RS & GIS for Natural Resources
(Vol. 11/ Issue 2) Summer 2020
Indexed by ISC, SID, Magiran, Noormags, Civilica, Google Scholar
journal homepage : www.girs.iaubushehr.ac.ir

Predicting the effects of the climate change on the geographical distribution of *Astragalus verus* Olivier in the Central Zagros region

Sima Teimoori Asl, Ali Asghar Naghipour, Mohammad Reza Ashrafzadeh, Maryam Haidarian Aga Khani

Received: 13 March 2020/ Accepted: 6 May 2020
Available online 5 July 2020

Abstract

Background and Objective Climate, soil characteristics, topography, land use, and biological relationships at various scales are the most important influencing factors on distribution and ecological niches of species. The climate is one of the most important determinants of plant distribution. Therefore throughout the past ecological history, climate change has had profound consequences on the current conditions of the world's ecosystems, including the existing distribution of species. Changes in the distribution of one species in a given geographical area due to the climate change can lead to shifting the presence regions of that species toward higher elevation that leads up to vegetative restriction or even extinction of the species. Shifting, or changing the geographical distribution of species is a strategy to be resistant to the climate change. Therefore, in order to protect the key ecological and valuable plant species, it is necessary to determine suitable habitats via identifying the most important environmental and human factors affecting the species presence in the current and future conditions. *Astragalus* L. (Fabaceae) is a genus widely distributed throughout the temperate regions. The *Astragalus verus* Olivier is a small, valuable shrub with many branches. In addition to its protective role from the point of view of the soil, this species has medicinal and industrial values. In recent decades, the geographical range of the *A. verus* variety has been significantly declined due to factors such as land degradation and over utilization. Despite the national importance of the *Astragalus* genus, so far little research has been done on the consequences of the climate change on the distribution of species of this genus. The present study was conducted to accomplish the following objectives; 1) To identify suitable habitats and determin the geographical distribution of *A. verus* in Central Zagros in the current situation; 2) to predict of the consequences of climate change by 2050 and 2070 under different scenarios on geographical distribution of A. verus; 3) to determin the most important factors affecting the distribution of this species. distribution of A. verus; 3) to determin the most important factors affecting the distribution of this species.

Materials and Methods This study was carried out in Chaharmahal and Bakhtiari province in an area about 1.65 million hectare thai is totally located in Central Zagros region. Extensive field studies were integrated to collect geographical coordinates of the presence point (112 points) of this species by using Global Positioning System (GPS) throughout Chaharmahal and Bakhtiari province. Bioclimatic (bio1–bio19), Physiographic variables (elevation, aspect, and slope) and land cover/land variables were used for modeling. Before modeling, two methods of Pearson correlation analysis and Variance Inflation Factor (VIF) were used to check out the correlation between the various environmental variables. In order to model, 19 environmental variables including bioclimatic variables, physiography and land cover / land use were

S. Teimoori Asl [1], A.A. Naghipour(✉) [2], M.R. Ashrafzadeh [3], M. Haidarian [4]

1. MSc. Student of Range Management, Faculty of Natural Resources and Earth Science, Shahrekord University, Shahrekord, Iran
2. Assistant Professor, Department of Natural Engineering, Faculty of Natural Resources and Earth Sciences, Shahrekord University, Shahrekord, Iran
3. Assistant Professor, Department of Fisheries and Environmental, Faculty of Natural Resources and Earth Sciences, Shahrekord University, Shahrekord, Iran
4. PhD. of Rangeland Sciences, Faculty of Natural Resources, Sari Agricultural Sciences and Natural Resources University, Sari, Iran
e-mail: aa.naghipour@nres.sku.ac.ir

applied to model the distribution based on correlation analysis. Variables with Pearson's correlation coefficient, $r^2<\pm0.8$, VIF<3) were selected. Finally and after the omission of the layers having high correlation, nine variables were used for modeling. In order to predict the distribution of the suitable habitats of the *Astragalus verus* Olivier, Biomad2 software package in R environment (3.1.2 version) was used. In this study, ensemble methods including Maximum Entropy (MaxEnt), Artificial Neural Network (ANN), Generalized Boosting Method (GBM), the Generalized Linear Model (GLM), Flexible Discriminant Analysis (FDA), Random Forest (RF) and Multivariate Adaptive Regression Splines (MARS) were used to estimate the suitable habitats. We used 80% of the occurrence points as training data for model calibration and 20% of the rest of the data set to evaluate the predition of the models. Prediction of the geographical distribution of the *Astragalus verus* Olivier in the future (years 2050 and 2070) was made based on four scenarios of the increase in the greenhouse gases (Representative Concentration Pathways; RCPs) RCP2.6, RCP4.5, RCP6, RCP8.5 in general circulation model MRI-CGCM3. Model performance was assessed by using the area under the receiver operating curve (AUC) and the true skill statistic (TSS).

Results and Discussion Our results revealed that the most effective variables in desirability of the study species habitat were the isothermality, mean temperature of the wettest season of the year and seasonal precipitation variables respectively. In keeping with the findings, the *Astragalus verus* Olivier mostly exists in habitats with Isothermality (bio3) from + 36.8 to + 39.7 °C, Mean Temperature of the Wettest season of the year (bio8) from - 2 to + 3.5 °C, and seasonal precipitation variables (bio15) from 100 to 112 mm and the Annual Precipitation of 280 mm to 490 mm. Based on the results of modeling of current conditions, in comparison to the other regions, northeast and east of the province had the most habitat importance for the *Astragalus verus* Olivier. Our findings show that about 27.43% of the study area was identified as suitable habitats for the *Astragalus verus* Olivier. Prediction of the geographical distribution of the *Astragalus verus* Olivier in the future (years 2050 and 2070) was made based on four scenarios of the increase in the greenhouse gases (Representative Concentration Pathways; RCPs) RCP2.6, RCP4.5, RCP6, RCP8.5 in general circulation model MRI-CGCM3. Based on the future projections were made for the year 2050 and 2070 with four Representative Concentration Pathways (RCPs) scenario (2.6, 4.5, 6 and 8.5) and general circulation model MRI-CGCM3. In keeping with our findings, climate change can have significant consequences for the *Astragalus verus* Olivier suitable habitats in the study area. Based on various senarios, about 45.70 percent (year 2050, RCP2.6) to 89.88 percent (year 2070, RCP8.5) of the current habitats for the *Astragalus verus* Olivier will be unsuitable due to the climate change by 2050 and 2070. While in the same period of time, about 1.58 (RCP8.5, 2050) to 13.19 percent (RCP2.6, 2070) may be added to the suitable habitats of this species in areas with higher elevation. According to all scenarios, the suitable habitats of this species will decrease in all habitats, especially in areas with lower elevation. The climate change consequences especially the probability of decling and shifting the geographical range of the plant species in various habitats of Iran especially in the central Zagros and also in Central Iran range are predicted. Assessments showed that the models had acceptable accuracy and Random Forest model was determined as the most reliable model to predict the distribution of this species.

Conclusion Generally, this study indicated that ensemble model might predict the potential distribution of the *Astragalus verus* Olivier with a relatively high accuracy (AUC= 0.92 and TSS= 0.79). The scenarios used in this study predict the probability of the shift of the geographical range of the studied species under climate change scenarios of 2050 and 2070. According to the results, it seems that the suitable habitat extent of the *Astragalus verus* Olivier in the study area has been decreased and will shit toward the higher elevation. Although land degradation and over utilization may be considered as two important factors in habitat degradation of this species but this study highlights the importance the effects of climate change on the distribution of the *Astragalus verus* Olivier. As a result of the severe and inappropriate harvest of the *Astragalus verus* Olivier, the range of its distribution and density has decreased in some areas, which has increased the intensity of phenomena such as soil erosion. This issue requires a double attention of the managers and experts of natural resources to the *Astragalus verus* Olivier and the other species with similar performance in ecosystems having importance from the view point of economic productivity as well as their ability to conserve the soil.

Keywords Chaharmahal va Bakhtiari province, Species distribution modeling, Representative concentration pathways (RCPs), Ensemble modeling