Impact of Climate and Land Use / Land Cover Change on Endemic Bat *Myotis csorbai* in Nepal

Submitted by

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Sundarharaincha, Morang, Nepal

Submitted to

Research Management Cell

Sukuna Multiple Campus

Sundarharaincha, Morang, Nepal

July, 2025

Declaration

This report details the work undertaken to fulfill the requirements of a mini-research grant provided by the Research Management Cell (RMC), Sukuna Multiple Campus, Tribhuvan University, Nepal. This report represents the outcome of original research conducted by the author, which has not been previously submitted for other projects or to other organizations. All views and opinions expressed herein are the sole responsibility of the author.

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Date: July, 2025

To the Head of Research Management Cell,
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Recommendation

This is recommended that the research report "Impact of climate and land use / land cover change on endemic bat *Myotis csorbai* in Nepal" has been carried out by Dibya raj Dahal, PhD faculty of zoology, Sukuna Multiple Campus under my supervision.

To the best our knowledge, this is original work which has been rigorously tested for plagiarism by iThenticate software and has passed with similarity index of just 5 % overall similarity index.

Dr. Dahal's research support is through and well ex-executed, providing significance information on impacts of climate change in endemic mammalian species in Nepal. The methodologies and presentation are international standard.

RMC-Sukuna founded for completion this project. Finally, I like to recommend this report to research management cell, Sukuna Multiple Campus for final approval.

Ganesh Prasad Dahal
Research facilitator.
Assistant campus chief and head research management cell Sukuna Multiple Campus.

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Letter of Approval

This mini research submitted by Dibya Raj Dahal, PhD faculty of this campus entitled "Impact of climate and land use / land cover change on endemic bat *Myotis csorbai* in Nepal" is funded and approved by research management cell (RMC-Sukuna) of this campus.

Approval Committee

1. Ganesh Prasad Dahal
   Assistant campus chief and head research management cell Sukuna Multiple Campus.

2. Nara Prasad Bhandari
   Member, RMC-Sukuna Multiple Campus

3. Dipak Neupane, PhD
   Member, RMC-Sukuna Multiple Campus

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Thanking Letter

Dibya Raj Dahal, PhD
Teaching assistant
Faculty of Zoology
Sukuna Multiple Campus
Sundarharaincha – 12, Morang

Dear Dahal

I would like to express my heartfelt thanks to Dibya Raj Dahal, PhD a faculty of zoology of this campus for this in valuable contribution to research report entitled **"Impact of Climate and Land Use / Land Cover Change on Endemic Bat *Myotis csorbai* in Nepal"**. Dr. Dahal's dedication and hard work have been instrumental in the successful completion of this project.

The mini research has been financially supported by Research Management Cell of Sukuna Multiple Campus, and we are confident that the finding of this report will significantly contribute to our academic community.

Once again, thank you for your hard work and valuable study. Lastly, we are proud to have him as a part of campus community. We also look forward to continuing our collaboration in future projects.

2082-03-27
Arjun Raj Adhikari
Campus Chief
Sukuna Multiple campus

Abstract

Endemic species like *Myotis csorbai* are confined to narrow geographic ranges and face heightened extinction risks due to climate change. In Nepal, two species of endemic mammals, including *Myotis csorbai*, have been recorded. *M. csorbai* is an endemic chiropteran species for Nepal, primarily found in the Mid Hills and Higher Himalayas, with caves and cavities in secondary forests serving as its main habitats. It has been recorded at 21 locations between Dolakha and Mugu. To predict the impact of future climate change, weighted ensemble models were developed based on distribution coordinates, bioclimatic variables, and land use/land cover changes. Current species distribution models predict that the possible coverage area is 6.21% of Nepal's total area. SSP scenarios 4.5 and 8.5 were used to forecast future distribution in 2050 and 2070. The weighted ensemble models for future distribution predict a reduction in the possible distribution range in Nepal. Due to the adverse effects of climate change, there is a high risk of extinction for this species. For future conservation efforts, regular surveys and monitoring focusing on endemic species, as well as habitat protection and conservation are essential.

Key words: Bat, Climate change, Distribution, Endemic species, SDMs

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Acronyms and abbreviation

AUC: Area Under Curve

asl: above sea level

BRT: Boosted Regression Tree

GAM: Generalized Adaptive Model

GLM: Generalized Linear Model

MARS: Multivariate Adaptive Regression Splines

RF: Random Forest

SDM: Species Distribution Model

SSP: Shared Socioeconomic Pathway

TSS: True Skill Statistics

Introduction

Endemic species are those that are specially confined specific geographical region or location (Danell & Aava-Olsson, 2002). These species typically have narrow habitat range leading to specialized adaptation. They exhibit unique adaptations and very sensitive to change of environment. Conservation of endemic species is crucial to maintain the ecological balance and genetic diversity(Burlakova et al., 2011; Danell & Aava-Olsson, 2002). Nepal has unique geographical location with remarkable topography and climate from plain to trans-Himalayan range. Unique topography and climatic factor contribute the possibilities of biodiversity hotspot. Nepal hosts diverse flora and fauna, including the endemic mammals *Apodemus gurkha* and *Myotis csorbai,* the latter being a cave-dwelling bat critical for insect population control (Jnawali et al., 2011).

Csorba's Mouse-eared Myotis is small sized of Myotis distributed in subtropical secondary forest of Nepal. They are roost in caves and foraging in river banks and forest edges. This species was first time record from Kailash Cave, Syangja district in 1997 (Csorba et al., 1999a). This species of bat is recorded from 21 locations in between Dolakha to Mugu, Nepal (Acharya et al., 2010; Dahal et al., 2024b; Rai et al., 2021). Species distribution modelling is (SDMs) is statistical technology which predict the distribution of species in possible area with reference of current distribution coordinates and environmental data (Guisan et al., 2017). SDMs are also related geographic information system because it generates the high-resolution map which predict how the species are interacting with environmental factors (Villero et al., 2016). Species distribution modelling are used for prediction of possible distribution range on the basis of habitat suitability (Fernandez et al., 2003).

Species distribution models (SDMs) use occurrence data and environmental variables (e.g., climate, land cover) to predict habitat suitability (Guisan et al., 2017). For endemic species like *M. csorbai*, SDMs are critical to identify climate refugia and prioritize conservation areas (Qazi et al., 2022). SDMs are essential for understanding the ecological and biological need of endemic species, given their unique status and conservation needs (Dahal et al., 2024b; Qazi et al., 2022). This species distribution

modelling aims to predict the possible distribution range of *M. csorbai* in Nepal. These predictions will be utilized as roadmap for future survey and conservation.

Rationale of modelling

Nepal is vulnerable in climate change due to its fragile combination of geographic, socioeconomic and geological factors. In Nepal high possibilities of climate related hazard. Climate change significant pressure on endemic species due to the unique adaption in small and significance habitat within distinct ecological conditions. Endemic species are facing the problems on contraction and alteration of habitats, increase competition due to the shifting the species and ecological stress due to the specific adaptational features. To minimized the adverse pressures of climate change on endemic species necessary to change future conservation strategy. This habitat suitability mapping useful to predict possible distribution range of *M. csorbai* in Nepal. This prediction is applicable for target of future survey and road map for long-term conservation strategy.

Objectives

Following are the objectives of this species distribution modelling.

1. To map the current distribution range of *M. csorbai* in Nepal using ensemble SDMs.
2. To project the future habitat suitability for *M. csorbai*.

Delimitation of species distribution modelling

1. This modelling uses presence-only data.
2. The records of occurrences this species from limited area of Nepal.
3. The models of predictions on the basis of bioclimatic variables, land use and land cover changes.

Literature review

Endemic species are those organisms that are restricted to specific geographical location. They often have unique adaption and play crucial role in ecosystem services in specific ecosystem. The specific geographic location they are rich in endemic species tend to be biodiversity hotspots and necessary to conserve in future. Nepal is one of biodiversity hotspot. sustainability of ecosystems, endemic species contributing to vital services that support human well-being and ecological balance (Burlakova et al., 2011; Danell & Aava-Olsson, 2002; Jnawali et al., 2011; Qazi et al., 2022).

M. csorbai is one of the endemic mammalian species of Nepal, recorded between the Dolakha and Mugu districts. It was first documented in Kailash Cave, Tanahun, in 1997. This species is a cave-dwelling bat that prefers tropical to alpine caves located in secondary forests. It is insectivorous, consuming small species of insects (Acharya et al., 2010; Csorba et al., 1999b; Csorba & Thapa, 2016; Dahal et al., 2024b).

Species distribution modelling is powerful computational tool, use to predict to analyze the possible habitat suitability under the response of future climate change. SDMs are useful to predict how species distribution is affected by climate change, informing conservation strategy, design of long-term conservation action plan, assessment of risk of extinction etc. The ongoing development and refinement of SDMs, along with rigorous validation performances, will continue to enhance their relevance in adapting to and preserving biodiversity amid climate change challenges (Guisan et al., 2017; Pearson et al., 2007; Phillips et al., 2009; Villero et al., 2016).

Species distribution modelling on 11 species of bats, golden monitor lizard (*Varanus falvescens*), fishing cat (*Prionailurus viverrinus*), One horned rhinoceros (*Rhinoceros unicornis*) were conducted in Nepal. Major of them are predicted in to shrink the habitat suitability under future climatic scenarios. This is adverse condition for biodiversity conservation in Nepal because it predict the possibilities of local extinctions (Baral et al., 2023; Dahal et al., 2024a; Mishra et al., 2022; Thapa, Baral, et al., 2021).

Materials and Methods

Study area

This species distribution modelling represents the whole Nepal (Fig 1). Climate and topography of Nepal is directly and indirectly influenced by elevation. Nepal is roughly divided in to three regions Terai, Mid Hills and Higher Himalayas. The terai is plain and low land up to 300 m above sea level (asl.) and characterized by humid and tropical climate. Moving northward, Mid Hills comprising nearly 68 % of total area of country and elevation be between 700 to 3500 m asl. Higher Himalayas is northernmost region of country which occupy nearly 15 % of area and elevation range between 3500 to 8848 m asl. (Karki et al., 2016).

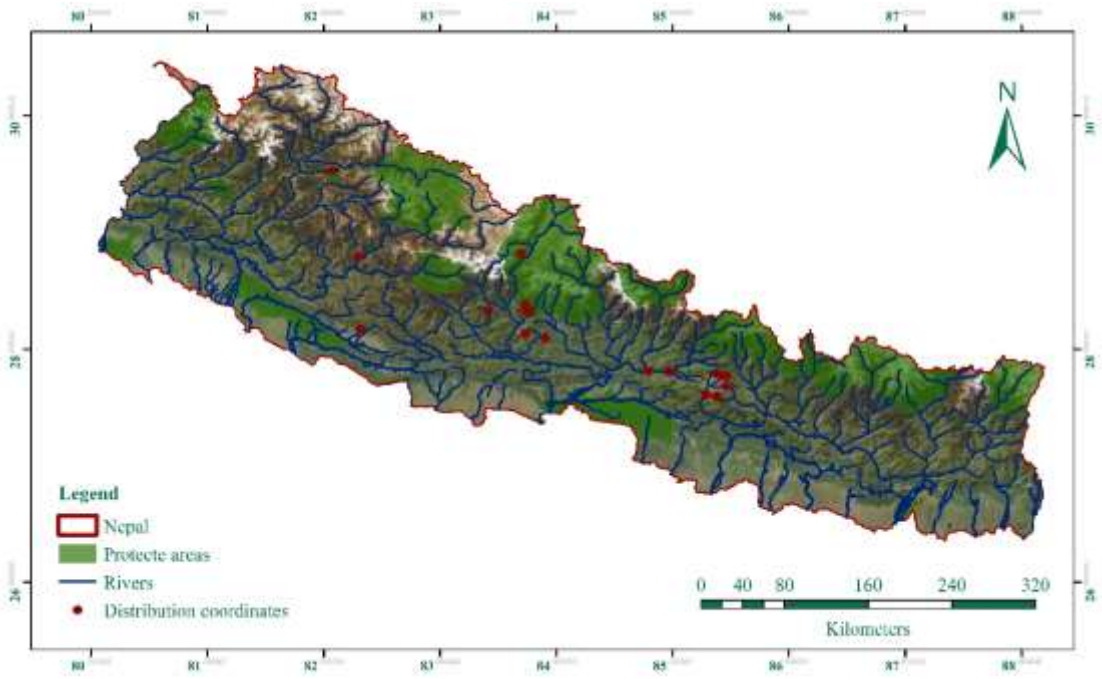

Figure 1

Map of Nepal; red circles indicate the confirmed distribution coordinates of *Myotis csorbai*.

Collection of distribution coordinates

Five distribution coordinates of *M. csorbai* were collected through field surveys, while the remaining were taken from published literatures with proper citation and

reference (Acharya et al., 2010; Csorba et al., 1999b; Csorba & Thapa, 2016; Dahal et al., 2024b; Rai et al., 2021; Thapa, 2020; Thapa, Dahal, et al., 2021).

Bioclimatic, land use and land cover data

19 bioclimatic variable (30 arc-second, ~1km) were downloaded from WorldClim (version 2). For future climatic scenarios, same numbers of bioclimatic variables are download from Coupled Model Inter Comparison Project Phase 6 (CMIP6) for the estimation of global climate model (GCMs) (Dahal et al., 2024a; Thapa, Baral, et al., 2021). For the data of land use and land cover (LULC), moderate resolution data was download from MCDI12Q1V006 (Li et al., 2021). From download LULC data six categories of land use and land cover were extracted these are Agriculture land, Urban land, Grass land, Water, Forest and Unused land.

For the modelling, uncorrelated bioclimatic variables namely Mean diurnal range (Bio2), Isothermality (Bio 3), Temperature seasonality (Bio 4), Mean temperature of coldest quarter (Bio 11), Precipitation of driest month (Bio 14), Precipitation of wettest quarter (Bio 16) and Precipitation of coldest quarter (Bio 19) and uncorrelated land use and land cover variables namely Agricultural land, Urban land, Unused land, Forest, Water, Grass land were used.

Species distribution modelling

Species distribution modelling of *M. csorbai* was conducted by weighted ensemble model by using sdm package R program version 4.3.1 (R, 2020). The weighted ensemble model for multiple algorithms included generalized linear model (GLM), random forest (RF), generalized additive model (GAM), multivariate adaptive regression splines (MARS), boosted regression tree (BRT) and support vector machine (SVM).

Model Validation

Models were evaluated by area under curve (AUC) value and value of true skill statistics (TSS) (Ahmadi et al., 2023; Jimenez-Valverde, 2012). The predicted

models were also evaluated by visual interpretation with the reference of occurrence coordinates (Dahal et al., 2024a; Thapa, Baral, et al., 2021). If the values of area under curve and true skill statistics are closer to one (AUC value > 0.75 and TSS value > 0.50) indicate the models are best to fit (Ahmadi et al., 2023; Dahal et al., 2024a).

Results

The weighted ensemble model showed moderate performance, with AUC = 0.775 ± 0.094 and TSS = 0.5362 ± 0.012 respectively. The estimated current possible distribution coverage is 9171.34 km^2, which is 6.21 % of total area of Nepal (Table 1). Altogether, 21 occurrence coordinates in between Dolakha and Mughu. Most of distribution coordinate were recorded from Mid hills. No distribution coordinates were recorded from Eastern region and western region of Nepal (fig 1). Urban land, agricultural land and mean temperature of coldest quarter (bio11) are major contributing factors but they influence negatively (Fig 2). The current possible distribution range of Csorba's mouse-eared bat in between Chure to Higher Himalayas (Fig 3).

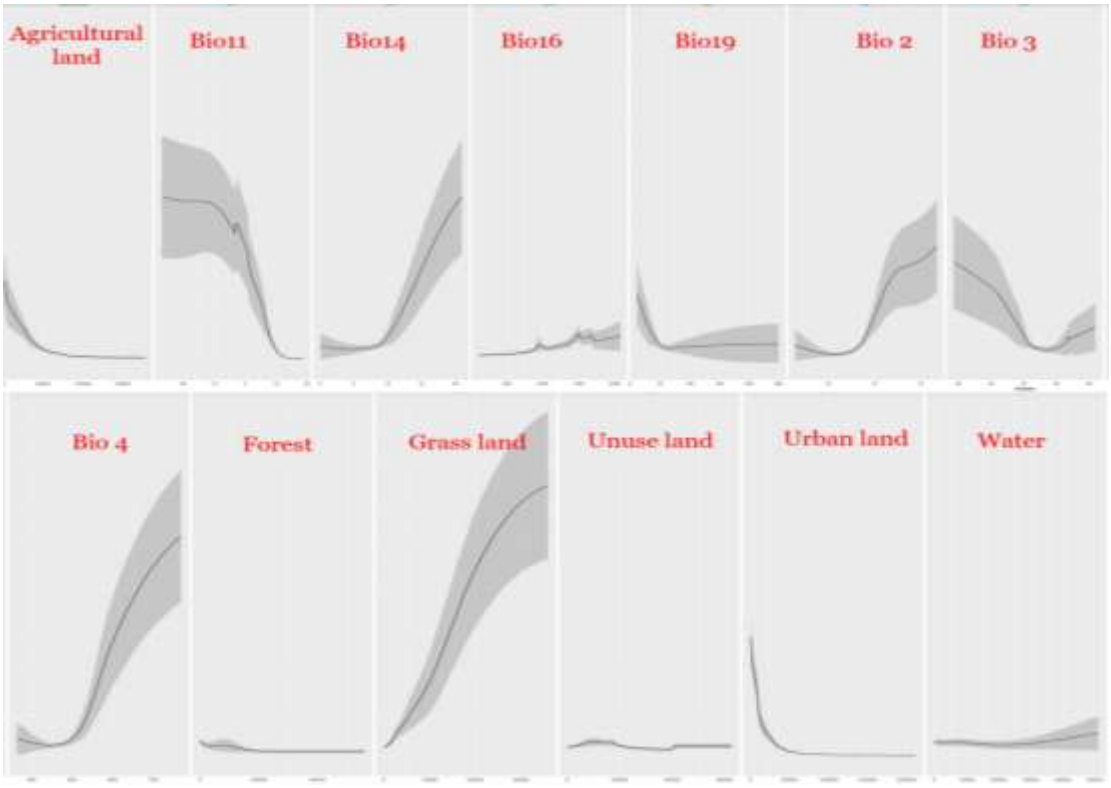

Figure 2

Plot showing the response curve of 13 uncorrelated variables

The projected ensemble with future climatic projections under the scenarios of SSP 4.5 and 8.5. SSP 4.5 represent the higher value of Co_2 emission and SSP 8.5

represent the highest value of Co_2 emission (Hijmans et al., 2005). Overall distribution ranges under future climatic scenarios predict to decreases (Table 1).

Table 1

Area of potential distribution range of *M. csorbai* in Nepal

Scenarios	Area in square kilometer	Total % of coverage in Nepal
Current	9171.34	6.21
4.5_2050	7239.05	4.90
4.5_2070	7423.84	5.03
8.5_2050	7087.2	4.80
8.5_2070	7391.77	5.01

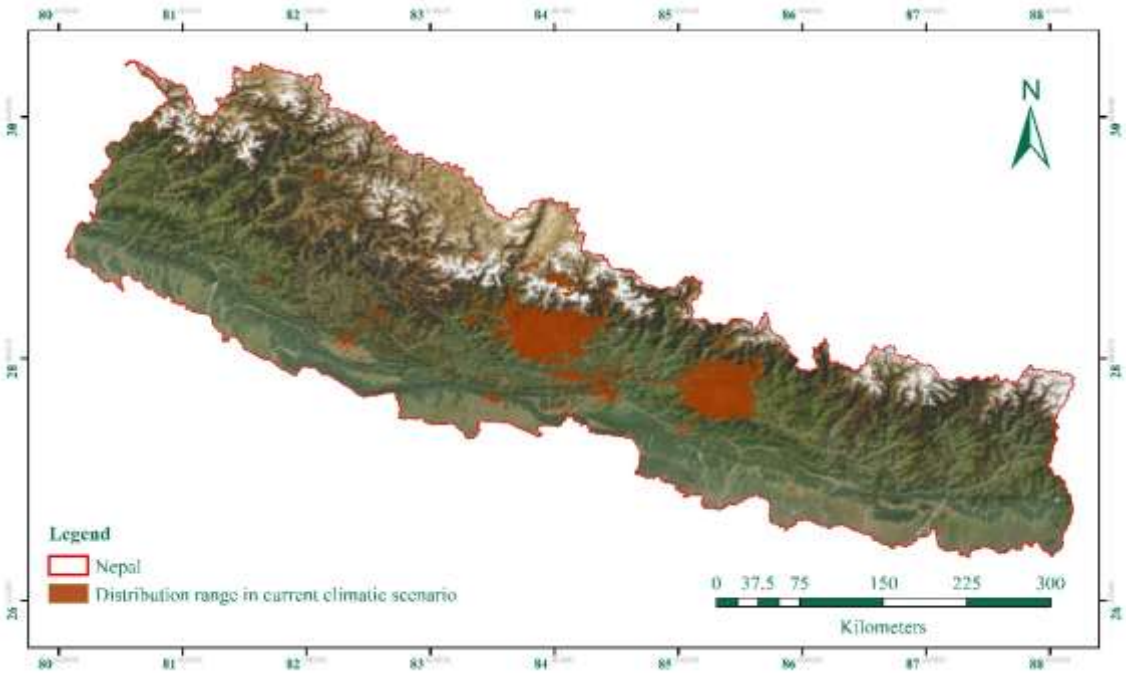

Figure 3

Map of Nepal showing the possible distribution range of *M. csorbai* under current climatic scenario.

By visual inspection of future climatic scenarios, possible distribution range of Csorba's mouse-eared bat is predict to shrink (Fig. 4 and 5). It may cause by the change of temperature and precipitation.

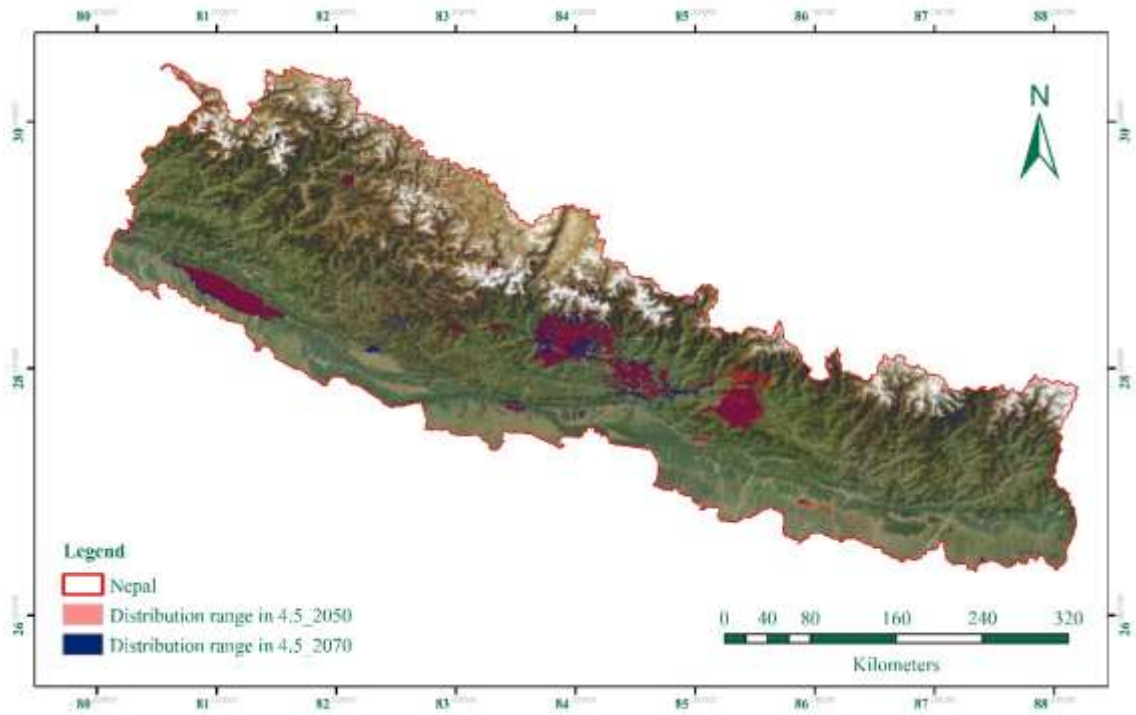

Figure 4

Map of Nepal showing the possible distribution range of *M. csorbai* under future climatic scenario SSP 4.5 in 2050 and 2070.

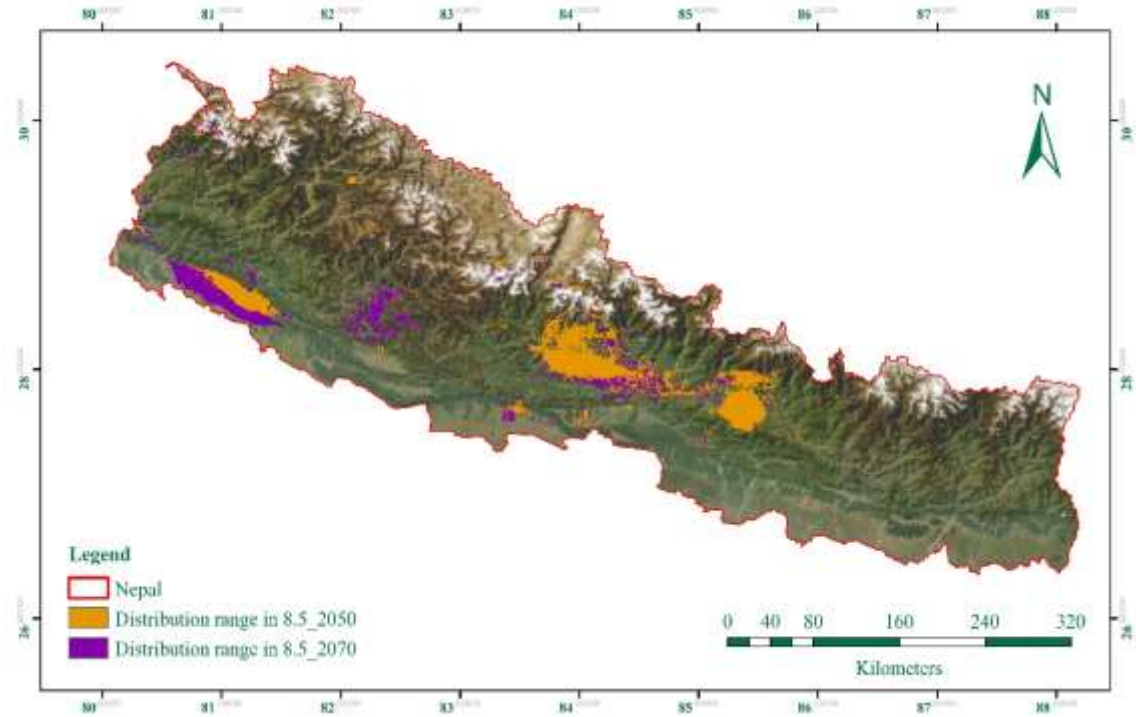

Figure 5

Map of Nepal showing the possible distribution range of *M. csorbai* under future climatic scenario SSP 8.5 in 2050 and 2070.

Conclusions and Recommendations

Conclusions

1. M. csorbai is one of the endemic mammalian species recorded from 21 coordinates situated between Dolakha and Mughu,
2. In the current climatic scenario, distribution of this species is predicted between the mid-hills and the higher Himalayas of central Nepal.
3. *M. csorbai* facing adverse impacts from future climate change, and these weighted species distribution models predict a reduction in their potential distribution ranges.

Recommendations

1. **Intensive survey**

   Intensive surveys and monitoring of *M. csorbai* focusing on caves of mid hill and higher Himalayas are essential for confirming its distribution range in Nepal.
2. **Habitat protection**

   Regular awareness is essential to emphasize the importance of ecosystem services provided by endemic species in Nepal.

   Required to designate critical caves as protected areas under Nepal's Forest Act (2019).
3. **Long term conservation and community engagement:**

   Launch awareness programs that highlight bats' role in pest control by partnering with schools and farmers' groups.

   Long-term conservation action plan is necessary to design for future conservation of endemic species.

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Supplementary Data

S1: Occurrence coordinates of M. csorbai in Nepal were used for Species Distribution Modelling (SDMs).

Species	Latitude	Longitude
M._csorbai	28.81667	83.70000
M._csorbai	28.13333	83.73333
M._csorbai	28.33333	83.41667
M._csorbai	28.38333	83.73333
M._csorbai	28.35000	83.75000
M._csorbai	28.09787	83.90530
M._csorbai	27.61308	85.28923
M._csorbai	27.68267	85.45795
M._csorbai	27.59297	85.37323
M._csorbai	27.59726	85.38081
M._csorbai	27.76667	85.46667
M._csorbai	27.81150	84.78751
M._csorbai	27.80712	84.96786
M._csorbai	28.33556	83.74268
M._csorbai	28.33561	83.74047
M._csorbai	28.31035	83.77351
M._csorbai	28.17123	82.31488
M._csorbai	28.7916	82.29906
M._csorbai	29.52914	82.06223
M._csorbai	27.79190	85.37126
M._csorbai	27.77324	85.42597