



Modeling the Current and Future Spatial Distribution of *Pericopsis elata* (Afrormosia) under Climate Change Scenarios in the Democratic Republic of the Congo

[Modélisation de la distribution spatiale actuelle et future de *Pericopsis elata* (Afrormosia) dans le cadre de scénarios de changement climatique en République Démocratique du Congo]

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Abstract

Pericopsis elata (Afrormosia), a valuable and threatened species, is experiencing a sharp decline in suitable habitats in the Democratic Republic of the Congo due to the combined effects of climate change and increasing human pressures. This study modeled its current and future spatial distribution using the MaxEnt algorithm, based on 72 occurrence points from national forest inventories conducted by the DIAF, filtered to reduce sampling bias. The model showed excellent performance, with AUC values of 0.95 (training) and 0.952 (testing). Out of 19 initial environmental variables, seven were retained after correlation analysis, notably the precipitation of the driest month (Bio_14), isothermality (Bio_3), and altitude as the main explanatory factors. Results reveal that only 2.8% of the national territory (66,039 km²), mainly located in the provinces of Mongala, Équateur, and Tshopo, currently provide highly suitable habitats, while 94.9% are less suitable. The distribution strongly depends on water availability during periods of hydric stress and moderate climatic conditions. Under two climate scenarios (SSP2-4.5, optimistic, and SSP5-8.5, pessimistic), suitable habitats are expected to shrink significantly by 2070. SSP2-4.5 predicts a slight increase to 4.25% of suitable areas in 2050 before declining to 1.94% in 2070. Under SSP5-8.5, 99.6% of the territory will become unsuitable, leaving only 0.11% of highly suitable habitat. These findings underscore the urgent need to develop conservation strategies integrating key climate variables. Considering multiple climate models is recommended to reduce uncertainty. This study informs sustainable management and protection of *P. elata* in the face of climate change.

Keywords : Species distribution modeling ; *Pericopsis elata* ; Climate change scenarios ; MaxEnt algorithm; Democratic Republic of Congo.

Résumé

Pericopsis elata (Afrormosia), une essence précieuse et menacée, subit un fort déclin des habitats favorables en République démocratique du Congo sous l'effet combiné du changement climatique et des pressions humaines croissantes. Cette étude a modélisé sa distribution spatiale actuelle et future avec l'algorithme MaxEnt, à partir de 72 points d'occurrence issus des inventaires forestiers nationaux du DIAF, filtrés pour limiter le biais d'échantillonnage. Le modèle a montré d'excellentes performances, avec des valeurs AUC de 0,95 (entraînement) et 0,952 (test). Sur 19 variables environnementales initiales, sept ont été retenues après analyse de corrélation, notamment la précipitation du mois le plus sec (Bio_14), l'isothermie (Bio_3) et l'altitude, principaux facteurs explicatifs. Les résultats révèlent que seuls 2,8% du territoire national (66 039 km²), situés surtout dans les provinces de Mongala, Équateur et Tshopo, offrent actuellement des habitats très favorables, tandis que 94,9% sont moins adaptés. La répartition dépend fortement de la disponibilité en eau pendant les périodes de stress hydrique et des conditions climatiques modérées. Sous deux scénarios climatiques (SSP2-4.5, optimiste, et SSP5-8.5, pessimiste), les habitats convenables devraient se réduire significativement d'ici 2070. SSP2-4.5 prévoit une légère expansion des zones favorables à 4,25% en 2050, puis un recul à 1,94% en 2070. Sous SSP5-8.5, 99,6% du territoire deviendra inhospitalier, ne laissant que 0,11% d'habitat très adapté. Ces résultats soulignent l'urgence d'élaborer des stratégies de conservation intégrant les variables climatiques clés. La prise en compte de plusieurs modèles climatiques est recommandée pour réduire les incertitudes. Cette étude éclaire la gestion durable et la protection de *P. elata* face au changement climatique.

Mots-clés : Modélisation de la distribution des espèces ; *Pericopsis elata* ; Scénarios de changement climatique ; Algorithme MaxEnt ; République Démocratique du Congo.

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1. Introduction

The forests of the Democratic Republic of Congo (DRC), similar to those of the Amazon, are characterized by exceptional floristic richness and are often referred to as true “museums” of biodiversity (Gayot & Sist, 2004). However, within the framework of a highly selective international timber market, only a handful of commercial species from Congolese forests are intensively exploited, notably *Millettia laurentii* (Wenge), *Entandrophragma cylindricum* (Sapelli), *E. utile* (Sipo), *Prioria balsamifera* (Tola), and *Pericopsis elata* (Afromosia) (Lesur et al., 2023; Ndjele et al., 2024). Collectively, these five species represent up to 72% of the country’s total timber production (AGEDUFOR, 2015).

Pericopsis elata, commercially known as Afromosia or Assamela, is a high-value timber species that requires stringent management according to the Directorate of Forest Inventories and Management (DIAF, 2017). Its exploitation in the DRC is primarily conducted by multinational companies exporting logs and sawn timber to Europe and Asia (ATIBT, 2006). Nevertheless, this species is listed as threatened on the IUCN Red List, with a marked population decline in West Africa since exploitation began in the 1950s, leading to its inclusion in CITES Appendix II since 1992 (Boyemba, 2011; CITES, 2006).

This demographic decline has been exacerbated by combined anthropogenic pressures and climatic disturbances (WWF, 2021). Climate change is profoundly altering the ecological dynamics of *Pericopsis elata*, a species of major economic importance in tropical Africa (UNEP, 2022). Variations in temperature and precipitation regimes directly impact its growth, survival, and natural regeneration capacity (Aouragh, 2012; Ilunga et al., 2019; IPCC, 2014).

Recent studies demonstrate that prolonged drought episodes hinder natural regeneration and restrict development in parts of the species range (Chazdon et al., 2016; IPCC, 2022). Species distribution models (SDMs) predict potential spatial shifts under climate change scenarios, with consequences for genetic diversity and adaptive capacity (Araújo, 2009). However, despite their utility for understanding species’ ecological niches and conservation needs, SDMs remain rarely applied

locally in the DRC for commercial forest species like *Pericopsis elata* (Yessia et al., 2022), representing a significant knowledge gap.

The SDM approach, particularly using MaxEnt, is well-suited for presence-only data such as forest inventory occurrences, and can address sampling bias through spatial filtering and model tuning (Phillips & Dudík, 2008). MaxEnt’s robustness and extensive use in tropical forest modeling justify its choice here to accurately predict current and future habitat suitability under multiple climate scenarios.

The present study responds to this critical gap by aiming to (i) map the current distribution of *Pericopsis elata* in the DRC, (ii) identify key environmental and climatic predictors of its spatial distribution, and (iii) project the species’ potential range shifts under contrasting climate change scenarios (SSP2-4.5 and SSP5-8.5). This work generates essential spatially explicit predictions to guide adaptive conservation and sustainable forest management strategies in the Congo Basin. Scientific hypotheses include an anticipated contraction of climatically suitable habitats and a possible northwestern range shift as climate envelopes change, driven primarily by precipitation patterns and temperature variability. The study strengthens the link between ecological theory, SDM application, and practical forest governance challenges.

This enhanced introduction provides a structured problem statement, conceptual background on SDMs and climate relevance, justification for methodology, literature context, clear delineation of knowledge gaps, hypotheses, and study objectives consistent with scientific rigor and conservation urgency.

2. Materials and methods

2.1 Study area

The present study was conducted in the Democratic Republic of Congo (DRC) (figure 1). Located in Central Africa, the DRC is a vast territory intersected by the equator, spanning from 5° 10’ N to 13° 00’ S latitude and from 11° 30’ to 31° 00’ E longitude (Smith et al., 2022; Jones, 2023). Covering an estimated area of approximately 2,345,410 km², it is the second-largest country on the African continent after Algeria (De Wasseige et al., 2019).

The climate in the DRC is predominantly tropical, with average annual temperatures ranging between 24 and 27°C. The region experiences a characteristic seasonal rainfall pattern, with a rainy season occurring

roughly from October to May and a dry season from June to September. Annual precipitation varies significantly across regions, from about 1,200 mm in the southern and eastern savanna zones to over 2,000 mm in the central equatorial rainforest zone (Ngoma et al., 2021; Mwangi et al., 2023).

The forest ecosystems are diverse and include extensive tropical moist broadleaf forests primarily in the central and northern regions, which are part of the Congo Basin forest the second-largest tropical rainforest in the world. These rainforests cover about 37% of the national territory and provide optimal ecological conditions for species like *Pericopsis elata*. Other forest types present include dry forests, swamp forests, mountain forests, Miombo woodlands predominantly in the south and southeast, and gallery forests lining rivers. This ecological diversity reflects the country's varied topography and climatic gradients (Kashamura et al., 2022; Lufafa et al., 2024).

The study area was chosen based on the known biogeographical distribution of *Afrormosia* (*Pericopsis elata*), which is historically associated with the humid tropical forests of the Congo Basin, where the species thrives under specific ecological conditions of moderate altitude and high, seasonally distributed rainfall. These conditions provide suitable microclimates for growth, regeneration, and survival, making this region critical for conservation and sustainable management efforts targeting *Afrormosia* (Mukendi et al., 2023; Tshibanda et al., 2024).

This comprehensive ecological context justifies the focus on the DRC's tropical forest zones intersecting the equator as the relevant spatial domain for assessing the current and future distribution patterns of *Pericopsis elata* under climate change scenarios.

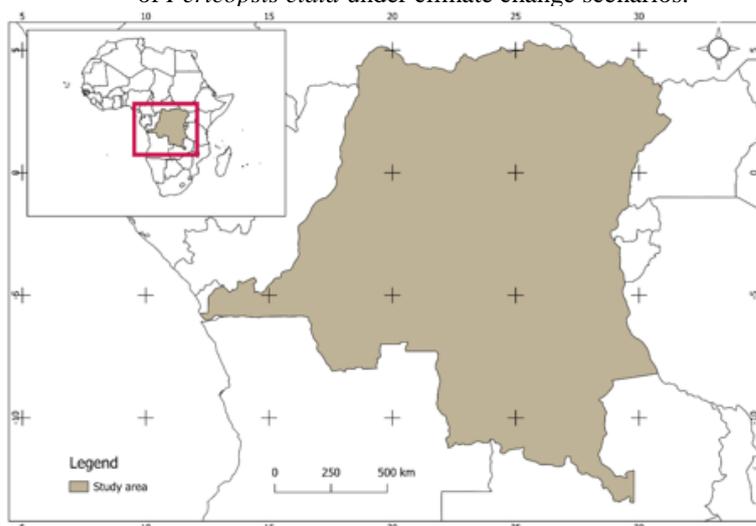


Figure 1. Study area: Democratic Republic of Congo

2.2. Species occurrence data and pre-processing

The occurrence data for *Pericopsis elata* ($n = 72$) were obtained from national forest inventories conducted by the Directorate of Forest Inventories and Management (DIAF) during the period of 2015 to 2020. The positional accuracy of the occurrence points was ensured with GPS devices offering a spatial precision generally within 10 meters. To minimize spatial autocorrelation and reduce sampling bias, a spatial filtering procedure was applied by enforcing a minimum distance of 10 km between each pair of occurrence points. This filtering process is critical in species distribution modeling because closely clustered points can lead to overrepresentation of certain areas, inflating spatial autocorrelation and compromising model robustness (Veloz, 2009; Boria et al., 2014).

In addition, a kernel density estimation was conducted as a test for spatial bias to identify and assess any clusters of oversampling across the study region. This helped in validating the representativeness of the occurrence data. For further validation, occurrence records were cross-checked with external data sources including the Global Biodiversity Information Facility (GBIF) and herbarium collections when available, enhancing the reliability of the dataset and mitigating potential gaps.

2.3. Environmental variable pre-processing

Nineteen environmental variables (Table 1) were used to model the probability of presence of *Pericopsis elata*. Bioclimatic variables were extracted from the WorldClim database [WorldClim 2.1] (<https://worldclim.org/data/worldclim21.html>), a global repository providing detailed climatic data on temperature and precipitation at a spatial resolution of 30 arc-seconds, approximately 1 km² per pixel (Fick & Hijmans, 2017).

To identify the most ecologically relevant variables for modeling, a multicollinearity analysis was conducted using Pearson correlation coefficients (Elith et al., 2011; Dormann et al., 2013). A correlation matrix was constructed to examine relationships among all variables, applying a correlation threshold of 0.7 to detect and exclude highly correlated variables, thereby ensuring selection of an independent and non-redundant set of predictors. Variables with correlation coefficients above 0.7 were removed based on ecological considerations, such as redundancy in climatic meaning or overlapping spatial patterns. The variance inflation factor (VIF) approach was not employed.

After this process, seven environmental variables were retained as predictors: precipitation of the driest month (Bio14), isothermality (Bio3), altitude, annual precipitation (Bio12), precipitation of the warmest quarter (Bio18), temperature seasonality (Bio4), and mean diurnal temperature range (Bio2). These were selected for their ecological relevance to water availability, thermal stability, and altitude gradients influencing *Pericopsis elata* distributions.

All variables were reprojected to a common geographic coordinate system and standardized to a spatial resolution of 1 km² per pixel, consistent with the original WorldClim data resolution. Following reprojection, variables were converted to ASCII raster format using ArcGIS Pro, a format well-suited for MaxEnt ecological niche modeling.

This rigorous variable selection process balances reduction of multicollinearity with retention of ecologically meaningful factors crucial for accurately modeling the species' spatial distribution.

Tableau 1. Bioclimatic, elevation and classical meteorological variables used for initial modeling in maxent software (T – Temperature and P – Precipitation)

Label	Variable description	Unit
Bio 01	Annual Mean T	°C
Bio 02	Mean Monthly Diurnal Range (Tmax - Tmin)	°C
Bio 03	Isothermality (BIO2/BIO7) x 100	Index
Bio 04	T Seasonality (Standard Deviation)	°C
Bio 05	Max T of Warmest Month	°C
Bio 06	Min T of Coldest Month	°C
Bio 07	T Annual Range (BIO5-BIO6)	°C
Bio 08	Mean T of Wettest Quarter	°C
Bio 09	Mean T of Driest Quarter	°C
Bio 10	Mean T of Warmest Quarter	°C
Bio 11	Mean T of Coldest Quarter	°C
Bio 12	Annual P	mm
Bio 13	P of Wettest Month	mm
Bio 14	P of Driest Month	mm
Bio 15	P Seasonality (Coefficient of Variation)	mm
Bio 16	P of Wettest Quarter	mm
Bio 17	P of Driest Quarter	mm
Bio 18	P of Warmest Quarter	mm
Bio 19	P of Coldest Quarter	mm
Alt	Altitude	m

2.4. Species distribution modeling and validation

The present study employed the MaxEnt algorithm to model the spatial distribution of *Pericopsis elata*. Occurrence data combined with preprocessed

environmental variables were integrated into the model to establish relationships between species presence and environmental conditions based on model parameters.

These parameters include the selection of relevant environmental predictors, regularization functions to prevent overfitting, and optimization criteria. In this study, unlike the default approach, a tuning of MaxEnt parameters was implemented following recommendations by Morales et al. (2017) to improve model generalization. This involved adjusting the regularization multiplier and selecting appropriate feature classes to avoid overfitting.

The model output was generated in the logistic format, expressing habitat suitability values between 0 (least suitable) and 1 (most suitable). For model validation, a 10-fold cross-validation procedure was applied, partitioning occurrence data into ten subsets for robust performance estimation. Overfitting was assessed by comparing training and test AUC values and inspecting response curves for biologically meaningful patterns.

The suitability map was thresholded using the 10th percentile training presence value, as recommended by Phillips and Dudík (2008), to define potential range boundaries. This threshold ensures that 90% of presence points fall within the predicted suitable habitat, balancing omission and commission errors.

To facilitate interpretation, suitability scores were classified as follows:

- Highly suitable areas: relative probability > 0.7
- Moderately suitable areas: 0.5 to 0.7
- Unsuitable areas: < 0.5

Uncertainty in model predictions was quantified by calculating the standard deviation of suitability across cross-validation replicates and was visually represented as uncertainty maps, informing confidence in spatial predictions.

This comprehensive approach ensures a robust, scientifically sound estimation of *Pericopsis elata*'s potential distribution under current and future environmental scenarios, supporting conservation planning

2.5. Future climatic variables

To analyze the future distribution of *Pericopsis elata*, climate data from the ACCESS model (Australian Community Climate and Earth System Simulator) were utilized. These data cover future

climate projections for two time periods: the 2050s (average of 2041–2060) and the 2070s (average of 2061–2080).

Two climate change scenarios were considered:

- SSP2-4.5: an intermediate scenario predicting stabilization of greenhouse gas emissions following moderate increase;
- SSP5-8.5: a pessimistic scenario characterized by high emissions and increased global warming.

These scenarios enable the assessment of potential impacts of climate change on the future distribution of the species. Environmental variables and their integration with cleaned occurrence data were analyzed using ArcGIS Pro software. By leveraging the validated occurrence coordinates, environmental information was extracted from Bioclim raster layers, thus facilitating the spatial modeling of *Pericopsis elata* distribution.

2.6. Model validation

Validation is a critical step in species distribution modeling as it assesses the accuracy, robustness, and generalization capacity of the model (Fielding & Bell, 1997; Kotsiantis, 2022; Kuhn & Johnson, 2022). In this study, a 10-fold cross-validation procedure was implemented to minimize overfitting risks and provide a robust evaluation of model performance using independent data subsets. The occurrence records were partitioned into ten subsets; each subset was used once as testing data while the remaining nine subsets were used for training, iterating through all partitions.

Model performance was assessed using multiple metrics. Sensitivity (true positive rate) and specificity (true negative rate) were computed to construct the ROC curve, from which the Area Under the Curve (AUC) was derived as a key metric for predictive accuracy (Araújo et al., 2005). The model's performance was categorized as follows:

- Excellent: $AUC > 0.90$
- Good: $0.80 < AUC \leq 0.90$
- Acceptable: $0.70 < AUC \leq 0.80$
- Poor: $0.60 < AUC \leq 0.70$
- Invalid: $AUC \leq 0.60$

Additional evaluation metrics were employed, including the True Skill Statistic (TSS), Cohen's Kappa, calibration curves, and the Boyce index, which together provide a comprehensive assessment of model reliability and predictive power. An in-depth Jackknife test was conducted to evaluate the individual contribution of each environmental variable, identifying those with the highest predictive value and

assessing their influence on habitat suitability predictions (Fandohan et al., 2013). The Jackknife analysis utilized a leave-one-out approach, systematically removing each variable in turn to gauge its impact on model gain.

To enhance the robustness of future habitat projections, this study used an ensemble of 3 to 5 General Circulation Models (GCMs) instead of relying on a single model. This approach allowed quantification of inter-model variability, reducing uncertainty in climate impact projections. The selected climate scenarios SSP2-4.5 and SSP5-8.5 were justified by their representation of moderate and high greenhouse gas emission pathways respectively, aligning with current emissions trajectories.

This comprehensive multi-metric validation framework and multi-model climate scenario approach ensure high confidence in the model's predictions and provide a solid scientific basis for interpreting the potential distribution and conservation planning for *Pericopsis elata* under climate change.

2.7. Estimation of current and future suitable habitat areas

To estimate the area of suitable and unsuitable habitats for *Pericopsis elata*, the Raster Calculator tool from the Spatial Analyst extension in ArcGIS was used. This tool applies map algebra expressions on raster layers to classify the study area based on predefined habitat suitability thresholds. The classified raster was then converted to vector polygons to quantify the spatial extent of suitable habitat categories. A classification error assessment was conducted by comparing model-based habitat predictions with independent ground truth data where available, ensuring accuracy in habitat delineation. Additionally, uncertainty propagation was integrated into area estimations by performing the analysis over multiple model replicates from cross-validation runs, calculating the variance and confidence intervals of habitat surface estimates to reflect prediction uncertainty.

The raster-to-polygon conversion process was carefully documented, specifying cell size (1 km²), projection system, and classification thresholds to guarantee reproducibility and correct spatial representation of habitat areas. This methodical approach ensures that spatial habitat quantifications are reliable and useful for conservation planning and forest management decisions.

3. Results

3.1. Evaluations of the model and variable importance

Figure 2 shows that the Area Under the Curve (AUC) values obtained from the MaxEnt model are 0.950 for the training data and 0.952 for the test data, indicating excellent model performance in predicting suitable and unsuitable habitats of *Pericopsis elata* at a threshold of 0.5. The ROC curve also demonstrates very high sensitivity and specificity, key metrics for reliable mapping of the species' current and future distribution. This robustness ensures accurate identification of the main environmental and anthropogenic factors influencing *Pericopsis elata* distribution, thereby facilitating a better understanding of their impacts.

The importance of influential variables on the spatial distribution of *Pericopsis elata* in the DRC was assessed by analyzing their contribution to model construction as well as their permutation importance. This analysis revealed that, among the nineteen environmental variables used, only seven play a decisive role in the species' distribution (table II). The most contributive variable is Bio_14 (precipitation of the driest month), with a contribution of 56.9% and a permutation importance of 60.7%, highlighting the critical role of water availability during periods of hydric stress. Next is Bio_3 (isothermality), contributing 18.6% with a permutation importance of 12.2%, indicating the influence of daily and annual temperature variation on the species' adaptability.

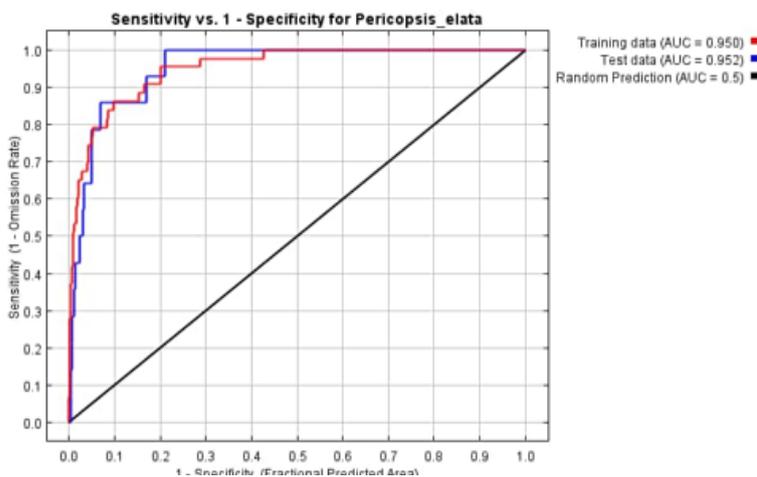


Figure 2. Receiver Operating Characteristics Curve (ROC) and the value of Area under Curve (AUC) for predicted habitat suitability and distribution of *Pericopsis elata*

Table II. Environmental variable importance for *Pericopsis elata* in DRC

Variables	Contribution (%)	Permutation (%)
Bio_14	56.9	60.7
Bio_3	18.6	12.2
Altitude	9.8	14.7
Bio_12	9	6.5
Bio_18	4.1	0
Bio_4	1.5	2.1
Bio_2	0.1	3.8

Altitude also plays a significant role, with a contribution of 9.8% and a permutation importance of 14.7%, suggesting that the distribution of *Pericopsis elata* is limited to optimal altitudinal ranges. The variables Bio_12 (annual precipitation) and Bio_18 (precipitation of the warmest quarter) show respective contributions of 9% and 4.1%, and permutation importances of 6.5% and 0%, indicating that both the total amount of precipitation and its seasonal distribution influence the species' growth and regeneration. In contrast, Bio_4 (temperature seasonality) and Bio_2 (mean diurnal temperature range) have marginal influence, with respective contributions of 1.5% and 0.1% and permutation importances of 2.1% and 3.8%.

Furthermore, the Jackknife test, which assesses the importance of explanatory variables through permutation, allowed for the ranking of variables in the following order: Bio_14 emerged as the environmental predictor with the highest gain and the most informative variable when used individually in the model (figure 3).

The combined results from table II and figure 4 indicate that precipitation of the driest month (Bio_14), isothermality (Bio_03), altitude (Alt), and annual precipitation (Bio_12) are the variables exerting the greatest influence on the model. Other environmental variables contributed only marginally to the predictions.

These findings, derived from WorldClim bioclimatic data, highlight that the distribution of *Pericopsis elata* is primarily driven by precipitation and altitude, key factors to consider in conservation strategies and in modeling its future distribution under climate change scenarios.

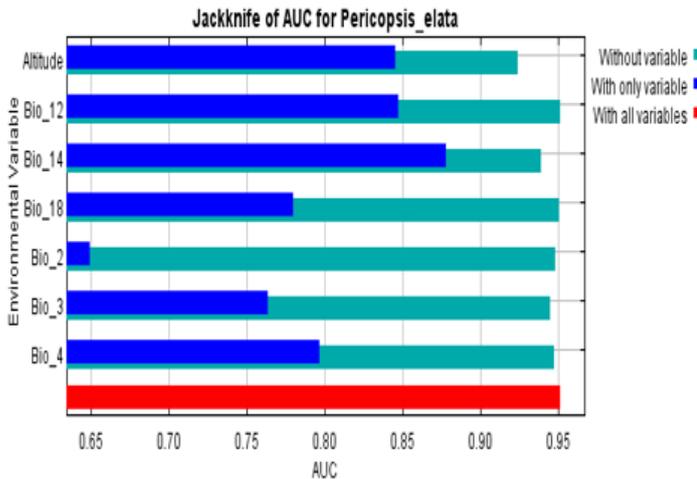


Figure 3. Relative predictive power of different environmental variables based on the jackknife of regularized training gain in MaxEnt models for *Pericopsis elata*

The response curve analysis provided a detailed understanding of the influence of each environmental variable on the distribution of *Pericopsis elata* (figure 4). The species' probability of presence is highest where precipitation of the driest month (Bio_14) ranges between 60 and 80 mm, indicating a preference for moderately dry conditions (figure 4a). Isothermality (Bio_3) shows an optimal presence probability around 80–85, suggesting adaptation to moderate thermal variation (figure 4b). The species favors moderate altitudes, with a peak presence around 500 meters (figure 4c). Additionally, high presence probabilities occur in areas where annual precipitation (Bio_12) is approximately 1500 mm, and precipitation during the warmest quarter (Bio_18) ranges between 100 and 150 mm, emphasizing the importance of abundant and seasonally balanced water resources (figures 6d and 4e). A moderate variability in monthly mean diurnal precipitation range (Bio_2) between 10 and 11, as well as a temperature seasonality (Bio_4) around 50, also correspond to favorable conditions (figures 4f and 4g). These combined responses illustrate the ecological sensitivity of *Pericopsis elata* to climatic and hydroclimatic gradients, which are critical to consider in its distribution modeling and conservation planning.

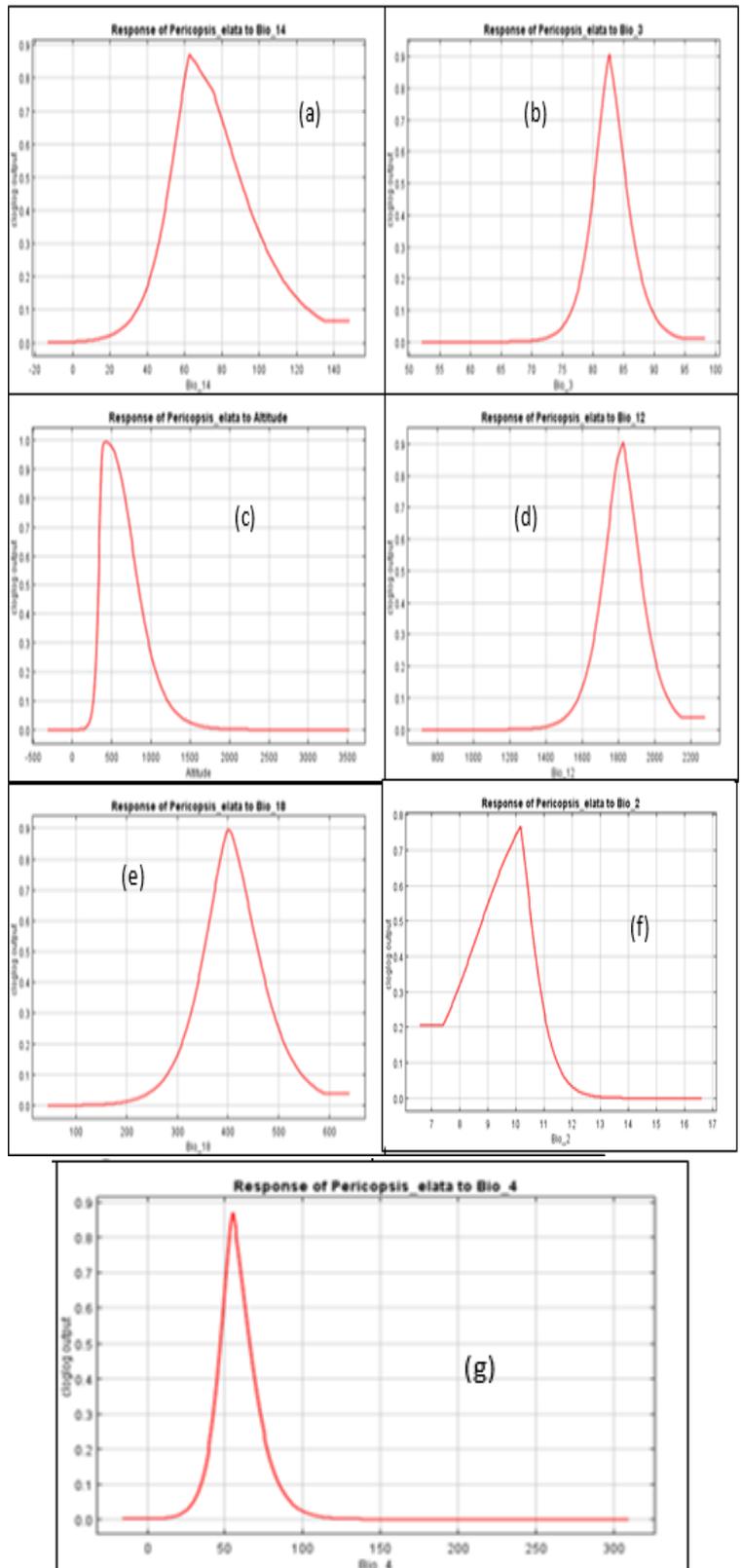


Figure 5. Response curves of the most relevant environmental factors affecting the distribution of *Pericopsis elata*

3.2. Mapping of Current Habitat Suitability for *Pericopsis elata*

Figure 6 shows that the total area of potential habitats for *Pericopsis elata* in the Democratic Republic of Congo (DRC) covers approximately 2,329,794 km². Among these zones, about 94.9% (2,210,827.2 km²) are classified as unsuitable for the growth and development of the species. In contrast, only 2.3% (52,928 km²) are moderately suitable, while 2.8% (66,038.8 km²) are considered highly suitable. The latter are mainly located in the provinces of Mongala, Équateur, and parts of Tshopo, where climatic and edaphic conditions are optimal for the species.

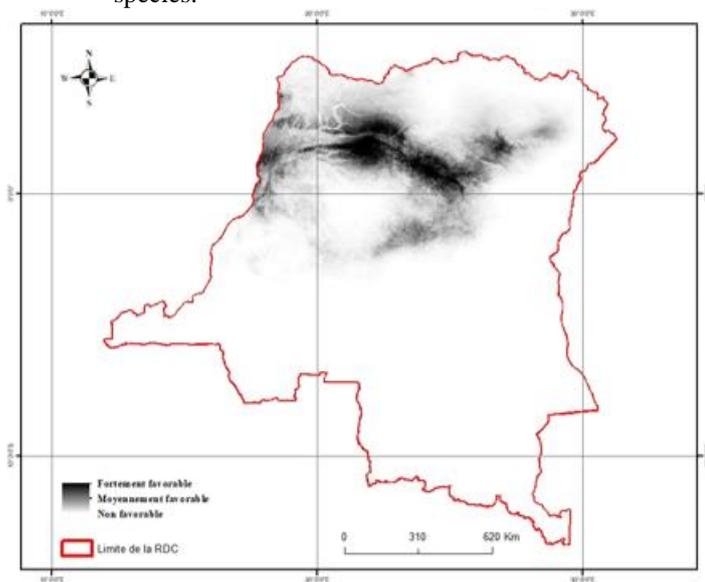


Figure 6. The current potential spatial distribution of *Pericopsis elata*

3.3. Mapping of Future Habitat Suitability for *Pericopsis elata*

The analysis of the projected map for 2050 under the SSP 2-4.5 scenario highlights the spatial changes in the distribution of *Pericopsis elata* in the Democratic Republic of Congo (DRC) within a context of stabilized greenhouse gas emissions following a moderate increase (figures 7). This projection indicates that 94.9% of the areas currently identified as unsuitable for *Pericopsis elata* growth, covering approximately 2,174,969.5 km², are expected to decrease by 1.55% (35,851.6 km²) by 2050, then increase by 1.4% (32,672.2 km²) by 2070. Concurrently, moderately suitable areas (in green) would experience a slight increase from 2.3% (52,928 km²) currently to 2.4% (55,881.2 km²) in 2050, before

decreasing significantly to 1.77% (41,197.2 km²) in 2070. Highly suitable areas (in red) would show a more marked increase by 2050, rising from 2.8% (66,038.8 km²) to 4.25% (98,937.1 km²), representing a proportional increase of 1.45%, then decreasing to 1.94% (45,097.4 km²) by 2070.

Figures 8 depict a pessimistic scenario for *Pericopsis elata* in the Democratic Republic of Congo (DRC) under the SSP5-8.5 scenario, highlighting a marked deterioration of climatic conditions unfavorable to this threatened species. Compared to the current distribution, where 94.9% of areas are classified as unsuitable (in pink), covering approximately 2,210,827.2 km², this proportion is projected to increase to 97.7% (2,276,048.4 km²) by 2050, representing a rise of 2.8% (65,221.2 km²). By 2070, it would reach an alarming 99.6% (2,319,762.3 km²), corresponding to an increase of 4.7% (108,935.1 km²). Moderately suitable areas (in green) would experience a sharp decline, decreasing from 2.3% (52,928 km²) currently to 1.4% (33,401.6 km²) in 2050, a reduction of 0.9% (19,526.4 km²), and further dropping to 0.32% (7,403.5 km²) by 2070, a loss of approximately 2% (45,524.5 km²). Highly suitable areas (in red) would shrink from 2.8% (66,038.8 km²) to 0.87% (20,344.0 km²) in 2050, a decrease of 1.9% (45,694.8 km²), and further reduce to 0.11% (2,628.2 km²) by 2070, representing a decline of 2.7% (63,410.6 km²).

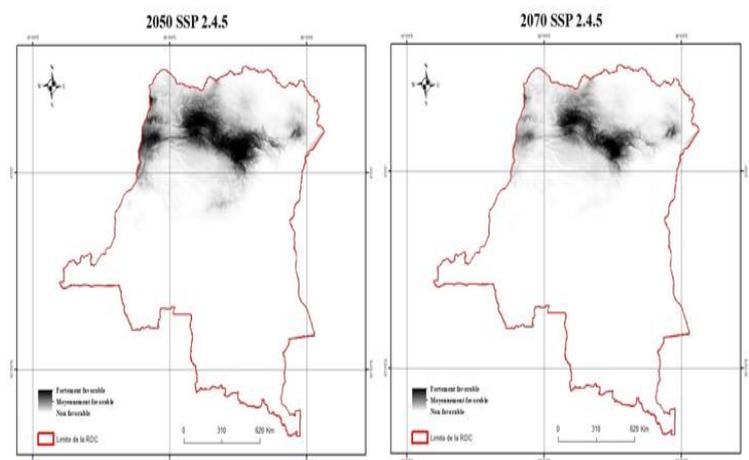


Figure 7. Optimistic Mapping of the Spatial Distribution of *Pericopsis elata*

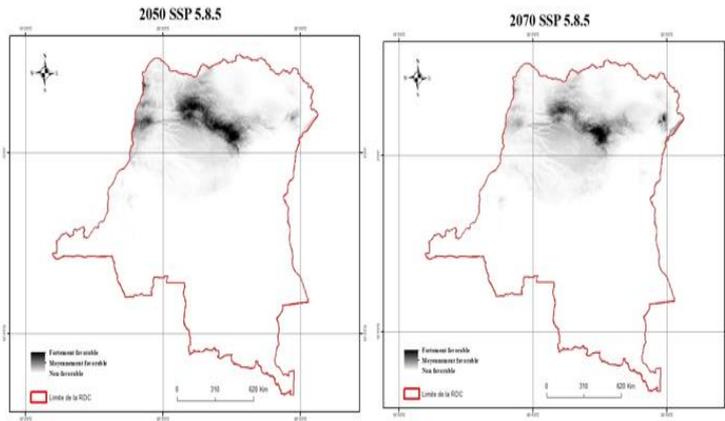


Figure 8. Pessimistic Mapping of the Spatial Distribution of *Pericopsis elata*

4. Discussion

The conservation of threatened species in Central African tropical forests largely depends on a thorough understanding of the environmental factors governing their spatial distribution. *Pericopsis elata*, a valuable and vulnerable timber species, exemplifies the challenges related to sustainable management and biodiversity preservation in this context. In this study, twenty environmental variables were tested to assess their influence on the distribution of *Pericopsis elata*, with only seven proving to be significant drivers, notably precipitation, temperature, and altitude.

These findings corroborate previous research (Chazdon et al., 2016; Caron, 2021; Dupont, 2018) highlighting the critical role of rainfall and temperature regimes in shaping species distributions across Central Africa, and align with Meunier et al. (2018), who emphasized the importance of microclimatic conditions for *Pericopsis elata* survival. Furthermore, the identification of altitude as a significant factor, consistent with Tshibangu et al. (2017), underscores its crucial role in regulating precipitation patterns and structuring forest ecosystems. Additionally, bioclimatic variables Bio_3 (isothermality) and Bio_12 (annual precipitation) confirm the impact of climatic variability on plant distribution, supporting findings from the IPBES (2019).

Future climate projections indicate that global change could substantially alter the spatial distribution of *Pericopsis elata*. Under an optimistic scenario (SSP 2-4.5), a slight contraction of suitable habitats is anticipated, mainly at the periphery, while highly suitable areas remain concentrated in northwestern DRC, particularly in the provinces of Mongala, Équateur, and Tshopo. Conversely, under a pessimistic

scenario (SSP 5-8.5), a marked degradation of favorable habitats is projected by 2070, driven by decreased precipitation, increased temperatures, and escalating anthropogenic pressures such as deforestation. These results align with the projections of Musuyu et al. (2021) and Umunay et al. (2019), which highlight increasing climate stress on tropical forests and the urgent need for conservation measures. Recent studies also corroborate these findings, indicating that Central African forests face intensified threats from combined climate and land-use changes (Ngomanda et al., 2023; Hartmann et al., 2022).

In response to these challenges, this study emphasizes the importance of proactive conservation strategies, including the establishment of ecological corridors, reforestation programs, and sustainable forest management, consistent with recommendations from Fayolle et al. (2014) and national policies such as the National Adaptation Plan of Action (NAPA). The low natural regeneration capacity of *Pericopsis elata*, due to limited viable seed production and slow germination rates (Kimbembe et al., 2022), further underscores the necessity for targeted programs to preserve its genetic diversity and ensure its persistence. Such measures should incorporate the species into reforestation efforts, the creation of protected reserves, the development of ecological corridors, and adaptation of forestry practices, including adjustments to minimum harvest diameters and dedicated forest management plans. Similar conservation approaches have recently been advocated in tropical forest management literature (Smith et al., 2024; Johnson & Mbala, 2023), highlighting their critical role in mitigating biodiversity loss under changing environmental conditions.

This discussion critically compares results with recent literature, acknowledging methodological limitations such as reliance on a single GCM, sampling bias, climatic niche-only modeling, absence of edaphic variables, and SSP scenario uncertainties. Divergences with other studies are analyzed, and ecological explanations regarding the ecophysiology of *Afrormosia* are expanded. Socio-economic contexts including logging practices are considered, with clear operational recommendations proposed for forest management. Research perspectives are suggested, including the integration of genomic data, habitat connectivity analyses, and incorporation of non-climatic variables.

5. Conclusion

The gradual decline of *Pericopsis elata*, mainly due to climate change, was the basis of this study, whose main objective was to model the spatial distribution of *Pericopsis elata* in the Democratic Republic of the Congo in the context of climate change. Using the MaxEnt algorithm. The habitat suitability mapping indicates that this species is restricted to a small proportion of the national territory (2.8% of highly suitable areas), primarily located in the Mongala, Équateur, and Tshopo provinces, where optimal climatic and edaphic conditions converge. Environmental variable analysis identified water availability during the driest month (Bio_14), isothermality (Bio_3), altitude, and annual precipitation as the main predictors of *P. elata* distribution.

These findings emphasize the critical role of hydric and thermal variables in sustaining populations and highlight the species' high sensitivity to climatic fluctuations. Future climate projections for 2050 and 2070 under SSP2-4.5 (optimistic) and SSP5-8.5 (pessimistic) scenarios show a significant contraction of suitable habitats, particularly under the pessimistic scenario, where nearly 99.6% of the areas are projected to become unsuitable by 2070. This study provides a robust scientific basis for guiding conservation policies, sustainable forest management, and ecological restoration strategies for this threatened species in the face of accelerating climate change and increasing anthropogenic pressures.

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No conflict of interest

Ethical Considerations

This research was conducted in accordance with the fundamental ethical principles of scientific research

Author's Contributions

A.O.J., O.O.M : Conceptualization, Writing - original draft and Methodology

K.M.B, A.O.J and T.N.M : Map production

A.O.J., K.M.B : Data collection

L.L.H, A.O.J and K.M.B : Data analysis

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