

Project title: Conservation of the African elephant (*Loxodonta africana*) in Chebera Churchura National Park, Ethiopia: habitat suitability mapping and assessment of human-elephant conflicts through community participation

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Project summary

African elephants (*Loxodonta africana*) in Chebera Churchura National Park, Ethiopia, are increasingly threatened by human-driven pressures and escalating human–elephant conflict. The situation is further intensified by illegal cattle grazing and the expansion of human settlements inside the park, which degrade and fragment the elephants’ natural habitat. These disturbances force elephants into smaller areas, increase competition for resources, and heighten the likelihood of crop damage and dangerous encounters with nearby communities. Despite these growing challenges, there is limited scientific knowledge about the distribution of suitable elephant habitats within the park or the environmental factors influencing their movements. Likewise, the extent and patterns of human–elephant conflict remain poorly understood, making it difficult to develop effective conservation strategies. To address these information gaps, the project focuses on mapping potential suitable habitats, identifying environmental factors influencing distribution and assessing human–elephant conflict. This process includes gathering ecological data, documenting conflict incidents, and engaging with residents to better understand their experiences and challenges. The project further incorporates conservation education and awareness to promote coexistence and strengthen local support for elephant protection. The findings will provide vital information to a more effective, practical, and cost-efficient conservation initiatives.

Conservation Issue

African elephants in Chebera Churchura National Park face mounting threats from habitat degradation and increasing human–elephant conflict (Ketema & Eshetie, 2018; Tsegaye et al., 2023). Illegal cattle grazing inside the park continue to reduce and fragment natural habitats, restricting elephant movement and concentrating them in areas where food and water are limited (Megaze et al., 2017; Techel et al., 2021). As land-use and land-cover changes fragment habitats and reduce resources, elephants become more vulnerable to retaliatory killings, threatening population stability (Yadeta et al., 2022; Yihune & Tsegaye, 2024). A critical obstacle to effective conservation in the park is the absence of a habitat suitability map and insufficient ecological information on the environmental factors shaping elephant distribution (Tesema et al., 2022). Without these data, conservationists lack the baseline information needed to identify priority

habitats and anticipate areas where conflict is most likely to occur (Guarnieri et al., 2024). Addressing these knowledge gaps is essential for developing targeted, cost-effective management initiatives that ensure both elephant protection and community safety (Ketema & Eshetie, 2018).

Project aims and objectives

Aim

The aim of the project is to support the conservation and management of African elephants in Chebera Churchura National Park by generating a habitat suitability map that incorporates key environmental variables influencing their distribution. The project also aims to provide basic information on habitat protection and engagement through the provision of educational materials.

Objectives

- ✓ Map suitable elephant habitat by identifying key environmental factors that shape elephant distribution.
- ✓ Assess human–elephant conflict and conduct provision of educational materials.
- ✓ Inform long-term conservation strategies by providing wildlife managers with evidence-based recommendations that address the needs of elephants, their habitats, and local communities.

Methods and Preliminary findings

Habitat suitability maps for African elephants and environmental factors affecting the species' distribution

The dataset included 69 presence points distributed across the study area. To reduce spatial autocorrelation, when multiple occurrences fell within the same 1 km × 1 km grid cell, only one point was retained, resulting in 42 unique presence points used for modelling. To characterize the species' environment, I compiled 28 predictor variables, including 19 bioclimatic variables (current), topographic variables (elevation and slope), and indicators of land-cover change such as annual vegetation cover loss and annual forest loss. Additionally, the tasseled cap vegetation indices have also been used in the habitat suitability modeling of endangered species (Treglia et

al., 2015). The tasseled cap indices include the green vegetation index (greenness), soil brightness index (brightness) and moisture index (wetness), indicating moisture retained by vegetation and soil (Campos et al., 2016; Parviainen et al., 2013; Zielinski et al., 2015).

Table 1. Table 1. Predictor variables used for modeling habitat suitability for African elephants

Abbreviation	Description
Bioclimatic variables	
Bio1	Annual mean temperature (Average temperature across the year)
Bio2	Mean diurnal temperature range (Mean difference between daily maximum and minimum temperatures)
Bio3	Isothermality (Ratio of day-to-night temperature variation to annual temperature range.)
Bio4	Temperature seasonality (Degree of temperature variation over the year)
Bio5	Max temperature of warmest month (Highest average monthly temperature.)
Bio6	Min temperature of coldest month (Lowest average monthly temperature)
Bio7	Temperature annual range (Difference between the warmest and coldest months)
Bio8	Mean temperature of wettest quarter (Average temperature during the wettest three-month period)
Bio9	Mean temperature of driest quarter (Average temperature during the driest three-month period)
Bio10	Mean temperature of warmest quarter (Average temperature during the warmest three-month period)
Bio11	Mean temperature of coldest quarter (Average temperature during the coldest three-month period)
Bio12	Annual precipitation (Total yearly rainfall)
Bio13	Precipitation of wettest month (Total rainfall in the wettest month)
Bio14	Precipitation of driest month (Total rainfall in the driest month)
Bio15	Precipitation Seasonality (Variation in rainfall across the year)
Bio16	Precipitation of wettest quarter (Total rainfall during the wettest three-month period)
Bio17	Precipitation of driest quarter (Total rainfall during the driest three-month period)
Bio18	Precipitation of warmest quarter (Total rainfall during the warmest three-month period)

Bio19	Precipitation of coldest quarter (Total rainfall during the coldest three-month period)
Topographic variables	
Slope	The steepness of a surface/angle of incline
Elevation	Height above sea level derived from NASA's Shuttle Radar Topography Mission (SRTM) digital elevation dataset (http://srtm.csi.cgiar.org)
Vegetation productivity	
NDVI	Non-linear transformation of the ratio between the band 3 (red) and band 4 (near-infrared) of Landsat and used as an index of vegetation biomass, density and canopy cover (Pettorelli et al., 2005).
Tasseled cap indices	
Greenness	A measure of photosynthetically active vegetation (Kauth & Thomas, 1976).
Wetness	A measure of soil and vegetation moisture content (Kauth & Thomas, 1976).
Brightness	A measure of bare soil (Kauth & Thomas, 1976)
Anthropogenic, Vegetation and forest	
Human foot print index	A composite indicator of human pressure on the landscape, combining data on population, infrastructure, and land use.
Annual vegetation cover loss	The yearly reduction in vegetation cover, indicating land disturbance or degradation.
Annual Forest cover loss	The annual loss of forested areas, reflecting deforestation and forest degradation.

To minimize multicollinearity among the data, I used a step-wise variance inflation factor (VIF) selection procedure (Guisan et al., 2017). Predictor variables with VIF greater than five were not used for model fitting to avoid multicollinearity effects. Only Six variables were used to map the potential distribution of the species. The selected predictors included Human foot print index, vegetation loss, annual precipitation (BIO12), Normalized vegetarian Index (NDVI), precipitation of the warmest month (BIO13) and Precipitation of driest quarter (Bio 17). The model performance was evaluated by the area under the receiver operating characteristic (AUC) of the receiver-

operating characteristic curve (ROC) (Elith et al., 2006), and the model performance was 'good' (AUC = 0.75).

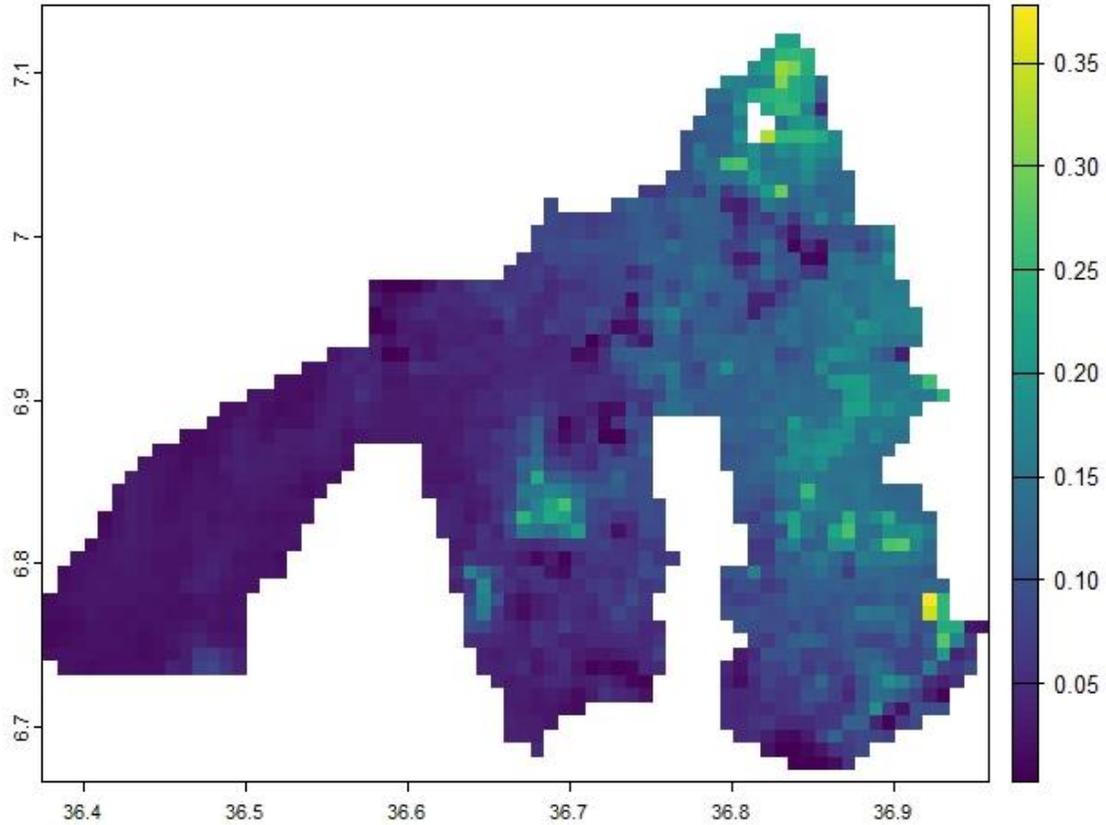


Fig. 1. Potential habitat suitability map African elephant (*Loxodonta africana*) in Chebera Churchura National Park, Ethiopia

Human-related variables dominate model performance, with the Human Footprint Index contributing the highest importance ($\approx 30\%$), followed by Vegetation Loss ($\approx 24\%$) and NDVI ($\approx 22\%$). In contrast, climatic variables play a smaller role, with Annual Precipitation (BIO12), Precipitation of the Warmest Month (BIO13), and Precipitation of the Driest Quarter (BIO17) each contributing less than 10%. Overall, the results indicate that human disturbance and vegetation

condition are stronger predictors of habitat suitability than precipitation-related climatic factors (Fig.2).

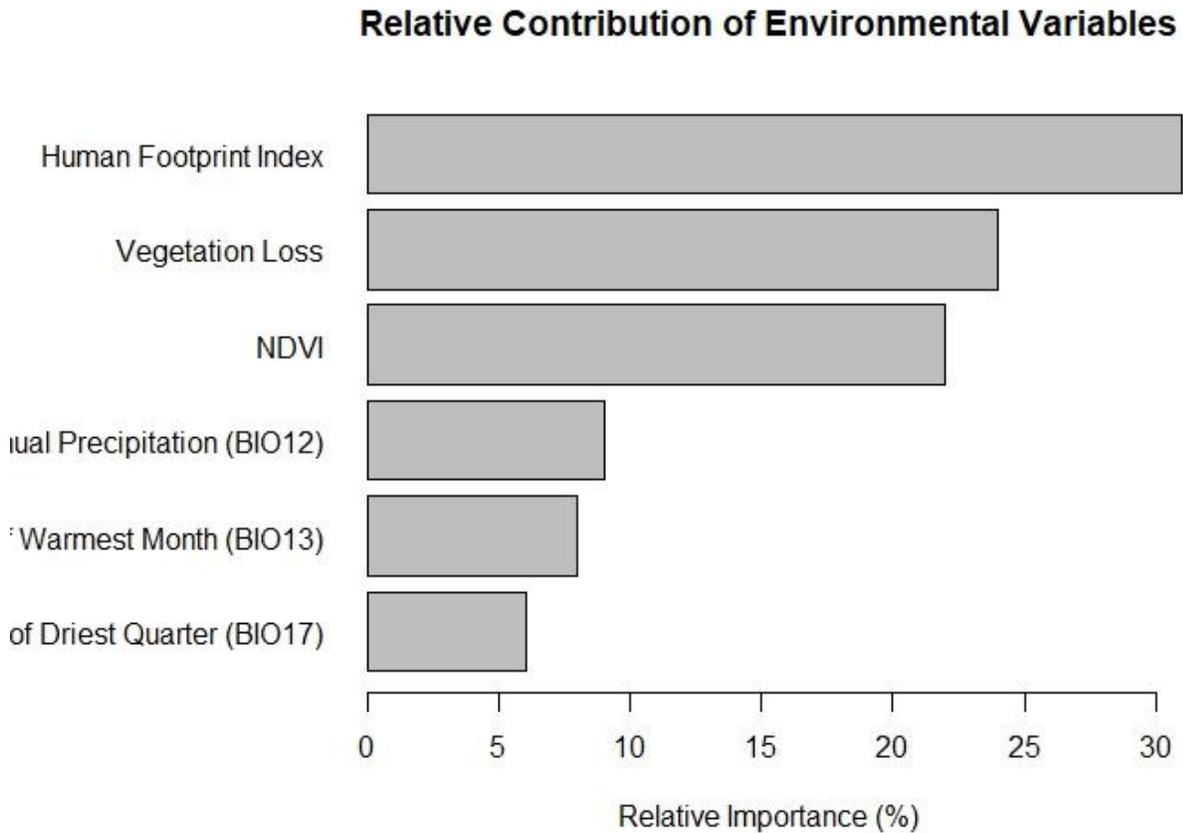


Fig. 2. Relative contribution of the predictor variables for mapping of the species suitability

Challenges facing African elephants (human–elephant conflict)

One of the major challenges to elephant conservation is rapid land-use and land-cover (LULC) change. In and around the Park, the expansion of agriculture, settlements, and infrastructure has led to a marked decline and fragmentation of woodland habitats, which are among the most important habitat types for elephants (Yadeta et al., 2022). As natural habitats are converted, elephants are increasingly pushed into cultivated areas, leading to frequent crop raiding and escalating human–elephant conflict.

Moreover, the expansion of settlements and road networks has facilitated increased human access, contributing to resource extraction, illegal grazing, and other disturbances. Together, these interacting pressures highlight that land-use and land-cover change is not only a driver of habitat loss but also a central factor linking management challenges, and human–wildlife conflict. Addressing these challenges requires integrated landscape-level.



Fig. Expansion of road networks (Photo by Behailu)

Discussions

The habitat suitability map highlights a spatially uneven distribution of suitable areas for African elephants in Chebera Churchura National Park. Highly suitable habitats are largely concentrated in areas with lower human footprint, higher vegetation productivity (NDVI), and limited vegetation loss, indicating the importance of relatively intact woodlands for elephant persistence. In contrast, areas characterized by high human pressure and ongoing vegetation and forest loss were predicted as marginal or unsuitable. This spatial pattern is particularly important for understanding human–elephant conflict, as it suggests that elephants are increasingly confined to shrinking patches of suitable habitat.

As suitable habitats become restricted, elephants are more likely to move through or occupy agricultural and settlement-dominated landscapes to access forage, water, and movement corridors. These transitions across suitability gradients increase the probability of crop raiding and

encounters with people, especially along park edges. From a management perspective, integrating habitat suitability maps with conflict data can help identify priority areas for intervention, such as restoring degraded woodlands, strengthening buffer zones, and implementing community-based conflict mitigation strategies.

Next Steps

Additional predictors will be incorporated to refine the habitat suitability models, and field validation will be conducted to assess the accuracy of model predictions across different suitability classes. This ground-truthing will help improve model reliability and inform management decisions.

In addition, the findings will be shared through conference presentations, and a systematic review of published literature on elephant conservation in Ethiopia will be conducted to place the results within a broader scientific and conservation context.

Recommendations

- 1) Integrate habitat suitability maps into land-use planning to prevent further encroachment into critical elephant areas.
- 2) Prioritize reduction of human pressure by strengthening park boundary enforcement
- 3) Protect and enhance high-NDVI areas identified as core habitat to maintain forage availability, especially during the dry season
- 4) Strengthen community engagement and benefit-sharing to improve local support for elephant conservation.

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