Spatial Habitat Suitability Assessment of the Wild Goat (*Capra aegagrus*) in Barzan District, Kurdistan Region of Iraq

Ahmed M.H. M. Mahmood[1]*, Jassim M. Abdo[2], Amin A. Khedher[1]
1 Department of Environment and Ecotourism, College of Agricultural Engineering Sciences, University of Duhok, Duhok, Iraq
2 Department of Biomedical Science, College of Medicine, University of Zakho, Zakho, Iraq
*Corresponding author: ahmed.mahmood@uod.ac
Email addresses of coauthors: amin.khedher@uod.ac, jasim.abdo@uoz.edu.krd

Abstract

Wild goat is an important mountain ungulate that occurs in a wide range of habitats, and often its distribution is dictated by some ecological conditions and increasing human pressure. Despite its significant regional importance, research on habitat suitability and the environmental factors influencing it in the Kurdistan Region is very limited. Therefore, the main objective of this study is to investigate the habitat suitability of the targeted species and finding out the impact of environmental variable on their presence. MaxEnt modeling was applied to presence-only data that had been collected across the study area to identify the major factors influencing the distribution of wild goat habitat. Before modeling, Pearson's correlation analysis was used to eliminate multicollinearity, and eight uncorrelated environmental variables were retained. The performance of the MaxEnt model was strong, exhibiting high training and test AUC values (0.989 and 0.990). Under all predictors, distance-to-water-spring was the most important, making a significantly larger contribution (71.9%) to the model than any other factor. This dominance was accomplished by means of the jackknife test, where distance to water springs gave the highest training gain from its exclusive use, whereas the other predictors had comparably low independent contributions. The resulting habitat suitability map indicated that areas most suitable for *C. aegagrus* are concentrated around permanent natural springs and associated mountainous terrain. These investigations underscore the importance of water availability in determining the use of habitat by wild goats and the critical conservation value in protecting natural water sources across the region.

Keywords: *Capra aegagrus*, habitat suitability, Barzan District, GIS, conservation, MaxEnt modeling.

Introduction

The wild goat, *Capra aegagrus*, is native to mountainous regions in the Middle East and Central Asia, extending from Turkey to Iran and Iraq and into parts of the Caucasus. It is regarded as the progenitor for the domestic goat (*Capra hircus*) and consists of several subspecies, such as *C. a. aegagrus, C. a. blythi*, and *C. a. turcmenica[28]*. Wild goats are normally found living in areas with steep rocky terrains 1,000 to 3,000 meters above sea level, scattered between sparsely vegetated land and human-disturbed sites. Their primary diet consists of grasses, shrubs, and leaves. Kaky, Alatawi (14)suggest that these animals have fitted themselves to rough terrains and can reach

ISSN 2072-3857

heights that are most probably inaccessible to humans and livestock using their excellent climbing capabilities.

C. aegagrus has been classified as "almost threatened" by the International Union for Conservation of Nature (IUCN) criteria basically because of its destruction of habitats, poaching, and even, competition with domestic herds[28].

Habitat suitability modeling (HSM) has become the centerpiece of any attempt to identify areas that offer favorable conditions for wildlife species. These models can predict potential habitat by combining field observations with environmental and topographic variables and point to the factors that are affecting most the distribution of the species. Another important use of HSM is to project how habitats may change in the future due to human interference and land-use activities. For instance, Zenbilci, Özdemir (34)used habitat-suitability modeling to observe that agriculture expansion and human settlements were important stakeholders in habitat deterioration of wild goat distributions across Turkey.

Among the available modelling techniques, the Maximum Entropy (MaxEnt) algorithm is particularly effective when only presence data are available. MaxEnt estimates the probability of habitat suitability using environmental predictors such as elevation, slope, vegetation cover, and proximity to water sources[31]. MaxEnt is able to process, visualize, and validate data well with the usage of spatial platforms such as ArcGIS Pro, allowing production of clear maps that can be used to identify the critical habitats requiring conservation. The studies conducted in Iran and Turkey reported a high degree of model accuracy (AUC above 0.9) whereby slope and water availability have always been strong predictors for the presence of wild goat[31,34]. The field of ecological niche modeling uses bioclimatic variables to establish the environmental boundaries which determine a species distribution range [4]. The annual trend data and seasonal patterns together with extreme environmental conditions create more biologically relevant data than simple averages because they explain the particular climatic factors which determine species survival, including drought and frost [30]. The mountain ungulate species *Capra aegagrus* depends on these indicators to pinpoint their essential mountain habitats in areas with difficult terrain which lack standard weather monitoring stations. Researchers use high-resolution precipitation and temperature data to create seasonal habitat suitability maps which scientists use for current conservation efforts and future climate change impact predictions[12].

Wild goats in Iraq, especially in Kurdistan, live on the rugged ranges of the Zagros Mountains, having steep slopes to provide vegetation and limited access to humans. The future for *C. aegagrus* in Northeast Iraq could be good; According to [14], the Kurdistan region of Iraq could be appropriate habitat under present climate conditions or possibly even now fall within the spectrum of suitable habitats. Rahim (20)undertook a similar study using MaxEnt modeling and showed that altitude, land cover, temperature, and precipitation play important roles in determining suitable habitats for the species; thus Barzan, Qara Dagh, and Peramagroon mountains have been suggested as suitable habitats. Consequently, Nature Iraq's conservation activities are focusing on these mountain regions in respecting the conservation of local wild goat populations. However,

ISSN 2072-3857

outbreaks like Peste des Petits Ruminants reported by [11] demonstrated that disease could quickly threaten these species, which already vulnerable populations, underscoring the need for long-term monitoring and management of originating habitat.

Fine-scale ecological information for *C. aegagrus* within the Barzan District remains limited, even though several conservation efforts have been made. This area possesses variable and considerably rugged topography, showing varying vegetation cover and increasing human activities, which tends to describe the ideal landscape for carrying out detailed habitat assessment. Thus, this study's objective is to identify the important environmental and ecological variables determining the distribution of wild goats in Barzan District and to develop a MaxEnt-based model forecasting areas of high habitat suitability while assessing model performance using field data at the end. The results will also provide very valuable information to conservation planning in identifying priority areas for protection and guiding further sustainable management practices to ensure that the wild goats of the Barzan district continue to persist.

2. Materials and Methods

2.1 Study Area

This study was conducted in the Barzan District, located on the northern banks of the Great Zab River in the Erbil Governorate of the Kurdistan Region in Iraq. Barzan is located at coordinates (longitude: 43.774403 to 44.414705; latitude: 36.750910 to 37.152746) on the western foothills of the Zagros Mountains (altitude: 504-2300m a.s.l.) (**Figure 1**). The habitat of this area is characterized by a sophisticated landscape consisting of deep valleys, large limestone formations, and high mountains that offer different microhabitats for a diverse range of living organisms, including wild goats. The climate of this region is distinguished by cold, wet winters and hot, dry summers, which affect the seasonal migration and habitat preferability of wild goats.

ISSN 2072-3857

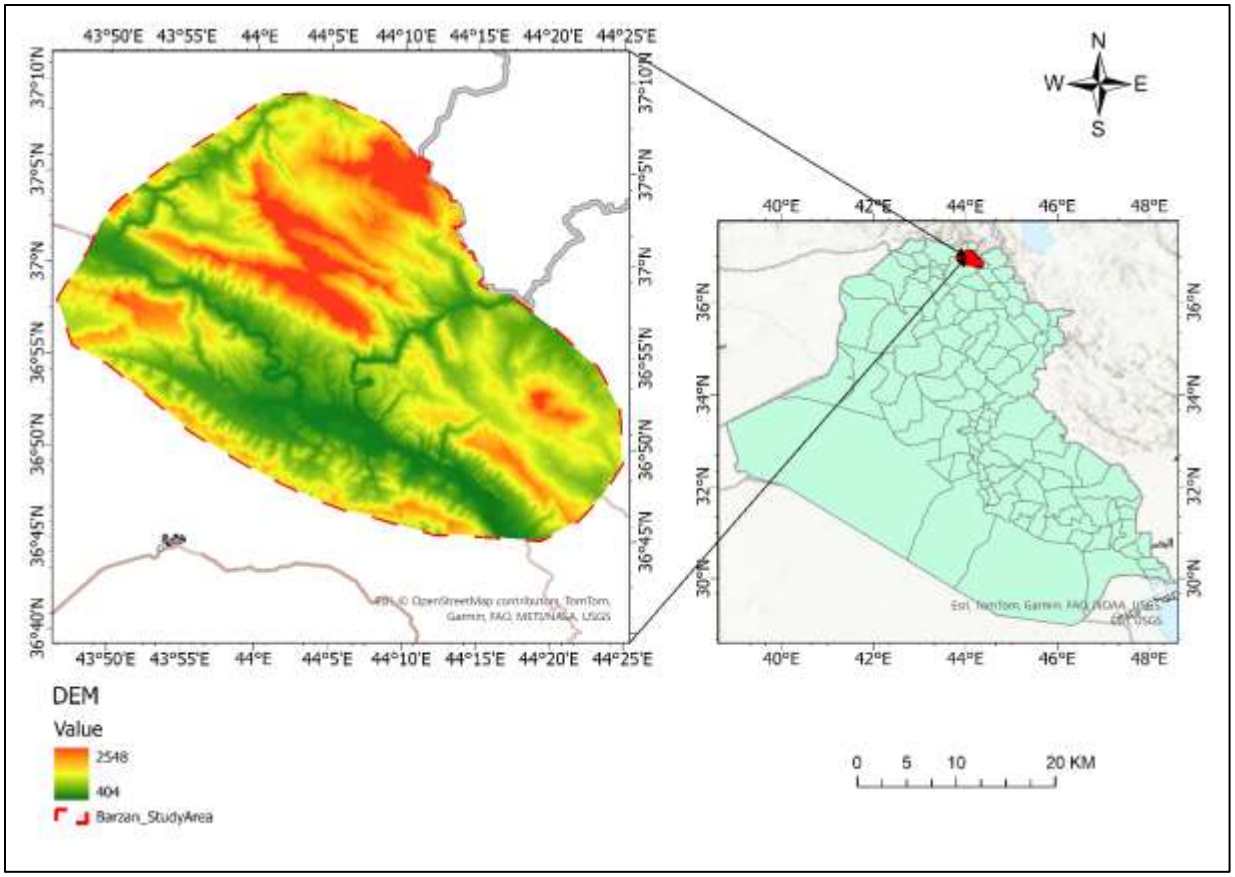


Fig 1: Location of the study area

2.2 Data collection

The field data were gathered for the study in order to get some insight concerning the presence and distribution of *Capra aegagrus* species in Barzan district. Field surveys were conducted in six different sites within the study area. All these sites employed a presence approach with multiple indicators, including direct observations with the naked eye and with binoculars, fecal droppings, footprints, tracks, resting sites, and feeding signs[23].

Habitat-use surveys were carried out in all four seasons (summer, autumn, winter, and spring) including two survey per season per site [35]. During each survey, GPS coordinates of confirmed presence points were randomly recorded for later use in spatial analyses and habitat suitability modeling. For the purpose of conducting further spatial and habitat suitability evaluations, a total of 1,403 presence sites were georeferenced as a result of the use of GPS (**Figure 2**). Through providing a comprehensive overview of the time and geographical patterns of wild goat activities across the Barzan region, this complimented the study that was conducted[26].

ISSN 2072-3857

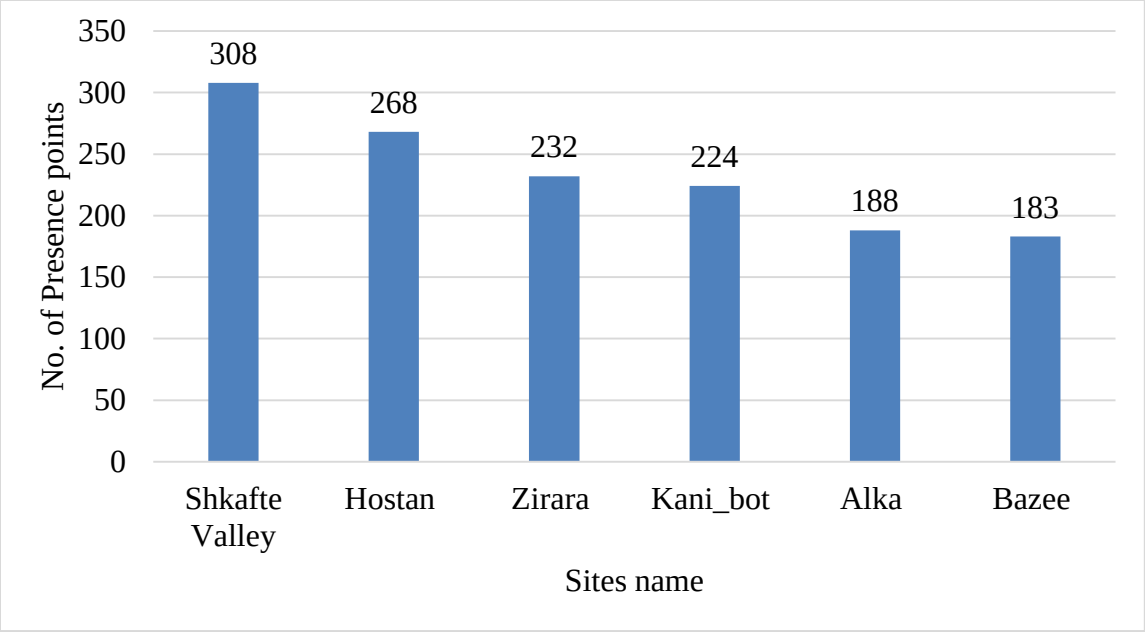


Fig 2: Number of presence points of *Capra aegagrus* at each site in 2024-2025

2.3 Environmental Variables

The datasets used in this study include Digital Elevation Model (DEM), obtained from (https://earthexplorer.usgs.gov/), NDVI used for vegetation cover for forage and shelter using Sentinel 2 obtained from (https://browser.dataspace.copernicus.eu /). Then for topographic position index layer ruggedness and hillshade were used. Furthermore, distance to roads and human settlements were used as an anthropogenic factor [15]. While proximity to water resources (distance to river and water springs) is a reflection of water accessibility. The coordinates of wild goats obtained from the field survey in 2024-2025 [1,22], while the distance to rivers and springs is a reflection of water accessibility [22]. All processing of spatial data and preparation of maps were executed with ArcGIS Pro version 3.3 (Esri, Redlands, CA, USA). The software was also used to clip, project, convert raster data, overlay for analysis, and create a habitat-suitability map tailored to the specified data (**Table 1**). In contrast, its advanced geoprocessing toolbox and compatibility with multiple spatial data formats render it suitable for integration of environmental, topographic as well as anthropogenic factors into the modeling framework [4].

These variables were selected due to their ecological relevance to the species' distribution; thus, ensuring a representation of the factors determining habitat preferences. To further perform the clipping of the layers in ArcGIS Pro 3.3 for the purpose of studying area borders, the unifying projection of all layers under the UTM coordinate system (WGS 1984 UTM Zone 38N) was utilized. This was done to ensure that the spatial consistency was maintained. At this stage, it was assured that all of the layers were in sync with one another and prepared for continuing spatial analysis [8].

ISSN 2072-3857

In converting environmental layers into raster format with a cell size of 30 m, it was decided to prepare for a good compromise between computational efficiency with ecological realism. It is important to have uniform resolution since varying pixel sizes might introduce bias in spatial analyses and represent lower model reliability. The resolution chosen allows fine-scale habitat heterogeneity to be captured, which is relevant to movement and resource use by *Capra aegagrus.* Resampling methods were accordingly applied to ensure that all such layers were matched to the same spatial resolution and extent [10].

Table 1: Sources and types of spatial data used to map *Capra aegagrus* habitat suitability

Data types	Format	Resolution	Date of acquisition	Function	Data sources
Study area boundary	Vector/shapefile	–	2024	To generate the analysis extent of all variables.	Digitizing from Google Earth pro
Water springs	Raster/TIFF	–	2025	To produce water springs proximity	Field survey Using (GPS), Digitizing from Google Earth pro
Rivers	Raster/TIFF	–	2025	To produce river proximity	Digitizing from Google Earth pro
Human Settlements	Raster/TIFF	–	2025	To produce Human Settlements proximity	Digitizing from Google Earth pro
Roads	Raster/TIFF	–	2025	To produce road proximity	Digitizing from Google Earth pro
Sentinel-2 (MSI, multispectral)	Level-1C (Top-of-Atmosphere), Level-2A (Bottom-of-	10 m (Visible/NIR), 20 m (Red Edge/SWIR), 60 m	2025	Used to produce land use land cover	Copernicus Open Access Hub

ISSN 2072-3857

	Atmosphere)	(Atmospheric)		(LULC)	
SRTM DEM (Shuttle Radar Topography Mission)	GeoTIFF, HGT	30 m (1 arc-second)	2025	Elevation, slope, delineation, habitat suitability modeling	USGS Earth Explorer
Species location	X, Y coordinates saved in Excel		2024-2025	To identify wildlife location	Field survey Using (GPS)

2.4 Habitat suitability modeling:

The MaxEnt (**Maximum Entropy Species Distribution Modeling version 3.3.4**) modeling method was used to predict the potential spatial distribution of *Capra aegagrus* in the area under study based on the ecological variables involved for better performance [13,18]. MaxEnt is a machine-learning algorithm that estimates species distributions from presence-only data by finding the probability distribution of maximum entropy, subject to environmental constraints inferred from known occurrence points[7]. In order to use the principle of maximum entropy to predict possible distribution areas of a targeted species. All of the presence points of the wild goats were combined with environmental variables to run the MaxEnt method with presence-only data. Using bootstrap choices, 90% of the data set for training the model and 30% for random testing it, and maximum number of background points (20000). According to [25], a key advantage of maximum entropy bootstrap is that it allows the model to provide values that go beyond the extremes. A further method for assessing the performance of a model is the area under the curve, also known as AUC. When the Value of area under the curve is 1 it means that the model has perfectly performed. While 0.5 score of AUC reveal that the model did not perform better than random [29]. This approach has provided insights into habitat suitability and the environmental factors affecting wild goat distribution in the region.

3. Results and Discussion

The first modeling processes were from a complete initial set of 1,403 presence points that collected from the six different sites within the study area. Variables were first examined by using Pearson's correlation test to ensure that the environmental predictors to be used in MaxEnt did not introduce multicollinearity. This step allowed the removal of any factors that were strongly correlated and helped to avoid any issues related to multicollinearity during model calibration. Taking into consideration the results of the correlation study, a total of 8 environmental variables were chosen for inclusion in the modeling process as shown in (**Figure** 3).

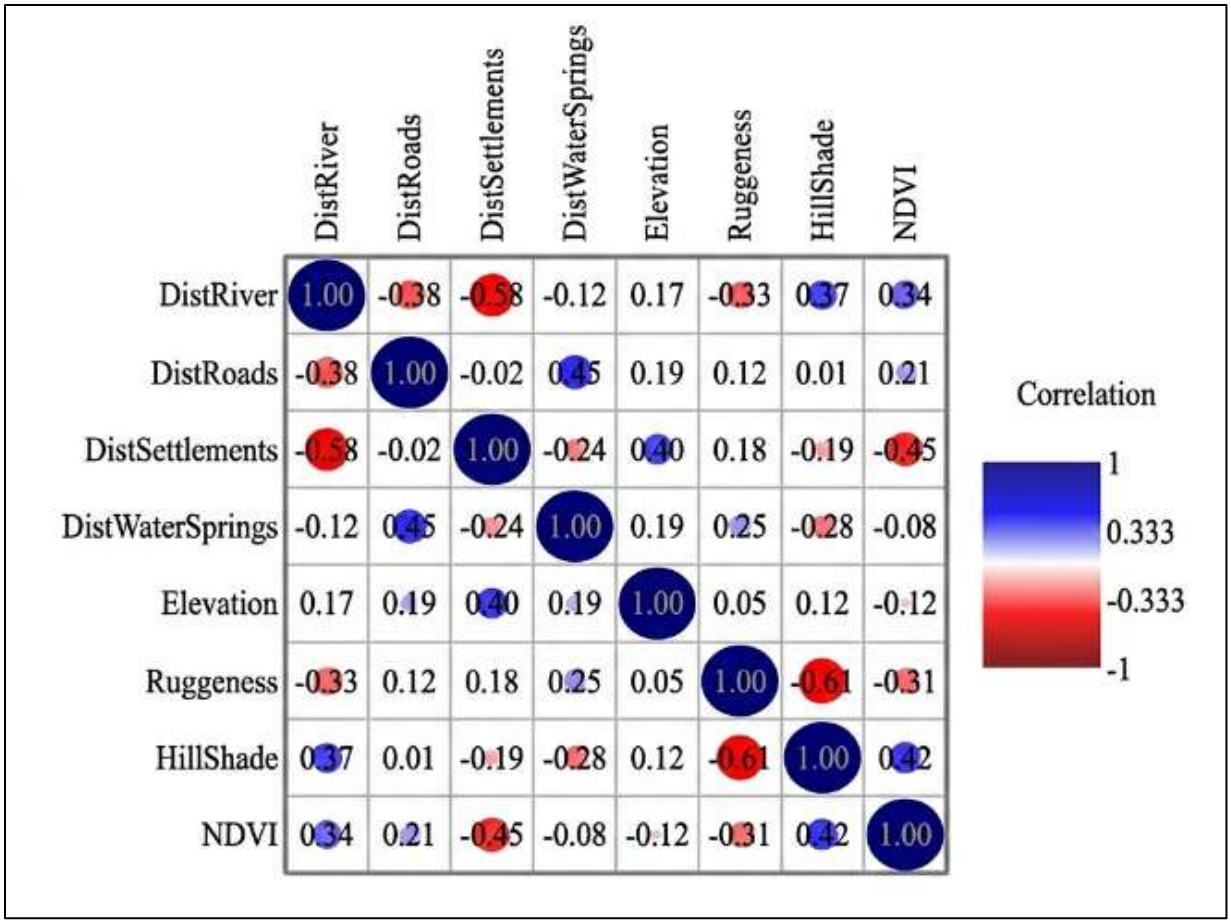


Fig 3: The results of the Pearson correlation investigation carried out on environmental variables

In training and testing on *Capra aegagrus*, the MaxEnt model performed excellently, presenting AUC values of 0.990 for the training data and 0.989 for the test data (**Figure 4**). According to [7], the AUC values above 0.9 suggest that the species distribution models are very accurate, and the minimal difference between training and test AUCs testifies to the strong generality of the model with low incidence of overfitting. The steep ROC curve, nearing a sensitivity of 1.0 at very low false-positive rate, indicates that the model is able to distinguish suitable from unsuitable habitats reliably (**Figure 4**). Consistent with previous habitat modeling investigations of mountain ungulates conducted in similar environments, the results indicate that the chosen environmental variables appropriately reflected the biological niche of wild goats [34]. Very high predictive accuracy instills confidence in the resultant habitat suitability map, together with its prospective application in conservation planning, particularly in identifying priority habitats and managing threats induced by human activities.

ISSN 2072-3857

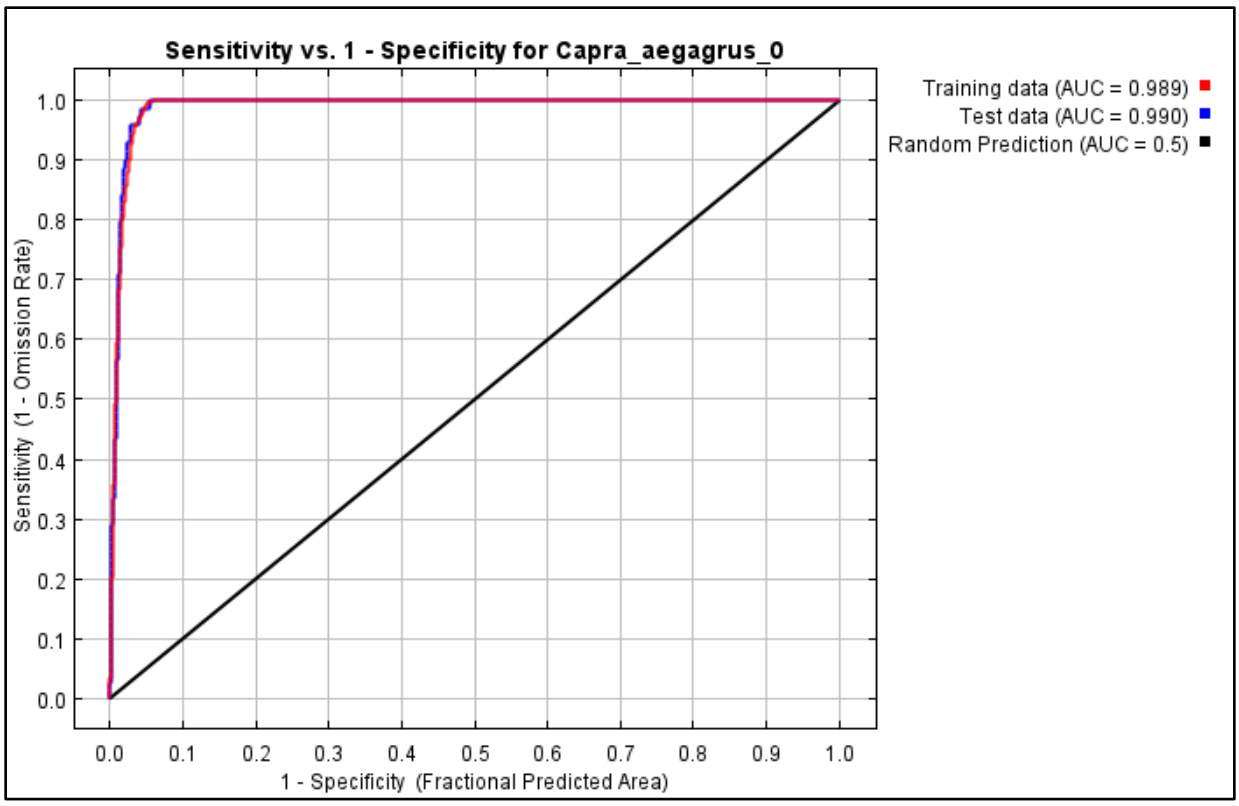


Fig 4. ROC curve of the model obtained with MaxEnt for *C. aegagrus*

On the Average Omission and Predicted Area curve, the MaxEnt model appears to perform consistently, with a test omission rate of 0.26, demonstrating that suitable habitats for *Capra aegagrus* can be accurately identified. The close match between predicted and expected omission values, along with narrow standard deviation ranges, indicate model performance that is stable and well calibrated (**Figure 5**). These results are consistent with more recent findings on effective habitat modeling for mountain ungulates [17].

ISSN 2072-3857

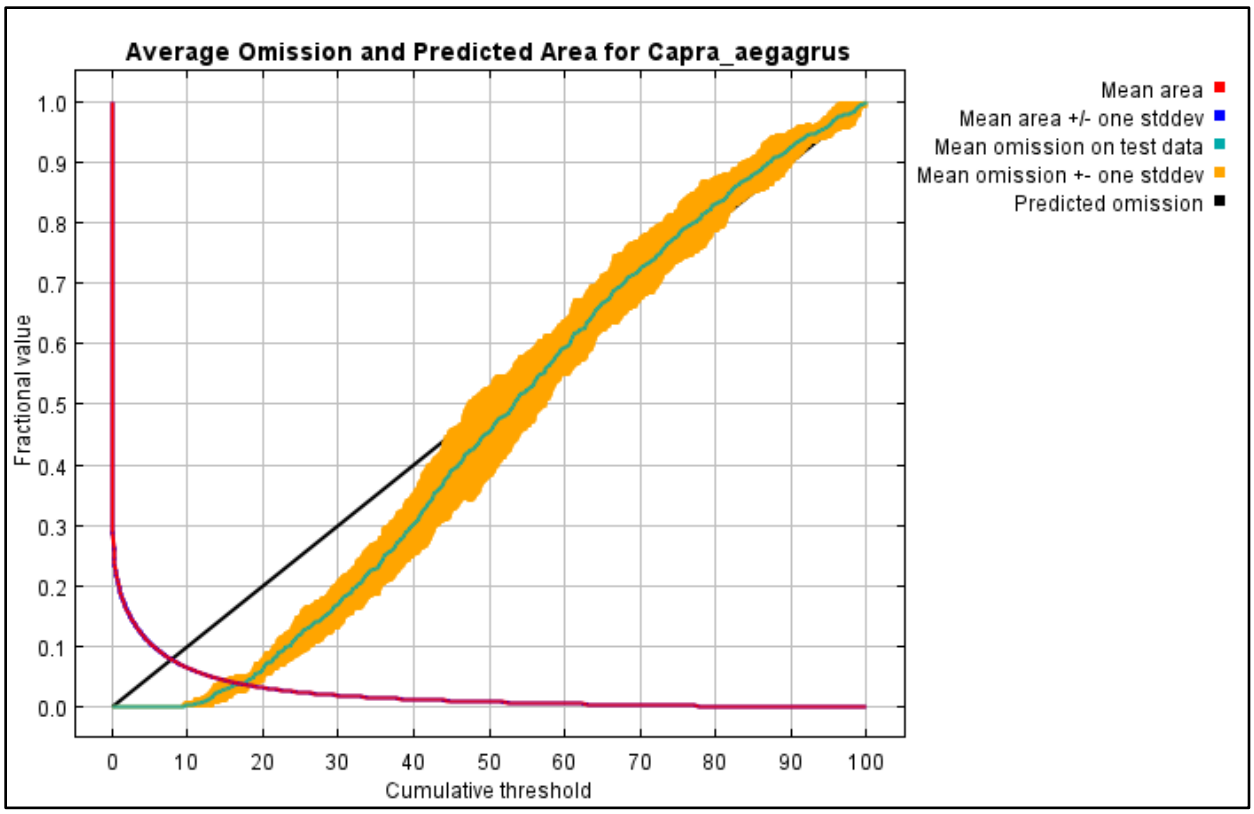


Fig 5. Average omission and predicted area curve for *Capra aegagrus*

The MaxEnt model identified distance to water_springs as the most important predictor of habitat suitability for *Capra aegagrus* and accounts for 71.9% of the contribution percent with (60.9%) permutation importance, meaning that the most important factor affecting the wild goat distribution in arid and semi-arid landscapes is the proximity to perennial water sources (**Figure 6**). Recently, this strong dependence has been found to coincide with the fact that water is essential for mountain ungulates in their habitat utilization during the drought conditions[2,33]. Distance to rivers, though minor, was nonetheless important, which were contributed in 7.8% of the permutations by 23.6%. In other words, rivers are also hydrological features important for the spatial distribution of the studied species. A few terrain-related variables, like hillshade, elevation, and ruggedness, contributed very little (<5%). This shows that even though topography affects movement and predator avoidance, in this region it affects them less than access to potable water. Human-related predictors such as distance from settlements (3.9%) and roads (3.8%) had little effect, as reported in other studies in which wild goats displayed partial tolerance of moderate anthropogenic disturbance if critical resources are accessible [5]. Overall, the overwhelming importance of water variables indicates that the species has an ecological dependence on reliable water points and suggests that conservation efforts should focus mainly on the protection of natural springs and riparian zones.

ISSN 2072-3857

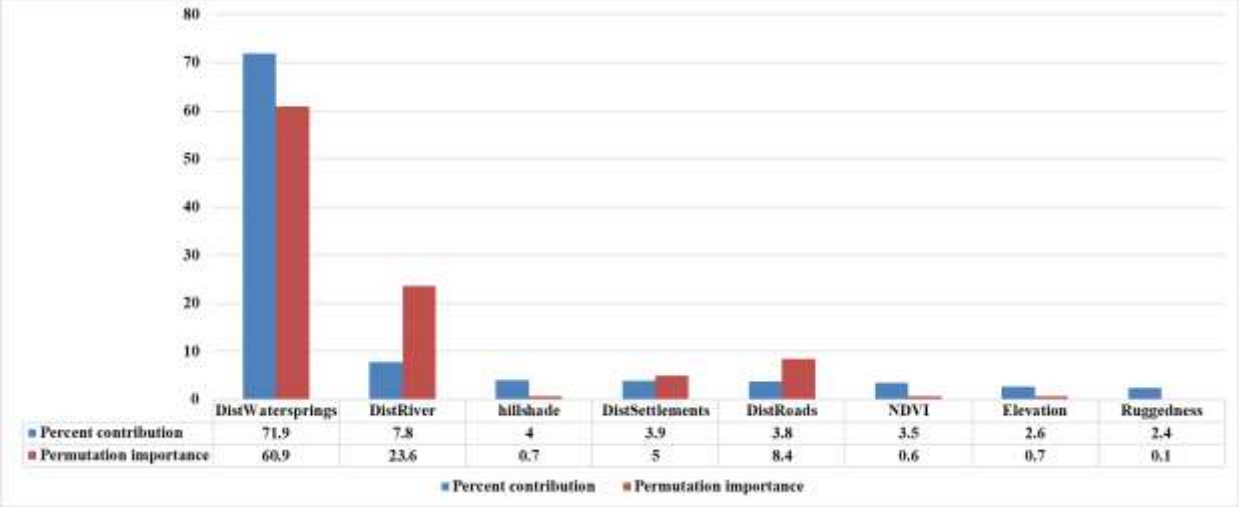


Fig 6: Percent contributions of the variables acquired by MaxEnt model using *C. aegagrus* presence data

The jackknife test established that distance to water springs was the single strongest predictor in the MaxEnt model, producing distinctly the greatest training gain when considered by itself, while the other eight environmental variables had comparatively low and very similarly gained results. This trend suggests that water availability is the primary ecological constraint affecting the distribution of *Capra aegagrus* in the study area, diminishing the importance of topographic, vegetative, and anthropogenic factors. This extreme dependence upon water sources has been reported for mountain ungulates in arid and semi-arid lands, where access to the presence of the spring is necessary for thermoregulation, foraging efficiency, and survival during the dry season [2,33]. The uniformly low influence of the other variables seems to indicate that these may control the fine-scale movements of the animals but fall significantly short of interpreting habitat suitability independently of water availability (**Figure 7**). In general, the conservation strategies for *C. aegagrus* need, according to the jackknife results, to give priority to the conservation and restoration of natural springs, the main environmental driver of suitable habitat in this landscape.

ISSN 2072-3857

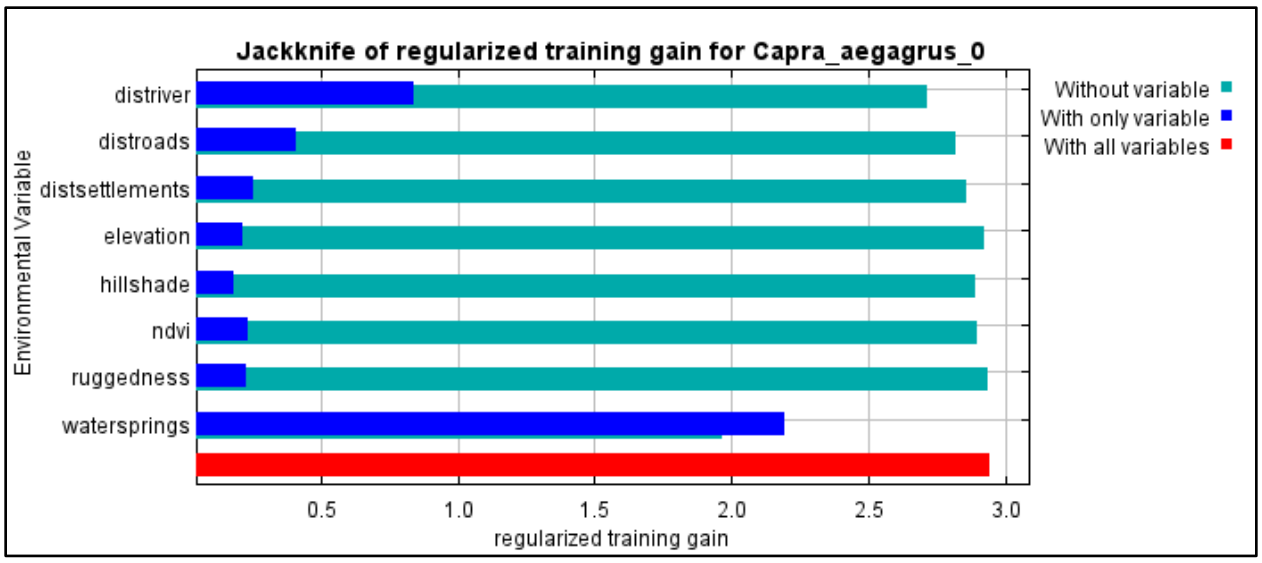


Fig 7: The outcomes of the jackknife test obtained by MaxEnt modeling with *C. aegagrus* presence data

Percent contribution results indicated the distance to water spring as by far the most important variable, achieving an influence much greater than that of all other predictors . This trend was confirmed with the jackknife test in which distance to water springs, when used in isolation, gave the highest training gain (**Figure 8**), whereas for the other eight environmental variables, their gains were low and almost identical, That maybe referes to the intact habitat with high vegetation cover, that provide a significant limiting factors for the wild goats such as (food diversity and availability and shelter). In other hand, possibly due to the low human activities in the Barzan habitat, suggesting very little independent power in explaining [2,33]. This indicates that access to reliable water is the primary factor determining suitable habitat for *C. aegagrus* in the study area. The marginal response curves for the key variables accentuate that strong water availability dependency [31].

ISSN 2072-3857

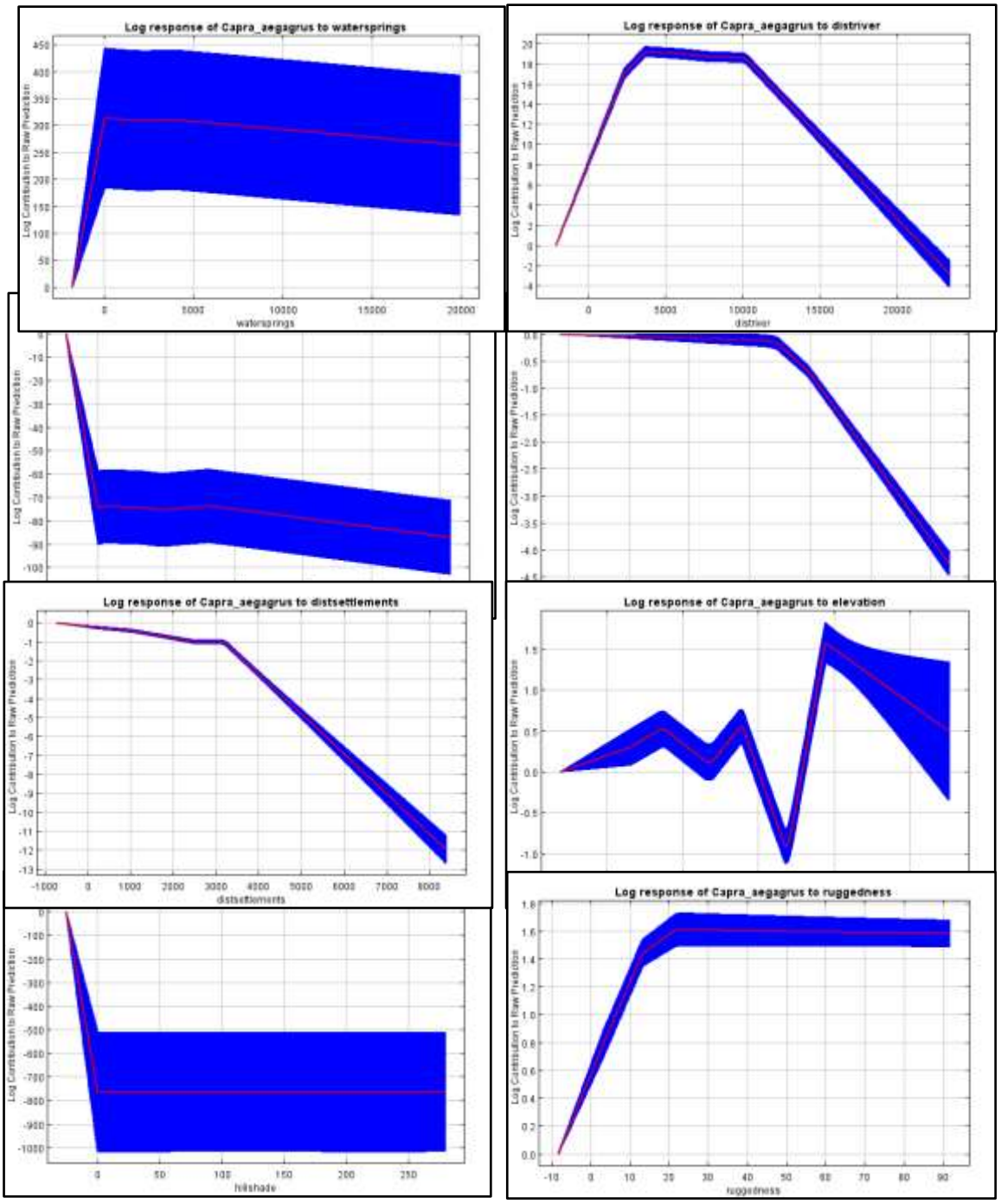


Fig 8: MaxEnt-derived marginal response curves based on the presence_only data of *Capra aegagrus*.

The final habitat suitability map produced by the model supports this pattern, predicting areas next to the natural springs as the most suitable habitat for the species (**Figure 9**). Nonetheless, the other explanatory variables reveal very low

response to the model perhaps due to the strong protection afforded by the government, reflected by the Barzan Environmental Protection Battalion and their important role in biodiversity conservation. Furthermore, the tradition-based protection established over a century ago, beginning from the era of Shekh Ahmed Barzani. Over time, these conservation techniques have become deeply integrated into the local culture and traditional rituals of the indigenous population. This permanent protection has significantly affected the behavior of wild goats, resulting in reduced fear of wild goats and feel more freedom within their natural habitat. As a result, other ecological constraints are no longer a significant predictor of their spatial distribution, as the species now exhibits enhanced adaptation to diverse altitudinal and anthropogenic habitats [24].

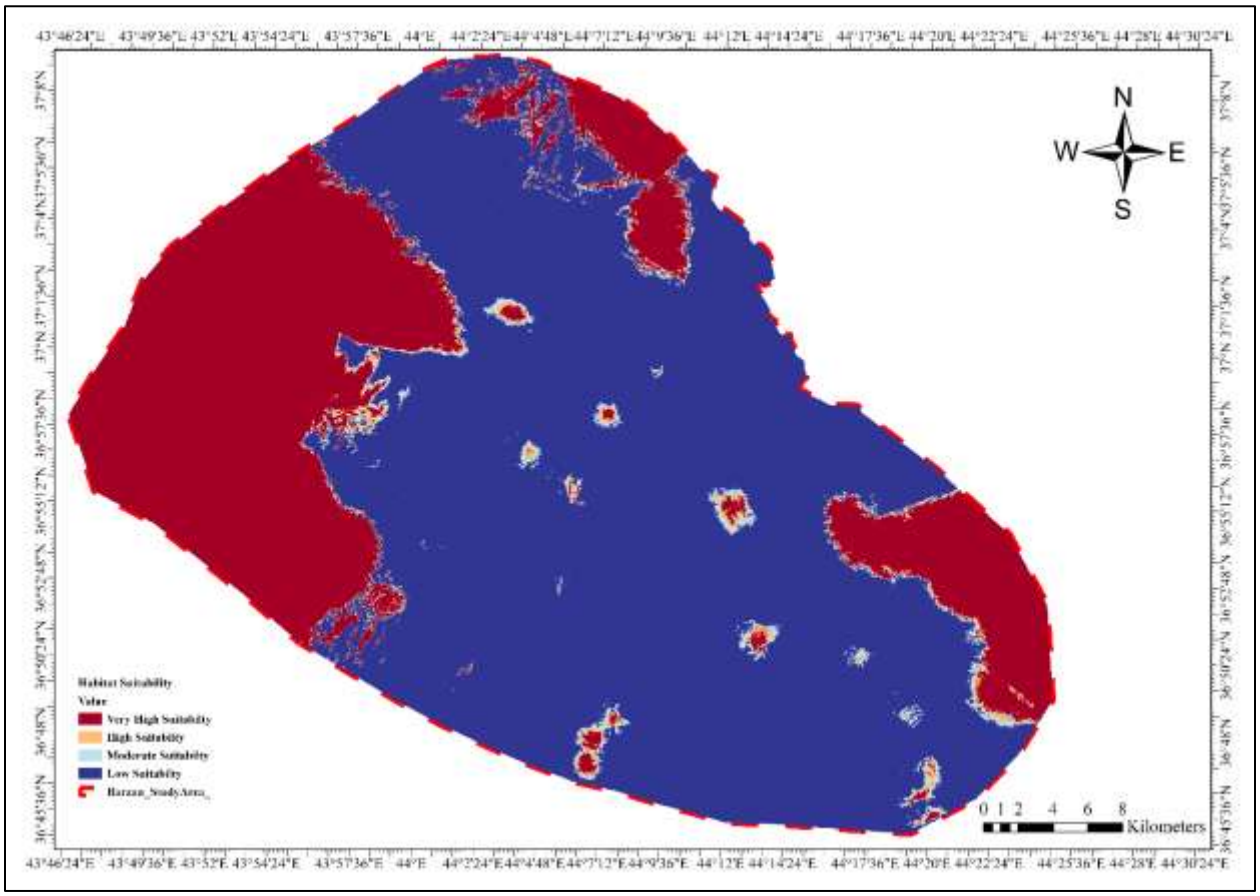
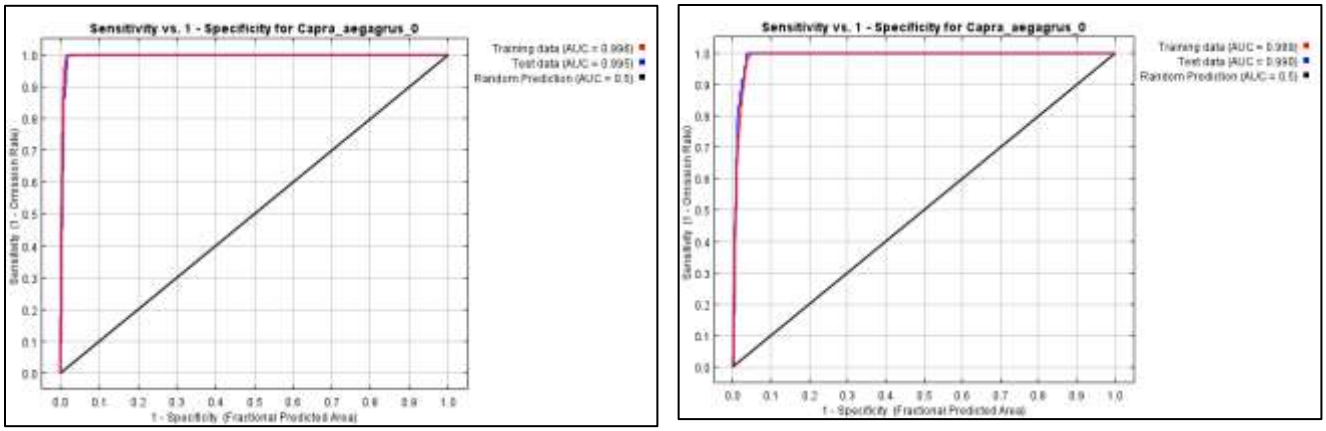


Fig 9: Habitat suitability map of *Capra aegagrus* in Barzan district

Seasonal Variations in Spatial Habitat Suitability for the *Capra aegagrus*: Influence of Environmental Variables on *Capra aegagrus* Distribution

MaxEnt model outputs for the four seasons of autumn, winter, spring, and summer indicated a high degree of unstable spatial configuration of habitat suitability for the Wild Goat. The Area Under the Curve (AUC) values obtained through Receiver Operating Characteristic (ROC) analysis serve to validate the high predictive capabilities of these models with high stability and minimal spatial shift in the species, as the outcomes consistently revealed high accuracy across the entirety of the yearly timeframe. The model obtained its best results during Autumn with a Test AUC of 0.995 and Summer with a Test AUC of 0.997, also the model maintained its high performance through Winter and Spring with scores of 0.990 and 0.989 (**Figure 10**), referring to the high accurate performance of the spatial distribution models. The current research shows ecological consistency with Zagros range studies which demonstrate that topographic ruggedness functions as essential escape terrain while wild goats depend on hydrological resource stability to determine their seasonal carrying capacity and spatial occupancy [34]. Rather than undergo drastic seasonal changes, predicted high-suitability areas remain spatially constant across all models. This indicates that, within this population, the species exhibits a high degree of seasonal niche conservatism as its fundamental requirements are anchored more to static geomorphological features than to dynamic climatic ones [9]. In areas of rough mountainous terrain, fixed factors such as steep slopes and high ruggedness index provide predator escape cover all year round, which may be acting in concert with the primary drivers that tether the species into specific localities regardless of the season [32]. In addition, the unchanging suitability maps may support the argument that the study area presents a "stable mosaic" in which goats can fulfill their biological requirements without the necessity of large-scale altitudinal or horizontal migration [19].

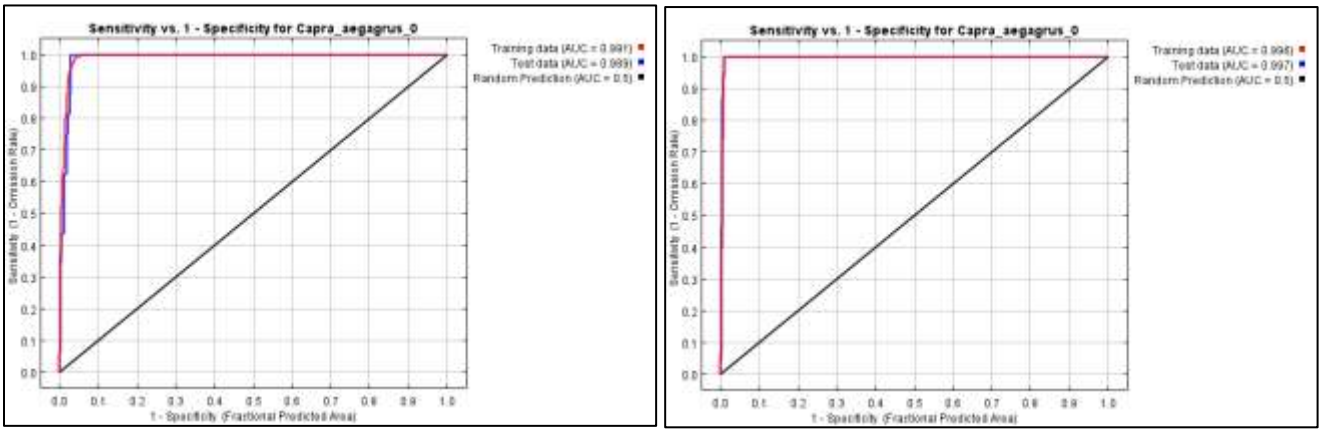
ISSN 2072-3857



1. Autumn 2. Winter
3. Spring 4.Summer

Fig 10. Receiver Operating Characteristic (ROC) curves and Area Under the Curve (AUC) values for seasonal habitat suitability models of the Wild Goat (*Capra aegagrus*)

This analysis of environmental variable contribution has established that hydrological factors govern the distribution of the *Capra aegagrus* across seasons. The most important predictor was the presence of water springs, with summer showing the highest permutation importance at 83.1%, followed by Spring 50.6% and Winter 56.9% (**Figure 11**) importance during summer only emphasizes the physiological dependency of the species on such sources during aridity and high thermal stress [3]. Contributions of NDVI were significantly high during spring (9.6% percent contribution) in comparison with other seasons, indicating the tactical movement of the species to exploit the pulse of high-quality forage required for the offsprings and lactation period [16] Inconsistently, geomorphological factors such as elevation and ruggedness showed a steady influence as relative importance was lower than expected, probably because water demand and the avoidance of human-induced disturbances, represented by distance to settlements and roads, weighed more than pure topographic selection [34]. These findings confirm that while the spatial



ISSN 2072-3857

distribution of suitable habitat remains stable, the ecological drivers fluctuated in intensity to meet seasonal biological needs.

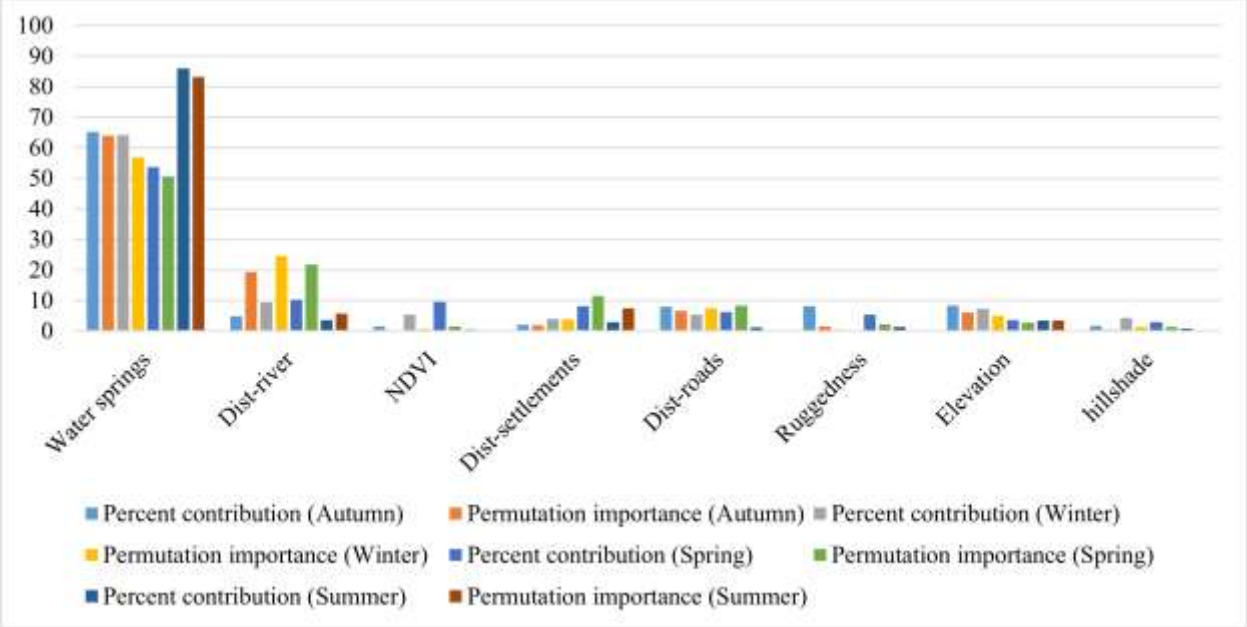


Fig 11: Percent contribution and permutation importance of environmental variables in the seasonal MaxEnt models for *Capra aegagrus*.

The Jackknife method of evaluating regularized training gains analyzes various aspects of single variable importance. It was found that water springs turned out to be the most important feature for the *Capra aegagrus* across all seasons (**Figure 12**). Alone, it proved to give maximum training gain for even seasonal models indicating it has the most significant constituent of useful information in isolation. During summer, however, this dominance reaches a peak with the variable's permutation importance sailing to the level of 83.1%, a rise that emphasizes the physiological relationship of the species with perennial water courses during periods of high thermal stresses [3].

Such high spatial stability in habitat selection among seasons implies seasonal niche conservatism whereby the goats are fixed in relation to constant hydrological features despite change in climatic conditions. Although secondary variables such as distance to rivers and distance to settlements added gains to the models, their lower individual gains in Jackknife test imply that hydrological availability is still the primary restricting factor in habitat selection through the annual cycle [34].

ISSN 2072-3857

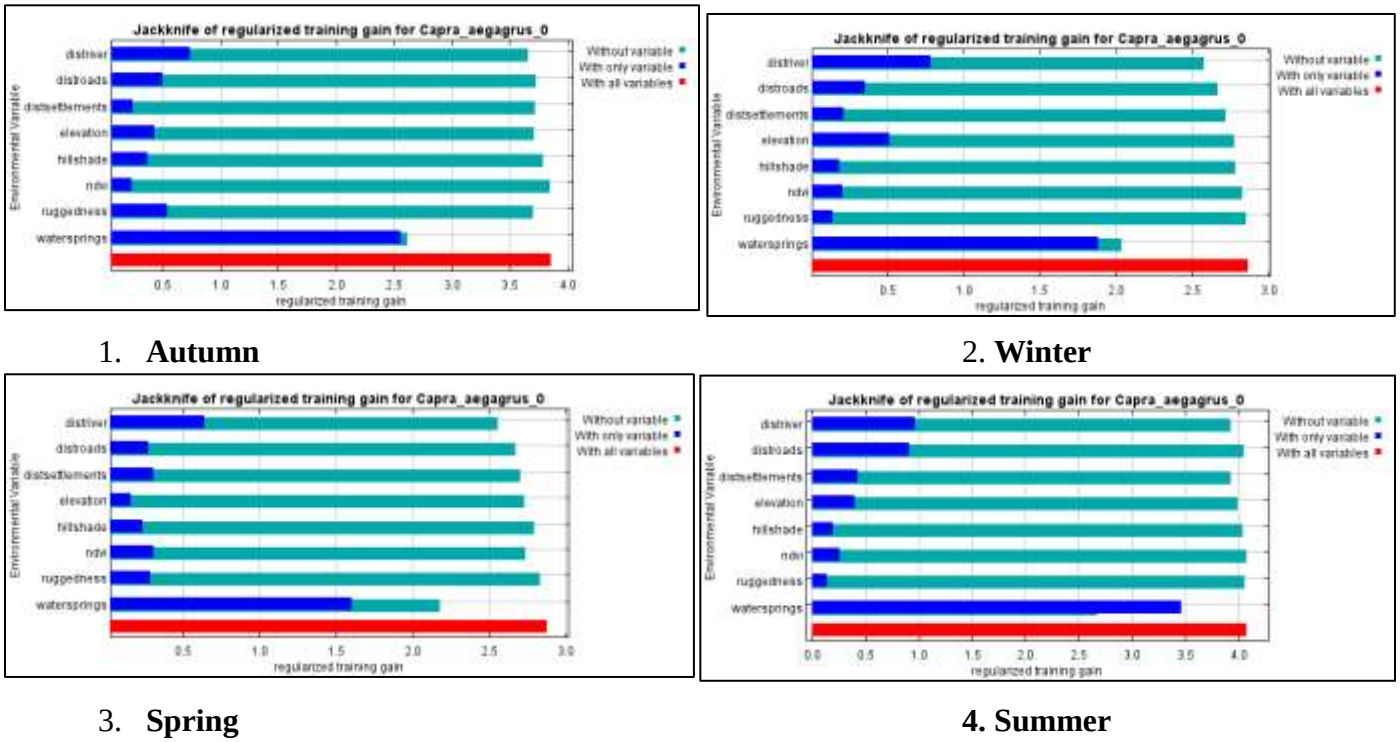


Fig 12. Results of the Jackknife test of regularized training gain for the seasonal habitat suitability models of *Capra aegagrus*.

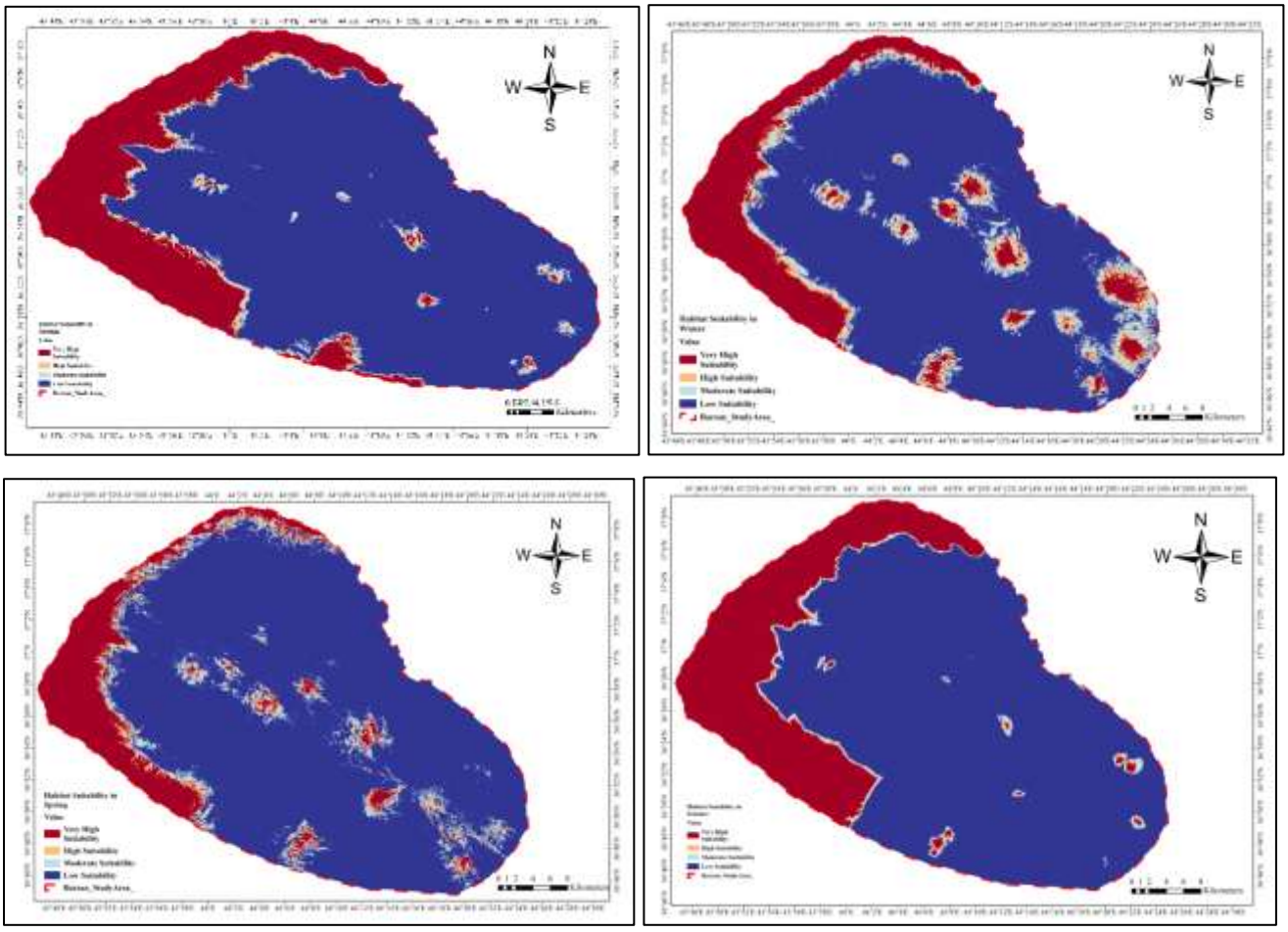
Seasonal habitat suitability modeling using presence data of *C. aegagrus*

Seasonal habitat suitability models for *Capra aegagrus* in the Barzan district show that high-quality patches contracted and expanded primarily based on the changes in forage availability due to the emergence of thermal regulation (**Figure 13**). During the Winter and Spring seasons, there was a dramatic increase in the area classified as "Very High Suitability" more-or-less exclusively in the rugged, high altitude mountainous sectors of the study region. This suggests that during these seasons, the species will use areas with high solar radiation and early-season vegetation flush to meet energetic demands associated with gestation and post-winter recovery [27]. It assumes that wild goat movement must change during harsh winters to descend to lower altitudes due to snow and precipitation; however, the weather in winter 2025 was mild, with very little precipitation. This mild weather affected the movement of the studied species, that stayed relatively at the high altitudes in the Winter. Interestingly enough, the Summer and Autumn are cast in stark contrast from the previous two maps-inhabited by high suitability habitat, such as what is likely to indicate that the species retreats to localized high-altitude refugia or areas near perennial water sources to avoid heat stress and limited forage quality. This seasonal "bottleneck" during the dry months exposes the population to climate-induced aridification since fragmented patches of high suitability are becoming increasingly isolated by vast stretches of low-suitability matrix. These findings are consistent with recent studies suggesting that mountain ungulates are now very much restricted by the "thermal landscape," which in semi-arid

ISSN 2072-3857

regions usually means summer temperatures force individuals into the thermoregulation-foraging trade-off [6,21].

Fig 13: Seasonal Habitat suitability maps of *Capra aegagrus* in Barzan district



Conclusion

The habitat suitability modeling for *Capra aegagrus* in the Barzan District demonstrates that the species' distribution is strongly influenced by the proximity to water springs, while other environmental factors showed minor effect on the presence of wild goats due to the availability of limiting factors, and ancient strict traditional based conservation strategies that dominating all over Barzan habitat. Furthermore, the results shows that hydrological dynamics, are the primary factors that determine the seasonal distribution of *Capra aegagrus* in the Barzan area. The spatial classification showed that most of the landscape was designated as high and very high suitability zones which established the main areas for conservation. The study results demonstrate that vital habitats and water sources must be preserved to safeguard the wild goat populations which inhabit the Barzan district.

ISSN 2072-3857

References

[1] Abdollahi S, Morovati M, Jumapour M, Moghadam MRD. Evaluation of Wild Goat (Capra aegagrus) Habitat and Spatial Data Mining of Habitat Hotspots in Daruneh Protected Area, Khorasan-e Razavi. Advanced Environmental Sciences. 2025;23(1)

[2] Akinmoladun OF, Muchenje V, Fon FN, Mpendulo CT. Small ruminants: Farmers' hope in a world threatened by water scarcity. Animals. 2019;9(7):456

[3] Almasieh K, Cheraghi M. Habitat suitability, core habitats and diversity hotspots for the conservation of the mustelid species in Iran. Global Ecology and Conservation. 2022;36:e02120

[4] Amininasab SM, Zamani N, Taleshi H, Xu CC. Ensemble modelling the distribution and habitat suitability of wild goat Capra aegagrus in southwestern Iran. Biodiversity. 2023;24(3):124–36

[5] Balyx L. Human conflict and coexistence with mountain goats in a protected alpine landscape: University of British Columbia; 2022.

[6] Chauveau V, Garel M, Toïgo C, Anderwald P, Beurier M, Bouche M, et al. Identifying the environmental drivers of corridors and predicting connectivity between seasonal ranges in multiple populations of Alpine ibex (Capra ibex) as tools for conserving migration. Diversity and Distributions. 2024;30(8):e13894

[7] Elith J, Phillips SJ, Hastie T, Dudík M, Chee YE, Yates CJ. A statistical explanation of MaxEnt for ecologists. Diversity and distributions. 2011;17(1):43–57

[8] Guisan A, Thuiller W, Zimmermann NE. Habitat suitability and distribution models: with applications in R: Cambridge University Press; 2017.

[9] Hassan LM, Omer EA. Nubian Ibex in Sudan: Key Aspects for Management and Conservation. Wildlife Conservation-Natural and Human-Influenced Ecosystems: Natural and Human-Influenced Ecosystems. 2025:9

[10] Hijmans RJ. raster: Geographic data analysis and modeling. R package version. 2018;2:8

[11] Hoffmann B, Wiesner H, Maltzan J, Mustefa R, Eschbaumer M, Arif F, et al. Fatalities in wild goats in Kurdistan associated with Peste des Petits Ruminants virus. Transboundary and emerging diseases. 2012;59(2):173–6

[12] Hu X, Shi Y, Song B, Hu L, Zhao Q, Pang D, et al. Habitat distribution of major wildlife in the Sanjiangyuan National park under climate scenarios based on maxent modeling. Scientific Reports. 2025;15(1):39789

[13] Hussein A, Workeneh S. Modeling the impacts of climate changes on the distribution of Aloe vera species in Ethiopia. 2021

[14] Kaky ED, Alatawi AS, Jaf AA, Gilbert F. Predicting current and future habitat refuges for conservation of wild goat (Capra aegagrus Erxleben 1777) under climate change in Iraq. Journal of Arid Environments. 2022;199:104699

[15] Koohestani M, Naderi S, Shadloo S. Evaluation of habitat quality and determining the distribution of Wild goat (Capra aegagrus) in Roodbarak prohibited hunting region, Kelardasht, Iran. Caspian Journal of Environmental Sciences. 2022;20(5):863–70

[16] Malagnino A. Environmental and individual-level drivers of movements and space use in three ungulate species: Université Grenoble Alpes [2020-....]; University of Swansea (Swansea (GB)); 2022.

ISSN 2072-3857

[17] Niu L, Li P, Hao Z, Ma J. Maxent modeling for predicting suitable habitats for wild ungulates: a case study of typical canyons in the Sanjiangyuan Nature Reserve of China. 2024

[18] Phillips SJ, Anderson RP, Schapire RE. Maximum entropy modeling of species geographic distributions. Ecological modelling. 2006;190(3-4):231–59

[19] Pourmosa H, Ghasempouri M, Mahini AS, Rezaei H. Habitat suitability modeling of the Caspian Red Deer (Cervus elaphus maral) in the central zone of the Hyrcanian region: Identification of priority conservation areas. Journal of Wildlife and Biodiversity. 2024;8(4):148–72

[20] Rahim M. Influence of environmental variables on distribution of wild goat (Capra aegagrus), in Iraq by Maxent. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS). 2016;18(1):97–107

[21] Rumiano F, Wielgus E, Miguel E, Chamaillé-Jammes S, Valls-Fox H, Cornélis D, et al. Remote sensing of environmental drivers influencing the movement ecology of sympatric wild and domestic ungulates in semi-arid savannas, a review. Remote Sensing. 2020;12(19):3218

[22] Sarhangzadeh J, Yavari A, Hemami M, Jafari H, Shams-Esfandabad B. Habitat suitability modeling for wild goat (Capra aegagrus) in a mountainous arid area, central Iran. Caspian Journal of Environmental Sciences. 2013;11(1):41–51

[23] Schmidt BR, Cruickshank SS, Bühler C, Bergamini A. Observers are a key source of detection heterogeneity and biased occupancy estimates in species monitoring. Biological Conservation. 2023;283:110102.https://doi.org/10.1016/j.biocon.2023.110102.

[24] Seddon PJ, Griffiths CJ, Soorae PS, Armstrong DP. Reversing defaunation: restoring species in a changing world. Science. 2014;345(6195):406–12

[25] Srivastav RK, Simonovic SP. Multi-site, multivariate weather generator using maximum entropy bootstrap. Climate Dynamics. 2015;44(11):3431–48

[26] Store R, Jokimäki J. A GIS-based multi-scale approach to habitat suitability modeling. Ecological modelling. 2003;169(1):1–15

[27] Tulu D, Gadissa S, Hundessa F. Impact of water stress on adaptation and performance of sheep and goat in dryland regions under climate change scenarios: a systematic review. Journal of Animal Behaviour and Biometeorology. 2023;11(2):0–

[28] Weinberg P, Ambarli H. Capra aegagrus. The IUCN red list of threatened species 2020: e. T3786A22145942. 2020.

[29] Yang X-Q, Kushwaha SP, Saran S, Xu J, Roy P. Maxent modeling for predicting the potential distribution of medicinal plant, Justicia adhatoda L. in Lesser Himalayan foothills. Ecological engineering. 2013;51:83–7

[30] Yıldırım E, Ulutürk S. Modeling the Spatial Distribution and Habitat Suitability of Capra aegagrus from South-Eastern Türkiye using Distance Sampling and Kernel Density Estimation. 2026

[31] Yousefi B, Jafari A, Naghipour AA. Habitat suitability modelling of wild goat using Maximum entropy (MaxEnt) model in Hormood protected area (Fars province, Iran). Journal of Animal Environment. 2025;17(1):1–8

[32] Zafar-ul Islam M, Gavashelishvili A, Kokiashvili L, al Boug A, Shehri AA. Modeling the distribution and movement

intensity of the Arabian Leopard Panthera pardus nimr (Mammalia: Felidae). Zoology in the Middle East. 2021;67(2):106–18

[33] Zannou OM. Tiques et maladies associées chez les bovins transhumants entre le Burkina Faso et la République du Bénin: aspects socio-épidémiologiques: Universite de Liege (Belgium); 2021.

[34] Zenbilci M, Özdemir S, Çıvğa A, Ünal Y, Oğurlu İ. Habitat suitability modeling of wild goat (Capra aegagrus Erxleben, 1777) in different periods. Šumarski list. 2024;148(5-6):273–84

[35] Zielinski WJ, Moriarty KM, Baldwin J, Kirk TA, Slauson KM, Rustigian- Romsos HL, et al. Effects of season on occupancy and implications for habitat modeling: the Pacific marten Martes caurina. Wildlife Biology. 2015;21(2):56–67.https://doi.org/10.2981/wlb.00077.

ISSN 2072-3857