Volume 14, Issue 2, 142413 (1-11)

Journal of Rangeland Science (JRS)

https://dx.doi.org/10.57647/j.jrs.2024.1402.13

Prediction of Climatic Ecological Nest of *Artemisia aucheri* Boiss, in Tehran Province, Iran Based on Modeling

Mahshid Souri[1]*, Morteza Khodagholi[1], Saeedeh Nateghi[1], Nadia Kamali[1], Parvaneh Ashouri[1], Razieh Sabuhi[2]

[1] *Rangeland Research Division, Research Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran.*
[2] *Isfahan Agriculture and Natural Resources Research and Education Center, AREEO, Isfahan, Iran.*

***Corresponding author:** souri@rifr-ac.ir

Research and Full Length Article

Received:
30 January 2022
Revised:
1 February 2023
Accepted:
8 March 2023
Published online:
10 March 2024

Abstract:

Optimal habitat has a beneficial effect on species survival. In this research, a logistic regression statistical method was used to prepare the potential distribution map of *Artemisia aucheri* Boiss, in Tehran province, Iran in 2020-2021. The maps of 19 bioclimatic and three physiographic variables with a resolution of 4.9 km under current conditions were prepared. Then, the sampling information in relation to the presence and absence of species and environmental variables was recorded and the relationship between species distribution and environmental factors was determined using logistic regression. Finally, the map of potential distribution of Tehran province was produced. The results of logistic regression model showed that in the current situation, 427057 ha (31% of the province) had a probability of more than 75% presence of this species. The kappa coefficient for evaluating the regression model was 0.86 that is one of the models with good accuracy according to Koch and Smith classification. In order to study the effect of climate change on the geographical distribution of the species, climate bio maps were prepared based on the MRI-ESM2-0 circulation model under two scenarios of 4.5 and 8.5 for 2050. The species under study is currently in the range of 1600 to 2800 m. The results showed that by changing the conditions from a balanced to a pessimistic situation, the area with the presence of more than 75% of the species decreases and the area with the presence of 25-50% increases. Also, results showed that the minimum and maximum altitudes in scenario 4.5 will be changed to 1500 and 2500 m, respectively. While according to scenario 8.5, the presence of this species will be only at above 2500 m. In fact, according to the 8.5 scenario, the species will be migrated to higher altitudes. The results identify climate sensitive areas and possible future shelters of *A. aucheri* to be used in conservation and rangeland planning.

Keywords: Climate change, Logistic regression, Climate scenario, Species distribution model, *Artemisia aucheri* Boiss.

1. Introduction

Nowadays, there is always discussion of climate change, and it is said that the amount of some climate parameters is increasing and some of them are decreasing. For example, increasing temperature over time or decreasing precipitation may be the issues that are constantly raised (Saboohi et al., 2012). Climate is the most important factor of plant distribution at a global and regional scale (Askarizadeh and Arzani, 2018). The researches of scientists have also shown that the earth's climate has not been stable, but the causes of these changes in the past and present are different (Chung and Yoon, 2000; Herath and Ratnayake, 2004; Yu et al., 2006).

Climate change is one of the most important ecological problems of the 21st century. According to the fifth report

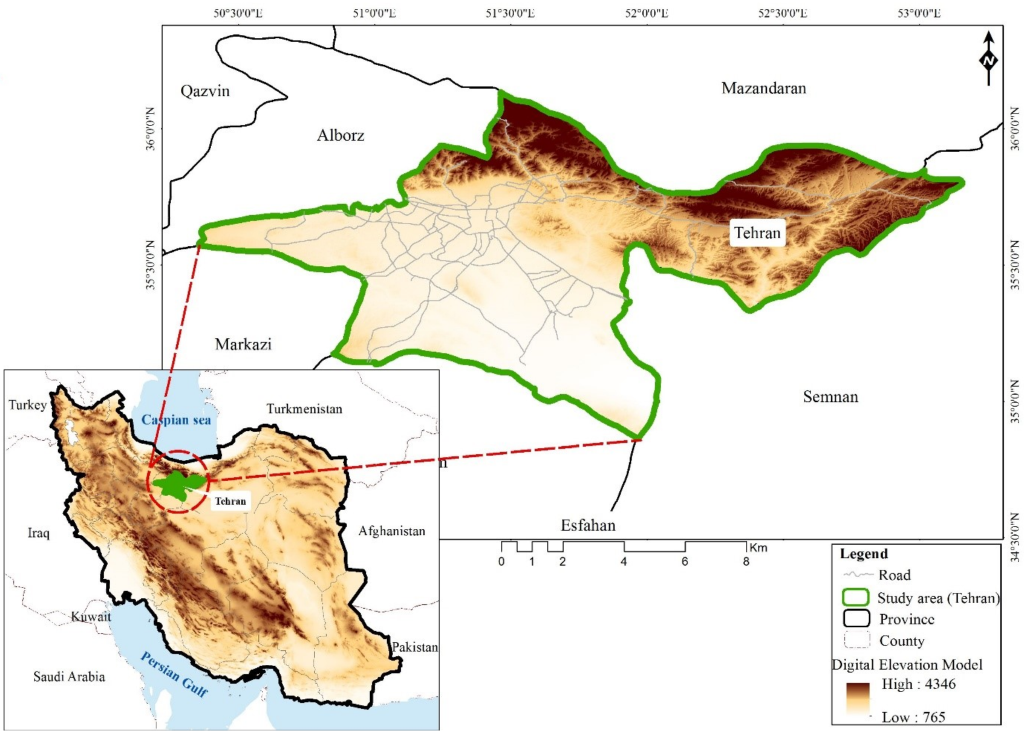

Figure 1. Geographical location of Tehran province.

of the Intergovernmental Panel on Climate Change (Pourmohammadi et al., 2017; Savari et al., 2020; Ghorbani et al., 2021; Ahmadaali et al., 2021), these global changes are most likely caused by human factors. Various studies show that this phenomenon can have negative effects on different systems of water resources, agriculture, environment, industry and economy (Darvand et al., 2021). Climate and land-use change are expected to substantially change future species distributions (Zhang et al., 2017).

Species respond to changes in climate in different ways. Some species may expand their distribution ranges and some of them may decrease or even extinct (Pimm et al., 2014). Climate change also affects floods, droughts, natural ecosystems, society and the economy (Oxoz and Bayazit, 2003). Rangeland ecosystems are very important due to the diversity of products and services including livestock, wildlife sanctuary, the diversity of animals and plant species, regulation of water flow and their quality. These ecosystems are sensitive to changes in environmental factors since the plants and animals of these ecosystems are on the verge of thermal and water stresses, small changes in temperature and precipitation regime, or changes in recurrence of climatic events can reduce the distribution of plant species as well as their production (Heshmati and Karimian, 2014). In general, climate change is a major concern for the management and conservation of biodiversity as it affects different aspects of the plant species (Safaei et al., 2022).

To understand the effect of climate change in the future, it is essential to identify the current and future distributions of plant species (Beaumont et al., 2005). Plant species distribution modeling is currently the only tool that can be used to assess the extent of changes in multiple species distribution in response to climate change (Williams et al., 2009). Many methods and models have been developed for this purpose. Modeling the prediction of plant species distribution, as predicting the potential distribution of a plant species across the landscape, is defined based on the relationship between plant species occurrence points and effective environmental variables. Habitat prediction models determine habitat suitability for plant and animal species and help natural resource managers to identify the threatening factors of populations, to determine the important factors in conservation planning, to study the climate change scenarios on the geographical distribution of species, the desirable habitats of plant and animal species with less time and cost (Jafarian et al., 2012). Interpreting and explaining changes in the geographical distribution of plant and animal species based on climate change are time consuming and difficult (Pejhan, 2013).

The results of investigation of climatic factors in relation to the distribution of *Artemisia sieberi* Besser and *Artemisia aucheri* Boiss in Iran showed that important factors including temperature, precipitation, wind, dust and cloudy days explained 82% of data variation. The autumn-winter precipitation and temperature had the greatest impact on the presence of *Artemisia sieberi* Besser and *A. aucheri*, respectively (Khodagholi et al., 2021). To predict the potential changes in the distribution of *A. aucheri* in Iran rangelands, six bioclimatic variables and two physiographic variables were used. The mean temperature of the coldest season and the mean annual precipitation played the most important role or exhibited relative importance in model fitting. The maximum presence of *A. aucheri* occurred at the 2000-3000 m elevation and the 100-250 mm annual precipitation. The highest amount of habitat displacement is likely to happen under the RCP8.5 scenarios in 2070 (Amiri et al.,

Table 1. Environmental variables used in the modeling process.

name of BIO	definition	unit
BIO1	average annual temperature	°C
BIO2	minimum and maximum monthly temperature	°C
BIO3	100% temperature (BIO_2 / BIO_7)	°C
BIO4	seasonal temperature (standard deviation × 100)	°C
BIO5	maximum temperature of the hottest month	°C
BIO6	minimum temperature of the coldest month	°C
BIO7	annual temperature range (BIO_5-BIO_6)	°C
BIO8	the average temperature of the wet season	°C
BIO9	the average temperature of the driest season	°C
BIO10	the average temperature of the hottest season	°C
BIO11	the average temperature of the coldest season	°C
BIO12	monthly precipitation	mm
BIO13	the wettest month is the wettest month	mm
BIO14	the driest month precipitation	mm
BIO15	seasonal precipitation (coefficient of variation)	mm
BIO16	the wettest season is the wettest	mm
BIO17	the driest season	mm
BIO18	precipitation is the warmest season	mm
BIO19	the coldest season	mm
slope		%
aspect		degree
height		meter

2019a). Pessimistic and optimistic scenarios of climate models for the years of 2050 and 2070 were evaluated to assess the trend in spatial-temporal variations of distribution *Artemisia sieberi* Besser in Central Iran. Analysis of the climate change scenarios showed that the species habitat would be decreased in 2070 more than 2050, leading to the expansion of desert areas (Amiri et al., 2019b). Modeling the distribution of *Artemisia aucheri* Boiss habitats in Iran showed that slope, pH, sodium absorption ratio, silt and annual mean temperature were the most important environmental factors influencing the distribution of the species (Borna et al., 2020). Haidarian Aghakhani et al. (2017) predicted the effects of climate change on the potential distribution of some species in the Central Zagros of Iran. Their results showed that the habitat size of the species will decrease. Naghipour Borj et al. (2019) investigated the application of the consensus modeling method in predicting the effects of climate change on the distribution of inverted tulip species in Chaharmahal and Bakhtiari province in Iran. The results of their research showed that seasonal changes in temperature and total annual precipitation had the largest share in determining the habitat of inverted tulip species. Also, the total habitat area of this species in the future under the scenarios of RCP4.5 and RCP8.5 will be about 19.7% and 61% smaller than 2022. Nicholas and Richard (2011) studied the vulnerability of 15 tree species to climate change in the northwestern United States. The results showed that 70% of the species remain at the current distribution site. Flower et al. (2012) studied the effects of climate change on the distribution of forest species in Italy and Colombia based on 9 climatic models and 3 release scenarios A_1B, B_1 and A_2 and concluded that the species will be distributed at high altitudes and latitudes.

A. aucheri, which grows in Iran-Turani area, is consumed by livestock at the beginning of autumn rains and has strong medicinal, antimicrobial and antioxidant values. Also, in semi-steppe rangelands of arid and semi-arid regions, in terms of environmental protection, prevention of soil erosion, providing fodder for livestock and wildlife is very valuable. This plant has remarkable vigor and renewable vigor, deep roots, wide propagation, fast seed growth, long period of growth, establishment and adaptation to semi-arid conditions and grazing resistance (Ghahraman, 2000). The genus Artemisia L. belongs to the Asteraceae family, having economical and medicinal significance. Species of this genus are commonly found in the temperate sectors of the northern hemisphere, with a limited number of species in the southern hemisphere of the world. It contains 500 species of both herbs and shrubs and is a diverse genus of the Anthemideae tribe (Hussain, 2020). Among about 500 species of Artemisia distributed in temperate, dry or semiarid zones, 34 species are endemic in Iran. *A. aucheri*, named locally as Dermaneh Koohi, is a well-known plant in Iranian traditional medicine for treatment of various diseases (KarimiPourSaryazdi et al., 2020). *A. aucheri* is limited mostly to mountainous landscapes with high slope and sandy soils. *A. aucheri* is well known for its medicinal uses and food value, and also used for ornamental purpose and as a soil stabilizer in disturbed habitats (Zamanian et al., 2021).

Due to the importance of Artemisia ecosystem, proper and planned management in these areas is essential to preserve biodiversity and reduce desertification. Therefore, the objectives of this research are to investigate the effect of

Table 2. Scenarios of the fifth climate change report (IPCC, 2013).

scenario	radiation induction	concentration of carbon dioxide
RCP[1]4.5	4.5 watts per m^2 will remain constant after 2100	650 ppm and remains constant after 2100
RCP8.5	more than 8.5 watts per m^2 in 2100	370 ppm by 2100

IPCC: Intergovernmental Panel on Climate Change.

climate change on the current geographical distribution of the *Artemisia aucheri* Boiss, also to find out the geographical distribution and to present the distribution map of the *A. aucheri* under current conditions and under the scenarios of climate change in the rangelands of Tehran province in Iran.

2. Materials and methods

2.1 Study area

Tehran province, the capital of Iran, is located in the center of Tehran with an area of about 12981 km^2 in central Iran (Fig.1). This province is limited to Mazandaran province from the north, Qom province from the south, Markazi province from the southwest, Alborz province from the west and Semnan province from the east.

Geographically, it is located at $51°17'$ to $51°33'$ eastern longitude and $35°36'$ to $35°44'$ northern latitude. Tehran extends from an altitude of 900 to 1800 m above sea level; the height decreases from north to south. Tehran province covers 2.1% area of the country. The climate of Tehran province is hot and dry in desert and southern areas, cold and semi-humid with long winters in the mountain areas. The warmest months of the year are reported in August and September with an average temperature of 35 to 45 °C and the coldest months of January and February with the temperature of -5 °C. The temperature in Tehran is reported a bit cold in winter and mild in summer (Climatology report of Tehran, Iran, 2000).

2.2 Preparation of distribution map of *Artemisia aucheri* Boiss

Preliminary maps of the presence of *A. aucheri* were obtained from the Forest and Rangeland Research Institute based on the information of the national plan for the identification of ecological areas in Iran. To validate and verify the species boundary, the original map was overlaid with satellite images, slope, aspect, and height maps and then, residential and agricultural areas were eliminated from the preliminary map. Then, the map of province was divided into 540 pixels with dimensions of 4.9 × 4.9 km^2, and in several points that were randomly located in the habitat range, the presence and absence of *A. aucheri* were recorded by GPS. Other areas where the species was not present and the areas with low presence were considered as absenteeism points. Finally, the boundaries were checked and modified with Arc GIS software and the current presence map of the species was drawn.

2.3 Environmental information

In order to prepare the environmental information layer, 19 bio-climates were currently provided for 8 synoptic stations in Tehran province (Table 1), and for preparing 19 bio-climates in 2050, they were downloaded from WorldClim.org with an accuracy of 30 seconds, which is one of the data production sites. These data were obtained for two scenarios RCP4.5 and RCP8.5 for the next period (Table 2).

2.4 Scenarios used

In its fifth AR5 evaluation report, the International Climate Change Board used the new RCP scenarios to represent the four key emissions trajectories of RCP2.6, RCP4.5, RCP 4 and RCP8.5. In this study, two RCP scenarios of RCP4.5 and RCP8.5 were used as follows:
Scenario RCP4.5: The concentration of carbon dioxide is estimated at 750 ppm by 2100, and the reflection from greenhouse gas emissions up to 2100 will remain constant at 4.5 watts per square meter. In this scenario, the population growth rate is estimated to be lower than the RCP2.6 scenarios (Hosseinabadi et al., 2021).
Scenario RCP4.5: The concentration of carbon dioxide is estimated to be 1960 ppm by 2100, which continues to lead to a radiation output of 8.5 watts per square meter in 2100. That is, the input radiation minus the output radiation from the atmosphere is 8.5 + watts per square meter (Hosseinabadi et al., 2021).

3. Predicting the geographical distribution of selected species

3.1 Logistic regression

The basis of the analysis used in this research is logistic regression, which is based on environmental values related to species presence and absence points. Logistic regression is a special form of generalized linear model (GLM) whose formula is as follows (1,2). This method can be implemented in various software from SPSS, the results of which are converted into maps using Arc GIS software.

$$p = \frac{1}{1+e^{-z}} \tag{1}$$

$$z = B_0 + B_1x_1 + B_2x_2 + \cdots + B_nx_n \tag{2}$$

where:
z is the dependent or response variable, B_n represents the coefficients of the regression model, and x_i represents the independent environmental variables.

Logistic regression allows the establishment of a multivariate regression relationship between a dependent variable and several independent variables, and one of the models of

Table 3. Calculated for meteorological stations in Tehran province, Iran.

station	Abali	Tehran	Chitgar	Doshantape	Geoeofizik	Shemiran	Firuzkualudegi	Firuzku
T min	4.2	12.2	11.9	13.00	12.8	10.7	1.7	1.8
T max	13.2	22.9	21.3	18.1	21.8	21.1	8.8	16.9
T mean	9.00	17.5	18.5	23.2	17.9	15.7	5.6	10.7
annual P	550.2	182.4	235.5	261.3	315	417.9	418.8	292.7
BIO_1	8.67	17.55	17.54	18.06	17.3	15.9	5.25	9.35
BIO_2	9.03	10.73	10.05	10.19	8.95	10.43	7.1	15.15
BIO_3	26.54	29.01	28.15	27.92	25.87	29.04	22.9	37.97
BIO_4	918.41	968.53	956.9	974.26	938.57	944.37	884.03	894.12
BIO_5	26.5	36.8	36	36.8	35.2	34.8	21.7	29.3
BIO_6	-7.5	-0.2	0.3	0.3	0.6	-1.1	-9.3	-10.6
BIO_7	34.0	37.0	35.7	36.5	34.6	35.9	31.0	39.9
BIO_8	1.97	7.03	11.4	7.4	7.22	5.72	-1.23	3.88
BIO_9	19.53	28.57	28.38	29.17	28.18	26.72	16.13	15.87
BIO_{10}	19.97	29.28	29.07	29.9	28.88	27.5	16.13	20.05
BIO_{11}	-2.43	5.42	5.63	5.85	5.87	4.18	-5.35	-2.13
BIO_{12}	550.3	229.6	242	264	315.7	417.9	418.9	292.9
BIO_{13}	96.2	38.2	37.3	43.4	51.7	69.7	55.4	36.2
BIO_{14}	7.5	1.1	1.2	1.4	2.1	4.0	15.1	11.5
BIO_{15}	65.09	73.14	70.8	73.08	74.94	73.93	43.04	37.78
BIO_{16}	237.5	103.9	101.5	121.2	148.4	189.8	163	106.1
BIO_{17}	29.7	5.2	7.9	6.6	8.1	13.3	53.6	39.9
BIO_{18}	33.2	6.9	8.5	8.8	9.8	13.6	53.6	43.3
BIO_{19}	203.9	98.8	99.2	117.7	142	181	142.8	95.8

multivariate analysis is to predict the presence or absence of a phenomenon such as a plant species based on a series of predictor variables. By extracting the predicted values from the map of environmental variables, a correlation matrix was formed and the variables that had a correlation of more than 80% were removed. Environmental variables were included in the logistic regression model, as predictive (independent) variables and species presence and absence as response (dependent) variables. The Enter method was used to fit the model and the variables with $P \geqslant 0.05$ were removed from the calculation process. Finally, potential map of the species was prepared (Pejhan, 2013).

3.2 Model evaluation

The Kappa statistical coefficient was used to evaluate the potential habitat map. On the Basis of this coefficient, at zero values, the probability of random or non-random values of real values, and predictions are equal, and a negative value indicates the unreality of the model (Basiri et al., 2012).

3.3 Prediction of *Artemisia aucheri* Boiss

In this study, to model the actual habitat of *A. aucheri*, the climatic data of the stations related to the beginning until 2018 by the logistic regression model were used, and after fitting the model, the current distribution map of the species was produced.

3.4 Prediction of *Artemisia aucheri* Boiss distribution in 2050

After fitting the model and mapping the potential distribution of the selected species for the present, the variables affecting *A. aucheri* were mapped using the MRI-ESM2-0 model for 2050 under the 4.5 and 8.5 scenarios which were predicted and replaced instead of the map of current variables in the fitted model, and by redefining the model in Arc GIS software, the potential species distribution map for 2050 was predicted.

4. Results

4.1 Bio values

The results of calculating the biomes of meteorological stations in Tehran province are presented in Table 3. Based on the information in Table 3, the lowest minimum, maximum and average annual temperature is related to Firuzkualudegi station. Also, the lowest amount of precipitation was reported in Tehran station and the highest amount of precipitation was reported in Abali station.

4.2 Model

At this stage, among the important and significant variables, the best regression model was fitted to determine the probability of occurrence, and with its help, the habitat map was classified into 4 classes. The model is presented below:

$$[\mathrm{EXP}((-3.606)+(0.001^{*}\mathrm{DEM})+(0.017^{*}\mathrm{slop}) +(0.001^{*}\mathrm{aspect})+(0.227^{*}\mathrm{BIO}_1)+(0.185^{*}\mathrm{BIO}_2) +(-0.35^{*}\mathrm{BIO}_5)+(-0.036^{*}\mathrm{BIO}_6)+(0.168^{*}\mathrm{BIO}_7) +(0.682^{*}\mathrm{BIO}_9)+(-0.475^{*}\mathrm{BIO}_{10})+(-0.01^{*}\mathrm{BIO}_{12}) +(-0.054^{*}\mathrm{BIO}_{15})+(0.02^{*}\mathrm{BIO}_{16})+(0.007^{*}\mathrm{BIO}_{18}))]/1 +[\mathrm{EXP}((-3.606)+(0.001^{*}\mathrm{DEM})+(0.017^{*}slop) +(0.001^{*}\mathrm{aspect})+(0.227^{*}\mathrm{BIO}_1)+(0.185^{*}\mathrm{BIO}_2) +(-0.35^{*}\mathrm{BIO}_5)+(-0.036^{*}\mathrm{BIO}_6)+(0.168^{*}\mathrm{BIO}_7) +(0.68^{*}\mathrm{BIO}_9)+(-0.47^{*}\mathrm{BIO}_{10})+(-0.01^{*}\mathrm{BIO}_{12}) +(-0.054^{*}\mathrm{BIO}_{15})+(0.02^{*}\mathrm{BIO}_{16})+(0.007^{*}\mathrm{BIO}_{18}))]$$

4.3 Model validation

The model was evaluated using species presence and absence data and kappa statistical coefficient. The value of this index for *A. aucheri* is 0.86 that according to the classification of kappa coefficients by Landis and Koch (1977), the model has a good and acceptable accuracy. Based on the AUC validity criterion, its value (0.90) was determined, which indicates the acceptable accuracy of the model, too.

4.4 Current distribution map

Based on current distribution map which is shown in Fig. 2, there is currently 75-100% probability of the presence of this species as spots in the western and northern parts. 25-50% probability of the presence of this species as spots is also seen in the central, eastern and southeastern parts. The map produced in four classes showed that the highest percentage of area is related to the probability of the presence of 25-50% of species, which is equivalent to 48% of the area of Tehran province and is about 668177 ha (Table 4).

Table 4. Percentage of habitat classes of *Artemisia aucheri* Boiss in the current conditions.

habitat classes (%)	area (ha)	area %
75-100	427057	31.3
50-75	268638	19.6
25-50	668177	48.9
0-25	-	-

Table 5. Percentage of *Artemisia aucheri* Boiss habitat classrooms in scenario 4.5.

habitat classes (%)	area (ha)	area %
75-100	545028	39.9
50-75	458113	33.5
25-50	360732	26.4
0-25	-	-

4.5 Prediction of *Artemisia aucheri* Boiss in 2050

The maps obtained from the prediction of the logistic regression model show that under scenario 4.5, the highest percentage of species presence is allocated with a probability of more than 75% presence of species in high altitude areas such as Damavand, which covers about 39% of the province, 545028 ha (Fig. 3). According to Table 5, the probability of 50-75% presence of the species in the area is about 33% of the province.

Table 6. Percentage of *Artemisia aucheri* Boiss habitat classrooms in scenario 8.5.

habitat classes (%)	area (ha)	area %
75-100	341612	25.0
50-75	401760	29.4
25-50	620501	45.4
0-25	-	-

The results of habitat prediction for scenario 8.5 also showed that the highest probability of the presence of the species is 25-50%, which is equivalent to 620501 ha, about 45% of the area of Tehran province. The lowest percentage of species probability is related to the probability of the presence of more than 75% (Fig. 4 and Table 6). Currently, the minimum and maximum altitude of the areas where *A. aucheri* is present are 1600 and 2800 meters, respectively. The results showed that by changing the conditions from a balanced state to a pessimistic state, the size of the areas with more than 75% species presence is reduced and the size of the areas with 25-50% presence is increased. Also, the modeling results showed that the minimum and maximum altitude in scenario 4.5 will change to 1500 and 2500 meters, respectively, but according to scenario 8.5, the presence of this species is only at altitude above 2500 meters. In fact, according to scenario 8/5, species migration will occur towards high altitudes.

5. Discussion

Species distribution models assume a certain equilibrium with climate (Haidarian et al., 2021). Although not all the causes of climate change in the world are fully understand, the discussion about climate change is now interesting to many researchers (Shirgholami and Ghahraman, 2005). Predictive models of geographical distribution of plant species can determine the relationships between the geographical distribution of a particular species and their current environment. They enable any environmental factor and prepare a spatial distribution map of the desired species for the present and in future periods. So, they play an important role in determining areas prone to rangeland restoration (Pejhan, 2013). Plant species respond to climate change through adaptation, movement in different aspects to achieve a suitable climate (Palmer et al., 2015) and in the worst case, extinction (Parmesan and Hanley, 2015).

Based on the results of the present research, it was determined that at present, the minimum and maximum altitudes in the areas where *Artemisia aucheri* Boiss is present are 1600 and 2800 m, respectively. The results showed that in the case of *A. aucheri*, whatever changes from balanced to pessimistic conditions, the area with a probability of more than 75% is reduced and the area with a presence of 25-50%

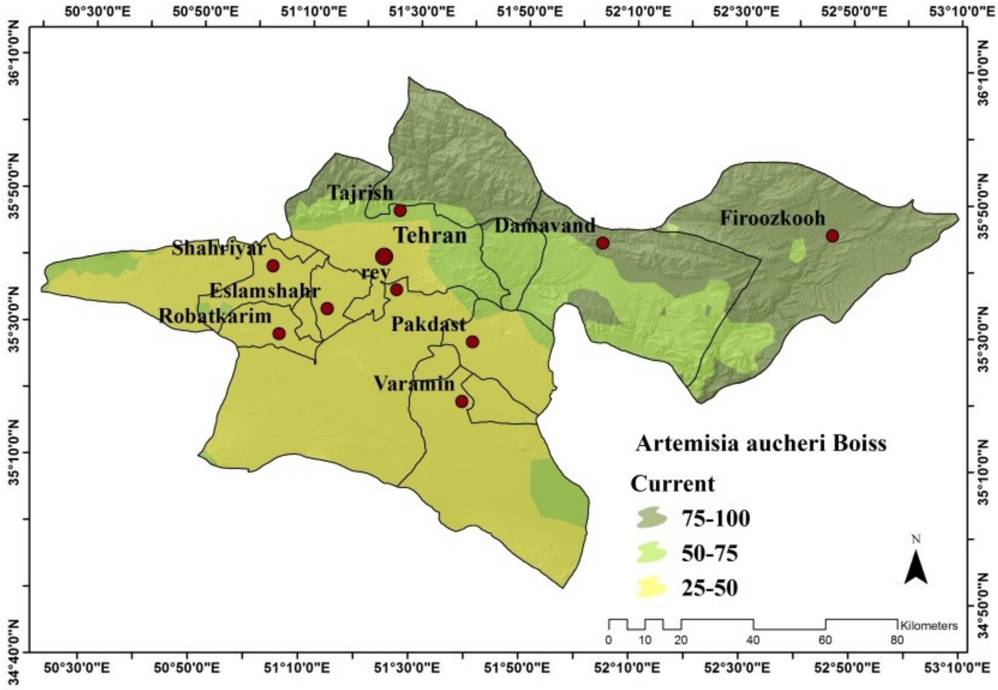

Figure 2. Current distribution map of *Artemisia aucheri* Boiss in Tehran province.

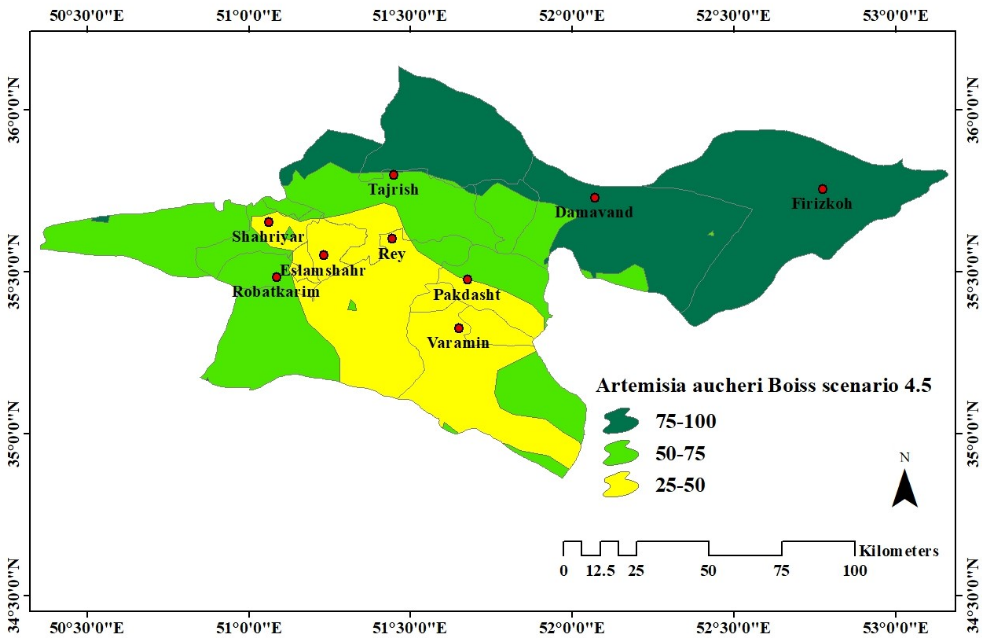

Figure 3. Map of potential distribution of *Artemisia aucheri* Boiss in Tehran province using scenario 4.5.

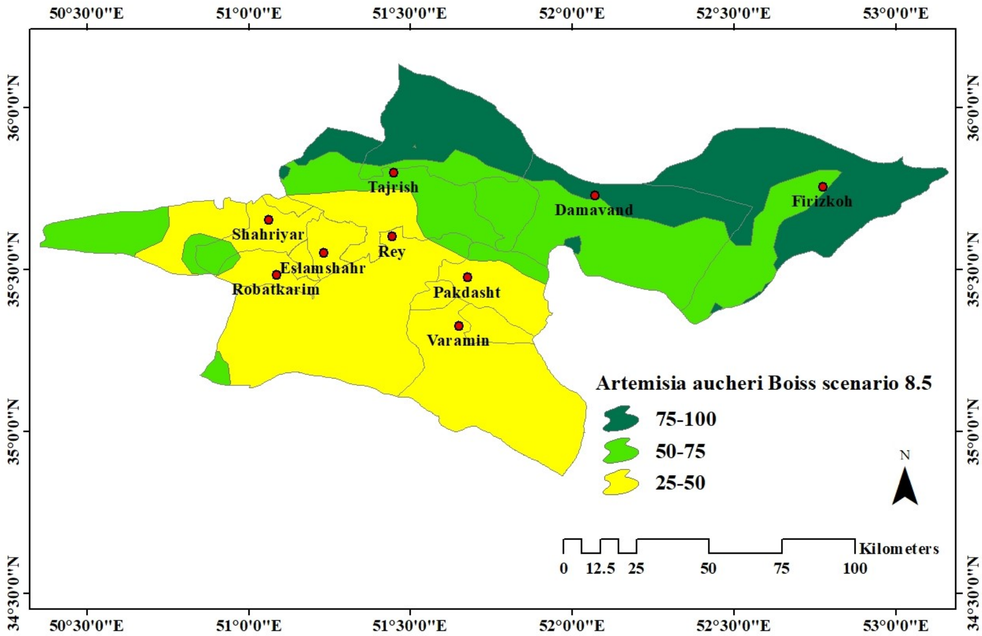

Figure 4. Map of potential distribution of *Artemisia aucheri* Boiss in Tehran province using scenario 8.5.

is increased. The results of the present study are consistent with the result of Amiri et al. (2019b) that illustrating *Artemisia aucheri* habitat would be decreased in 2070 more than 2050 in Iran, leading to the expansion of desert areas Amiri et al. (2019b). Also, the modeling results showed that the minimum and maximum altitude of *Artemisia aucheri* Boiss in the 4.5 scenario will change to 1500 and 2500 m, respectively, but according to scenario 8.5, the presence of this species is above 2500 m. According to scenario 8.5, in fact, species migration will occur to high altitudes. These results of the present study are consistent with the result of Amiri et al. (2019a) predicting that the habitat of *Artemisia aucheri* habitat will be displaced more in 2070 than in 2050, in Iran. Two important environmental variables that were used in the modeling in this research are: Slope and temperature affecting the distribution of this species because the slope affects the soil depth and thus affects the root establishment. These results of the present study are consistent with the result of Khodagholi et al. (2021) explaining that six factors including temperature, annual precipitation, wind, autumn and winter precipitation, and dusty and cloudiness days affect the distribution of *A. aucheri*. Also, Janisva (2005) showed that slope is one of the factors affecting the distribution of mountain artichoke and plain artichoke types. Also Forouzeh et al. (2017) introduced topographic features (height, slope and aspect) as the main factors on vegetation distribution pattern in mountainous areas. Borna et al. (2020) based on modelling the distribution of *A. aucheri* habitats in watershed of Baladeh Nour city, Mazandaran province, in Iran showed that slope, pH, sodium absorption ratio, silt and annual mean temperature were the most important environmental factors influencing the distribution of the species. Migration to high altitudes and regional expansion are two of the obvious effects of climate change on plants (Phillips and Dudík, 2008). The complex and diverse topography of mountainous areas creates diverse habitats for different plant species (Sun et al., 2020) and also causes the species to move to higher altitudes.

Also, in this species, excessive increase in temperature disrupts food production and reduces plant photosynthesis. On the other hand, while increasing evaporation from the soil and plant surface, it reduces the amount of water available to the plant and may reduce this species. Confirming the results, Moghaddam (2009) and also Safaei et al. (2013) during studies stated that food transfer in ecosystem is associated with moisture flow. In fact, the main condition of the material cycle between plants and soil is the presence of sufficient moisture and temperature is effective when the moisture is sufficient for plant growth. In other studies, similar patterns have been reported for the altitude distribution of the species (Teimoori Asl et al., 2020; Naghipour Borj et al., 2021). Of course, it should be noted that the altitude changes of mountain species in response to climate change may be different (Zu et al., 2021).

6. Conclusion

Currently, the minimum and maximum altitude of the areas where *Artemisia aucheri* Boiss is present are 1600 and 2800 meters, respectively. The results showed that by changing the conditions from a balanced state to a pessimistic state, the size of the areas with more than 75% species presence is reduced and the size of the areas with 25-50% presence is increased. Also, the modeling results showed that the minimum and maximum altitude in scenario 4.5 will change to 1500 and 2500 meters, respectively, but according to scenario 8.5, the presence of this species is only at altitude above 2500 meters. In fact, according to scenario 8/5, species migration will occur towards high altitudes. It is suggested that natural resource managers use species distribution models as useful and cost-effective tools to increase their awareness of the effects of climate change on species and manage these changes.

The results of the models identify climate change sensitive areas and possible future shelters of *A. aucheri* for use in conservation plans in these areas. This strategy is used to protect these areas from threats and to improve the resistance of *A. aucheri* to climate change to ensure its future presence.

Ethical Approval
This manuscript does not report on or involve the use of any animal or human data or tissue. So the ethical approval does not applicable.

Funding
No funding was received to assist with conducting this study and the preparation of this manuscript.

Authors Contributions
All authors have contributed equally to prepare the paper.

Availability of Data and Materials
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Ahmadaali K., Damaneh H.E., Ababaei B., Damaneh H.E. (2021) Impacts of droughts on rainfall use efficiency in different climatic zones and land uses in Iran. *Arabian Journal of Geosciences* **14** (2): 1–15.

Amiri M., Tarkesh M., Jafari R. (2019a) Predicting the climatic Ecological Niche of *Artemisia aucheri* Boiss in Central Iran using species distribution modeling. *Journal of Applied Ecology* **8** (2): 61–79. (In Persian).

——— (2019b) Predicting the distribution of *Artemisia Sieberi* Besser under climate change in the steppe and semi-steppe of Iran-Touranian region. *Desert Management* **7** (13): 29–48. (In Persian).

Askarizadeh D., Arzani H. (2018) Ecological effects of climate factors on rangeland vegetation (Case study: Polour rangelands). *Journal of Rangeland Science* **8** (4): 330–340 (In Persian).

Basiri M., Shred Alborzi M., Safaee M. (2012) Master thesis: Modeling the potential habitat of Astragalus verus Olivier using two methods of ecological nest factor analysis (ENFA) and logistic regression (LR). *Faculty of Natural Resources, Alborz University of Technology, Alborz, Iran,* 130. (In Persian).

Beaumont L.J., Hughes L., Poulsen M. (2005) Predicting species distributions: use of climatic parameters in Bioclim and its impact on predictions of species' current and future distributions. *Ecological Modelling* **186**:250–269.

Borna F., Tamartash R., Tatian M., Gholami V. (2020) Determination of the contribution environmental factors affecting the predicting distribution habitat Artemisia aucheri Boiss in the watershed of Balade, Nour. *Journal of Watershed Management Research* **11** (21): 119–128. (In Persian).

Chung Y.S., Yoon M.B. (2000) Interpretation of recent temperature and precipitationtrends observed in Korea. *Theoretical and Applied Climatology* **67**:171–180.

Climatology report of Tehran, Iran (2000) Report: Comprehensive studies of agricultural development, provincial synthesis studies, Tehran province. *Center for Economic Research and Planning of the Ministry of Jihad Agriculture,* (In Persian).

Darvand S., Eskandari Damaneh H., Eskandari Damaneh H., Khosravi H. (2021) Prediction of the change trend of temperature and rainfall in the future period and its impact on desertification. *Water and Soil Management and Modelling* **1** (1): 53–66.

Forouzeh M.R., Heshmati G.H., Barani H. (2017) Feasibility study of preparing prediction map of the possibility of presence of some important range species in Zagros Rangeland. *Journal of Plant Ecosystem Conservation* **5** (10): 53–74.

Ghahraman A. (2000) Color atlas of Iranian flora. *Research Institute of Forests and Rangelands Publishing, Tehran,* 126. (In Persian).

Ghorbani M., Eskandari-Damaneh H., Cotton M., Ghoochani O.M., Borji M. (2021) Harnessing indigenous knowledge for climate change-resilient water management-lessons from an ethnographic case study in Iran. *Climate and Development* **13** (9): 1–14.

Haidarian M., Tamartash R., Jafarian-Jeloudar Z., Tarkesh M., Tataian M.R. (2021) The effects of climate change on the future distribution of Astragalus adscendens in central zagros, Iran. *Journal of Rangeland Science* **11** (2): 152–170. (In Persian).

Haidarian Aghakhani M., Tamartash R., Jafarian Z., Tarkesh Esfahani M., Tatian M.R. (2017) Forecasts of climate change effects on *Amygdalus scoparia* potential distribution by using ensemble modeling in Central Zagros. *Journal of RS & GIS for Natural Resources* **8** (3): 1–14. (In Persian).

Herath S., Ratnayake U. (2004) Monitoring rainfall trends to predict adverse impacts—a case study from Sri Lanka (1964-1993). *Global Environmental Change* **14**:71–79.

Heshmati A., Karimian A. (2014) Predicting the richness distribution of rangeland species using environmental variables using species distribution models. *Journal of Agricultural Engineering and Natural Resources* **46**:1–38.

Hosseinabadi S., Yaghoubzadeh M., Amirabadizadeh M., Forouzanmehr M. (2021) Assessment of meteorological drought in future periods using the data of the fifth climate change report (Case Study: Zabol and Shiraz). *Journal of Geographical Studies of Arid Areas* **10** (40): 35–48.

Hussain A. (2020) The genus Artemisia (Asteraceae): A review on its ethnomedicinal prominence and taxonomy with emphasis on foliar anatomy, morphology, and molecular phylogeny. *Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences* **57** (1): 1–28.

IPCC (2013) Book: Climate change 2013: The physical science basis. *Cambridge: Cambridge University Press*

Jafarian Z., Arzani H., Jafari M., Zahedi G., Azarnivand H. (2012) Mapping spatial prediction of plant species using logistic regression (Case study: in Rineh Rangeland; Damavand Mountain) *Journal of Physical Geography Research Seasonly* **44** (1): 1–18.

Janisva M. (2005) Vegetation-environment relationship in dry calcareous grassland. *Journal of Ecologia-Bratislava* **24** (1): 25–44.

KarimiPourSaryazdi A., Ghaffarifar F., Dalimi A., Dayer M.S. (2020) *In-vitro* and *in-vivo* comparative effects of the spring and autumn-harvested *Artemisia aucheri* Bioss extracts on Leishmania major. *Journal of Ethnopharmacology* **257**:112910.

Khodagholi M., Saboohi R., Esfahani E.Z. (2021) A comparison of vegetative climate of *Artemisia sieberi* Besser and *Artemisia aucheri* Boiss in Iran. *Theoretical and Applied Climatology* **146** (3): 921–939.

Landis J.R., Koch G.G. (1977) The measurement of observer agreement for categorical data. *Biometrics* textbf33:159.

Moghaddam M.R. (2009) Book: Rangeland and Range Management. *University of Tehran, Iran Press,* 470. (In Persian).

Naghipour Borj A., Ostovar Z., Asadi Boroujeni E. (2019) Effect of climate change on distribution of an endangered medicinal plant (*Fritillaria Imperialis* L.) in Central Zagros, Iran. *Journal of Rangeland Science* **9** (2): 159–171. (In Persian).

Naghipour Borj A.A., Ashrafzadeh M., Haidarian M. (2021) Modeling the current and future potential distribution of *Fritillaria Imperialis* under climate change scenarios and using three general circulation models in Iran. *Journal of Plant Ecosystem Conservation* **8** (17): 219–235. (In Persian).

Nicholas C., Richard H. (2011) Estimating the vulnerability of fifteen tree species under changing climate in Northwest North America. *Journal of Ecological Modelling* **222**:2119–2129.

Oxoz B., Bayazit M. (2003) The power of statistical tests for trend detection. *Turkish Journal of Environmental Engineering and Sciences* **27**:247–251.

Palmer G., Hill J.K., Brereton T.M., Brooks D.R., Chapman J.W., Fox R., Oliver T.H., Thomas C.D. (2015) Individualistic sensitivities and exposure to climate change explain variation in species' distribution and abundance changes. *Science Advances* **1** (9): 745–758.

Parmesan C., Hanley M.E. (2015) Plants and climate change: complexities and surprises. *Annals of Botany* **116** (6): 849–864.

Pejhan A. (2013) MSc thesis: Effects of climate change on spatial distribution of Artemisia Dashti species in Alborz Province using species distribution prediction models (Case study: Alborz Province). *Alborz University of Technology, Alborz, Iran,* 119. (In Persian).

Phillips S.J., Dudík M. (2008) Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. *Journal of Ecography* **31**:161–175.

Pimm S.L., Jenkins C.N., Abell R., Brooks T.M., Gittleman J.L., Joppa L.N., Raven P.H., Roberts C.M., Sexton J.O. (2014) The biodiversity of species and their rates of extinction, distribution, and protection. *Journal of Science* **344**:1246752.

Pourmohammadi S., M.T. Dastorani., Jafari H., Rahimian M.H. (2017) Effects of climate change on river runoff and compatible solutions (CaseStudy: Tuyserkan Basin, Hamedan). (In Persian).

Saboohi R., Soltani S., Khodagholi M. (2012) Trend analysis of temperature parameters in Iran. Vol. **109**, 529–547.

Safaei M., Rezaian H., Ziaian Firozabadi P., Tarahi A.A. (2022) Potential modeling of climate change on the spatial distribution of oak (Case study: Ilam and Lorestan provinces). *Journal of Applied Research of Geographical Sciences* **65**:254–271. (In Persian).

Safaei M., Shreds M., Basiri M. (2013) Preparation of response curves of yellow species (*Astragalus verus* Olivier) to the slope of environmental changes using the None Parametric Multiplicative Regression method in Fereydunshahr region of Tehran province. *Journal of Plants and Ecosystems* **36**:53–64. (In Persian).

Savari M., Eskandari Damaneh H., Damaneh H.E. (2020) Factors influencing farmers' management behaviors toward coping with drought: evidence from Iran. *Journal of Environmental Planning and Management,* 1–49.

Shirgholami H., Ghahraman B. (2005) Investigation of the trend of annual average temperature changes in Iran. *Journal of Agricultural Science and Technology and Natural Resources* **1**:9–24. (In Persian).

Sun S., Zhang Y., Huang D., Wang H., Cao Q., Fan P., Yang N., Zheng P., Wang R. (2020) The effect of climate change on the richness distribution pattern of oaks (Quercus L.) in China. *Science of the Total Environment* **744**:140786.

Teimoori Asl S., Naghipoor A., Ashrafzadeh M., Heydarian M. (2020) Predicting the impact of climate change on potential habitats of *Stipa hohenackeriana* Trin & Rupr in Central Zagros *Journal of Rangeland* **14** (3): 526–538. (In Persian).

Williams J.N., Seo C., Thorne J., Nelson J.K., Erwin S., O'Brien J.M., Schwartz M.W. (2009) Using species distribution models to predict new occurrences for rare plants. *Diversity and Distributions* **15**:565–576.

Yu P.S., Yang T.C., Kuo C.C. (2006) Evaluating long-term trends in annual and seasonal precipitation in Taiwan. *Water Resources Management* **20**:1007–1023.

Zamanian M., Sharifi Z., Noormohammadi Z., Akbarzadeh T., Bineshian F. (2021) Antiviral effect of Artemisia aucheri aqueous extract on UL46 and US6 genes of HSV-1. *Antiviral Therapy* **26** (1-2): 43–48.

Zhang J., Nielsen S.E., Chen Y., Georges D., Qin Y., Wang S.S., Svenning J.C., Thuiller W. (2017) Extinction risk of North American seed plants elevated by climate and land-use change. *Journal of Applied Ecology* **54** (1): 303–312.

Zu K., Wang Z., Zhu X., Lenoir J., Shrestha N., Lyu T., Luo A., et al. (2021) Upward shift and elevational range contractions of subtropical mountain plants in response to climate change *Science of the Total Environment* **783**:146896.