_{a. min}$ in March had a significant relationship with cover percent.

In Sefiddasht, the most effective factors for estimation of the cover percent were precipitation of May, July and July to September. Also, in this site, T_{md} of February, $T_{a.min}$ in August, $H_{m.m}$ in July and August, $H_{a. max}$ in May and July and $H_{a. min}$ in July, August and September had significant relationships with cover percent (Table 4).

Table 4. The summary of simple regression analysis between climatic parameters and production and canopy cover in two study locations

Climatic factor	Location	Months	Dependent variable= Cover(%)	R	Sig
Precipitation = p	Margesar	Oct.-Dec.	Cover%=0.18p+30.96	0.99	**
		Jan.-Mar.	Cover%=0.32p+21.56	0.95	*
	Sefiddasht	May.	Cover%=0.16p+24.63	0.96	*
		Jul.	Cover%=-0.23p+29.76	0.99	**
		Jul.- Sep.	Cover%=-0.09p+30.57	0.95	*
Mean daily temperature = T_{md} (ºc)	Margesar	Dec.	Cover%=4.4T_{md}+49.44	0.96	*
		Jan.-Mar.	Cover%=4.6T_{md}+44.45	0.95	*
	Sefiddasht	Feb.	Cover%=-1.08T_{md}+27.6	0.95	*
Monthly Max temperature =$T_{m.max}$ (ºC)	Margesar	Dec.	Cover%=-3.33$T_{m.max}$+63.53	0.96	*
Monthly Min temperature =$T_{m.min}$ (ºC)	Sefiddasht	Feb.	Cover%=-1.03$T_{m.min}$+21.89	0.98	*
Absolute Max temperature= $T_{a.\ max}$ (ºC)	Margesar	Feb.	Cover%=-3.12$T_{a.max}$+75.95	0.99	**
	Sefiddasht	Aug.	Cover%=-0.11$T_{a.min}$+30.4	0.99	**
Absolute Min temperature= $T_{a.min}$ (ºC)	Margesar	Jun.	Cover%=6.38$T_{a.min}$-1.56	0.99	**
		Sep.	Cover%=1.05$T_{a.min}$+35.9	0.98	*
	Sefiddasht	Aug.	Cover%=-0.11$T_{a.min}$+30.4	0.99	**
Mean monthly humidity= $H_{m.m}$ (%)	Margesar	Feb.	Cover%=2.04$H_{m.m}$-87.39	0.99	**
	Sefiddasht	Jul.	Cover%=0.06$H_{m.m}$ +26.37	0.99	**
		Aug.	Cover%=0.05$H_{m.m}$+27.11	0.98	**
Absolute Max humidity= $H_{a.\ max}$(%)	Margesar	Dec.	Cover%=0.62$H_{a.max}$-11.11	0.97	*
		Jan.	Cover%=0.6$H_{a.max}$-9.42	0.96	*
		Apr.	Cover%=0.65$H_{a.max}$-13.91	0.95	*
		May.	Cover%=1.13$H_{a.max}$-50.65	0.99	**
	Sefiddasht	May.	Cover%=0.16$H_{a.max}$+24.63	0.96	*
		Jul.	Cover%=-0.23$H_{a.max}$+29.76	0.96	**
Absolute Min humidity= $H_{a.\ min}$	Margesar	Mar.	Cover%=-0.77$H_{a.min}$+71.44	0.95	*
	Sefiddasht	Jul.	Cover%=0.04$H_{a.min}$+28.02	0.99	**
		Aug.	Cover%=0.04$H_{a.min}$+27.96	0.99	**
		Sep.	Cover%=0.05$H_{a.min}$+27.73	0.99	**

Pro = Production, Cov= Cover, Sig= Significance level, * and ** = significance at 1% and 5% probability level, respectively

Stepwise Regression Analysis

Result of stepwise regression analysis is summarized in Table 5 which indicated that $T_{a.\ max}$ and humidity were the most effective climatic factors on canopy cover and production. In Margesar, the model showed that 95% of the cover percentage variation was affected by $T_{a.\ max}$ in December and in the second step, by entering $H_{m.m}$ in March to the model, the R=99%. As it is evident in the findings about production in the Margesar, in the first step, December $T_{a.\ max}$ enters the model; R=96.3% of the production fluctuations is related to this variable and by entering $H_{a.\ min}$ in December in the second step, it increases to 99%. In Sefiddasht, among all climatic factors, $H_{a.\ max}$ in May was the most effective parameter on cover percent, i.e. R=96% of vegetation cover can be predicted by $H_{a.\ max}$ at this time. For production, two variables of $T_{a.\ max}$ in June coupled with $T_{a.min}$ in August were entered in the final model (Table 5).

Table 5. The summary of stepwise regression analysis between climatic parameters and production and canopy cover in two study locations

Location	Trait	Step	Variables entered to model	Equation	R
Margesar	Production	1	$T_{a.\ max\ in\ Mah}$	Pro=-84.72$T_{a.max\ in\ Mar}$+1653.05	0.96
		2	$T_{a.\ max\ in\ Mar}$ &$H_{a.\ min\ in\ Dec}$	Pro=-111.5$T_{a.max\ in\ Mar}$+9.59$H_{a.min\ inDec}$-1652.4	0.99
Margesar	Cover	1	$T_{a.\ max\ in\ Dec}$	Cov=-1.62$T_{a.max\ in\ Dec}$+62.69	0.95
		2	$T_{a.\ max\ in\ Dec}$ &$H_{m.\ min\ Mar}$	Cov=-3.37$T_{a.max\ in\ Dec}$-1.95$H_{m.min\ in\ Mar}$+207.9	0.99
Sefiddasht	Production	1	$T_{a.\ max\ in\ June}$	Pro=0.94$T_{a.max\ in\ June}$+51.35	0.95
		2	$T_{a.\ max\ in\ Jun}$ & $T_{a.\ min\ in\ Aug}$	Pro=2.86$T_{a.max\ in\ Jun}$+19.58$T_{a.min\ in\ Aug}$-1183.2	0.99
Sefiddasht	Cover		$H_{a.\ max\ in\ May}$	Cov=$H_{a.max\ in\ May}$+30	0.96

$T_{a.\ max}$=Absolute Max Temperature, $H_{a.\ max}$=Absolute Max Humidity, Pro = Production, Cov: Cover

Discussion

As the results showed, the lowest production in both regions was in 2013-2014. The possible causes of observed decline rate are debated below: At first, an abrupt reduction in rainfall occurred in 2013-2014 and a continuation of dryness to the 2014-2015 (57% and 52% reduction of annual mean precipitation respectively). Based on the 2013-2014 ombrothermic curves, it can be concluded that the wet and dry periods were 5 and 7 months in this year, respectively. This indicates that in 2013-2014, the dry period was longer compared with two years ago. Altered precipitation patterns could mean delayed germination, resulting in shorter growing seasons and longer periods of inadequate forage quality. Previous studies also reported that the temporal distribution, rather than the annual sum of precipitation, determines aboveground net primary productivity of semi-arid grasslands (Ren *et al*., 2012). An increase in the frequency of extremely dry years also increases the uncertainty of forage availability. These shifts in forage production will affect the economic viability and conservation strategies for rangelands (Chaplin-Kramer and George, 2013).

It is noteworthy that although the 2014-2015 dry seasons began earlier and continued longer but the rainfall in March was more significantly than two previous years. It is expected that the longer drought period in 2014-2015 will affect the growth of plants in the following years. Our findings are in agreement with Miao *et al*., (2015) indicating that inter-annual variability in precipitation can explain the inter-year differences in herbage biomass. However, depending on the vegetative form, root system, timing and quality of precipitation, the response of plants to rain will be different (Jabbogy and Sala, 2000). As shown in results, rainfall affected production in March to June; that confirms the earlier findings of Ren *et al*., (2012) who stated that vegetation dynamics are strongly affected by precipitation and mean temperature in the early season (March to June). In this period, most species initiate their growth processes and thus, they are highly sensitive to precipitation variations and temperature. Also, accordingly, other researchers stated that winter and early spring rainfalls are effective because the precipitation is more likely to penetrate deep into the soil (Mesdaghi, 2015; Fakhar Izadi *et al*., 2019). Significant regression relationship between fall and winter precipitation with the cover percent was observed in Margesar. Precipitation of this period benefits to perennial species such as shrubs and bushes with deep roots (Paruelo and Lauenroth, 1996) while rainfall of growing season is more useful for herbaceous species or grasses with surface roots (Fakhar Izadi *et al*., 2019; Khumalo and Holecheck, 2005). In Sefiddasht early-season precipitation had a significant relationship with cover percent. It is worth noting that in Margesar, 22% of the total plant composition was dedicated to shrubs, which was about half in Sefidasht.

Although some researchers found that in arid and semi-arid rangeland ecosystems, among the climate variables, the amount of precipitation, its frequency and temporal distribution patterns showed the highest correlation with production (Karabulut, 2003., Khumalo and Holechek, 2005) but the results of this study indicate that although the lack of precipitation was a limiting factor for forage growth and production, it wasn't the only key determinant of rangeland production and rainfall is not able to accurately estimate yield lonely (Chaplin-Kramer and George, 2013; Fakhar Izadi *et al*., 2019).

In stepwise regression results of two locations, $T_{a.\ max}$, $T_{a.\ min}$, $H_{a.\ max}$ and $H_{m.m}$ were entered into the final models, not rain. That indicates the production variations highly sensitive to absolute parameters. We found that the most effective factor for estimating production in both locations was the $T_{a.\ max}$ that was effective at two critical times, March which coincides with the warming weather and start of plant growth, and June which is the peak of plant growth. Referring to the results, it can be seen that rainfall in the March-June period has greatly affected production in Margesar. This is an emphasis that usually, in the summer rangelands, the limiting factor is temperature not rain. In fact, an optimal combination of temperature, humidity and precipitation is essential for starting and continuing plant growth. Askarizadeh and Arzani (2018) confirmed that in upland rangeland (such as Jashloobar in this research), plants were in severe condition and the most life forms such as grass-shrubs need sufficient climatic components such as precipitation, humidity and temperature.

This result is consistent with studies of Liu *et al*., (2019) that in summer rangeland with sufficient precipitation to maintain soil moisture content, plants experienced little water deficit. With sufficient water supply, temperature became the primary limiting factor. The growth stage is occurred when environmental temperature copes with 10ºC; in this study, the temperature rises from late March and gradually reaches about 10º C which is mid-April. It provides the favorable conditions for beginning of growth. Temperature plays a role in the breakdown of bud dormancy and growth initiation of some plants in the spring (Parish and Fike, 2005) and will affect the amount of photosynthesis that determines the growth period and the rate of plant production. When the temperature is favorable, rangeland grasses with bunch form and extended root system can efficiently absorb more moisture from each event of rainfalls (Fakhr Izadi, 2019). As the dominant vegetation type of Jashloobar rangeland is perennial grasses, it should be noted that terminal bud of the most grasses are in accordance to leaf elongation zone where is the main site of shoot growth in grasses (Arredondo and Schnyder, 2003). Hence, they can resist against low temperature. The perennial forbs are also influenced by the climate factor because these species have so less preserved nutrients in the below ground organs and hence, they should be assured to grow with the minimum temperature (Askarizadeh and Arzani, 2018).

The optimum temperature for photosynthesis is 15 to 25°C and plants continue to grow until the optimum temperature and moisture are available for nutrition (Moghadam, 2001). Which as the ombrothermic curve has shown in 2013-2014, mean daily temperature in March to April duration was the lowest (8.3°C) and reaches to the optimum temperature later so that it may have effect on the decreasing the production. But excessive temperature on the one hand disrupts the process of plant nutrition and consequently reduced photosynthesis and on the other hand, by increasing evaporation from the soil surface and plant, it reduces the amount of water available for the plant; thus, they have negative effects on production (Moghadam, 2001). $T_{a.\ max}$ is one of the most important parameters imported to the plant production model and shows how much plants are sensitive to the extreme temperature. As temperature trend diagram shows, $T_{a.\ max}$ in June to august was the highest in 2013-2014 (up to 37.5 °C) (Fig. 3). As Nahar *et al*., (2015) have expressed, among the abiotic stresses, high temperature stress is one of the most detrimental stresses threatening higher plant productivity and survival throughout the world. These anomalies hamper plant growth and development. By each degree Celsius, increase of average growing season temperature may decrease crop yield and affect plant distribution. The metabolism in plants is altered in response to high temperature stress. Predicting future grassland ecosystem functioning relies on understanding how changes in climate alter the quantity of forage production, but also forage quality. Within regions, quality also declined with increased temperature (Craine *et al*., 2010). Munkhtsetseg *et al*., (2007) studied the effect of rainfall and maximum temperature on Mongolia's rangeland production and noted that July increases temperature and the decrease in precipitation in June as the main cause of the decline rangeland’s species.

$T_{a.\ min}$ was another factor affecting vegetation production and cover. Scientists from eight countries of South America showed that there were no consistent changes in the indices based on daily maximum temperature while significant trends were found in the indices based on daily minimum temperature (Vincent *et al*., 2005). The results of Askarizadeh and Arzani (2018) showed that minimum temperature was the most effective variable that influences the vegetation cover. As ombrothermic diagram showed, the most periods of vegetative growth stage are connected to temperature factor, especially the minimum temperature. Delay in flowering and rangeland plants growth is due to temperature reduction. Based on temperature trend diagram (Fig. 3), in 2013-2014, the range of temperature fluctuations was high as the lowest $T_{a.\ min}$ in Jashloobar during the experimental period that happened in January- February 2014 (-21°C). While in 2013-2014, it has had the lowest T_{md} in these four years (8.46°C). These factors make the appropriate growth period shorter in this year. Researches showed that production changes were highly sensitive to absolute parameters. The sudden decrease or increase in temperature and humidity as a stress greatly affected the growth of plants and make the growth period shorter. McKeon *et al*., (2009) said low temperatures limit plant growth in winter, while high temperatures restrict growth in summer in association with high vapor pressure deficits.

As Koocheki *et al*., (2006) have predicted, temperature will rise to 2.7°C and rainfall will decrease to 12% by 2050 in Iran. Although they said by 2050, length of the growth period will increase to 16 days, length of the dry period will increase to 22 days because of occurring a delay in the first freezing day and an advance in the last freezing day, and the subsequent increase in temperature and decrease in rainfall, but other researchers such as Chaplin-Kramer and George (2013) and Askarizadeh and Arzani, (2018) said growing seasons will be shorter and therefore, the grazing time will be limited. Rosenzweig and Parry (1994) and Downing *et al*., (1997) showed that in arid and semi-arid regions of the world such as Iran, the growing season will be shorter while in the high latitudes; growing season will increase in the future. Accordingly in a future with higher temperatures and lower precipitation, herdsmen will need to optimize their management options for grazing in shorter growing seasons and therefore, longer dry seasons(Chaplin-Kramer and George, 2013; Askarizadeh and Arzani, 2018) and decide on proactive operations such as stocking conservatively, resting rangelands (Liu *et al*., 2019) or national planning for other solutions such as industrial animal husbandry rather than traditional ranching to mitigate the effects of climate change. Also, ranchers and the government should decide about alternative livelihoods such as ecotourism, beekeeping and exploitation of medicinal plants.

Finally, long-term surveys and more researches on the relationship between these climatic extremes and vegetation production are needed to provide near real information about forage availability in future.

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چکیده. نوسانات سالانه آب و هوا باعث تغییر تولید، وضعیت، گرایش و ظرفیت چرای مراتع می‌شود. پژوهش حاضر اثر فاکتورهای اقلیمی را بر پویایی پوشش گیاهی مرتع ییلاقی جاشلوبار استان سمنان، ایران در تیپ-های *Festuca rubra* مرگسر و *Stipa lessingiana* سفید دشت، طی سال‌های ۱۳۹۴- ۱۳۹۱ بررسی کرد. عوامل اقلیمی شامل دما (میانگین روزانه، حداکثر دمای ماهانه، حداقل دمای ماهانه، حداکثر مطلق، حداقل مطلق)، رطوبت ماهانه (حداکثر مطلق، حداقل مطلق، میانگین) و بارندگی ماهانه بودند. این فاکتورها به‌خاطر فقدان ایستگاه سینوپتیک و کلیماتولوژی در منطقه، با روش معکوس فاصله وزنی توسط ۱۹ ایستگاه هواشناسی استان سمنان محاسبه شدند. درصد پوشش گیاهی و تولید در هر تیپ، در دو ترانسکت۴۰۰ متری و ۲۰ پلات یک مترمربعی اندازه‌گیری شد. برای سنجش اختلاف تولید و درصد پوشش بین سال‌ها از آزمون دانکن و جهت تعیین رابطه فاکتورهای اقلیمی و پارامترهای گیاهی از رگرسیون خطی استفاده شد. نتایج نشان داد تولید به‌طور معنی‌داری در سالهای مختلف تفاوت دارد(P < ۰/۰۵). کمترین مقدار تولید مرگسر و سفید دشت در سال ۹۳-۹۲ به‌ترتیب با ۲۵۴ و ۲۱۳/۳ کیلوگرم در هکتار مشاهده شد. اگرچه بارش در این سال به میزان قابل‌توجهی کاهش یافته و از ۲۹۳میلیمتر در سال۹۱-۹۰ به ۱۷۳ میلیمتر در ۹۳-۹۲رسیده(P < ۰/۰۵)، اما رگرسیون گام به‌گام نشان داد در نهایت در مرگسر حداکثر مطلق دما و حداقل مطلق رطوبتِ آذر و در سفید دشت حداکثر مطلق دمای خرداد و حداقل مطلق دمای مرداد به مدل پیش‌بینی تولید وارد شده‌اند. این مسئله مشخص می‌کند تغییرات تولید علاوه بر بارندگی، به پارامترهایی که حالت مطلق دارند، بسیار حساسند. همچنین با توجه به کاهش طول دوره رشد در این سال‌ها، دوره چرا باید محدود شود. بنابراین مرتعداران و دولت باید تدابیری برای بهینه سازی مدیریت مرتع، همانند کاهش طول دوره چرا و کاهش ظرفیت چرا و یا معیشت جایگزین نظیر اکوتوریسم، زنبورداری و بهره‌برداری از گیاهان دارویی در نظر بگیرند.

کلمات کلیدی: پارامترهای هواشناسی، علوفه، مراتع ییلاقی