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Current and future distribution of *Eucalyptus globulus* under changing climate in Ethiopia: implications for forest management

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Abstract
Eucalyptus globulus is a species endemic to southeastern Australia. It has naturalized non-native ranges in other parts of Australia, Europe, Africa, and the western United States. This study is the first of its kind in Ethiopia to model and map the spatiotemporal distribution of the species using species distribution models (SDMs). A total of 874 occurrence records were used from the online Global Biodiversity Information Facility (GBIF) database and field observation. Three environmental variables, including terrain, climate, and soil were used to predict the species' distribution. The terrain, climate, and soil raster grids were resampled to a 200-meter resolution. The Global Circulation Model (GCM) HadGEM3-GC3.1 was used to extract future climate data. This GCM has a good match between the atmospheric and oceanic components showing little drift in its surface climate. Besides, it has the best coverage of Africa. Three climate change scenarios (SSPs 1-2.6, SSPs 2-4.5, and SSPs 5-8.5) were used for predicting suitable habitat of the species. The jackknife test was chosen to assess the importance of each environmental predictor variable. The model's performance was evaluated using the Area under the Curve (AUC) of the Receiver Operating Characteristic (ROC) curve. The model had excellent predictive performance with an average AUC of 0.94. Altitude, rooting conditions, slope, dry-month precipitation, and temperature seasonality are the most important environmental factors in shaping *E. globulus* distribution. Ethiopian highlands are predicted to be more suitable to the species, but the increase in temperature seasonality may reduce suitable habitat under the high-forcing climate change scenario. Climate change is expected to create more suitable habitats for eucalyptus in the future which may encourage plantations in potential distribution areas. Consequently, ensuring long-term forest health necessitates robust management systems prioritizing native trees and responsible grower or farmer practices.

Keywords Climate change, Distribution, *Eucalyptus globulus*, Forest management, Maxent model

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Introduction

Climate change can create suitable niches for some species and challenges for others, leading to changes in species range and community composition (Harley 2011). Species with limited dispersal abilities are the most vulnerable to rapid environmental changes (Araújo and Pearson 2005). The position of a species within its climatic niche is a strong predictor of its sensitivity to climate change, even though other factors such as dispersal ability and genetic diversity play a role (Pérez et al. 2019). In other words, understanding how population growth affects the range of climatic conditions that a species can tolerate is critical for understanding how species will respond to climate change (Liang et al. 2021; Ralston et al. 2016; Valladares et al. 2014).

Eucalyptus globulus (hereafter referred to as Eucalyptus) is well-suited for a wide range of climates and soils. The species is widely distributed due to its ability to tolerate extreme conditions under severe conditions (Davidso, 1989; Paton 1980). Species can adapt to climate change quickly by evolving new traits or changing their behavior (Fensham et al. 2014). Climate change has both inhibiting and contributing effects on Eucalyptus growth and distribution. The species in tropical areas grow best when there is a combination of water scarcity and high temperatures but, in subtropical areas, its growth is more affected by low winter temperatures (Felipe et al. 2020).

The current trend of expanding Eucalyptus tree plantations without considering the environmental impacts is a cause for concern. The changes in land use coupled with climate change are leading to the expansion of Eucalyptus tree woodlots (Bajigo et al. 2019; Luzar 2007). The Eucalypts plantation in Ethiopia has extremely increased over the last decades. However, early Eucalyptus plantings in Ethiopia were not systematically evaluated, so there is no evidence that Eucalyptus was the best species to plant (Pohjonen and Pukkala 1990). The species is often planted for its high biotic potential, but consumes more water than other species (Demel 2000). The expansion of Eucalyptus in Ethiopia is increasing at alarming rate intentionally or unintentionally by farmers, government, and landowners covering farmlands, homesteads, and marginal lands, putting the future of biodiversity and water resources at risk (Bajigo et al. 2019; Gizachew 2017; Jenbere et al. 2012; Yitaferu et al. 2013). Environmentalists are concerned about the potential negative impacts of Eucalyptus plantations on the environment, particularly on water resources (Jaleta et al. 2016). In Ethiopia, several studies have been conducted in various aspects of Eucalyptus trees particularly on *E. globulus* (Abebe and Tadesse 2006; Demel 2000; FAO 2011; Jaleta et al. 2016; Pohjonen and Pukkala 1990; Tesfaw et al. 2023; Zerga 2015), our focal species, but mostly restricted to its hotspots, the highlands. Studies on the distribution of Eucalyptus trees have been conducted in several regions of Ethiopia, including the highlands, but rarely nationwide.

By combining information on habitat suitability and climate change, we can better understand the challenges that species face and how they may be able to adapt or factors contributing to their success (Suarez-seoane et al. 2004). This study aimed to identify overriding ecological factors that help the success of Eucalyptus in Ethiopia as non-native plant species; assess the present distribution status; and predict areas that are likely to become suitable for the Eucalyptus in the future under different climate scenarios. The potential role of climate change in the distribution of Eucalyptus in Ethiopia is a critical question that has not been adequately addressed in the literature. Thus, the study intends to fill this gap by developing a predictive model of Eucalyptus distribution in Ethiopia under changing climate. The results of this study will therefore have important implications for the management of Eucalyptus plantations in Ethiopia and for the broader understanding of the impacts of climate change on forest ecosystems.

Materials and methods

Study area description

Ethiopia, Africa's second most populous nation (after Nigeria) with about 110 million people, offers a treasure trove of cultural and geographic wonders. Ethiopia located between 03°N and 15°N latitude, and 33°E and 48°E longitude (Fig. 1), with a total land area of 1,104,300 km^2. The country's elevation ranges from 116 m below sea level to 4,620 m above sea level (Fig. 1). This diversity of altitudes has led to a wide variety of ecosystems, from the arid deserts of the Danakil Depression to the lush forests of the Western Highlands.

Eucalyptus is a diverse genus with over 100 species in Africa, of which about 55 are cultivated in Ethiopia (Friis 1995). Since introduced to the area, Eucalyptus globulus is a successful tree in Ethiopian highland climates and soil conditions because it coppices vigorously, is not palatable to livestock, and is suitable for fuel wood and construction (Pohjonen and Pukkala 1990). Eucalyptus plantations cover an estimated 506,000 hectares of land in Ethiopia (Birhanu and Kumsa 2018).

Data sources and preprocessing

This study employed four distinct data types for various applications including: (a) point occurrence data were used to fit the species distribution model (b) present environmental variables were used to develop and map species distribution models (c) future climatic data under different emission scenarios were used to predict the potential impact of climate change on species distribution, and (d) land use spatial data was used to track

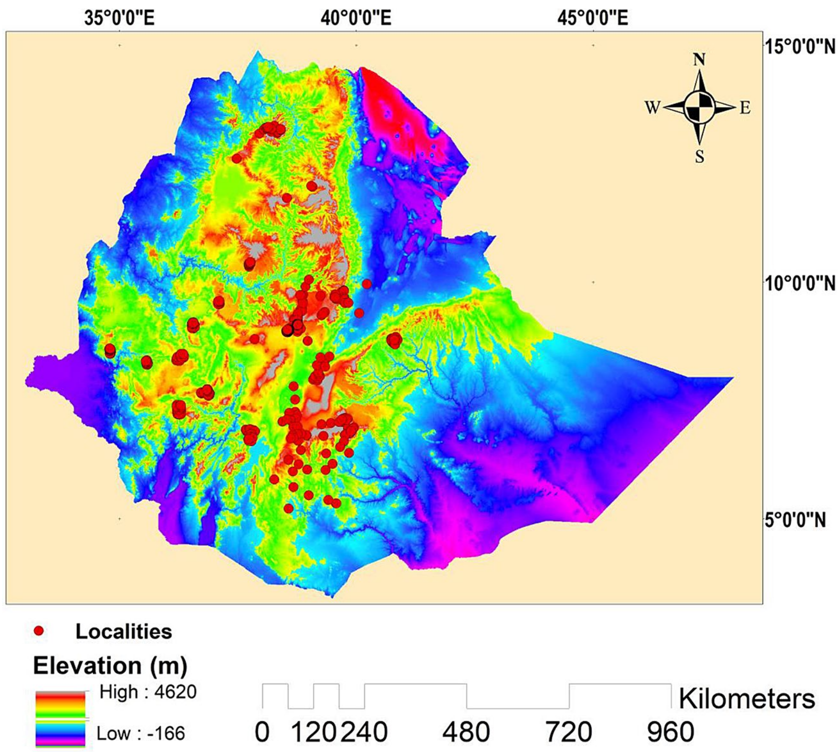

Fig. 1 Localities along elevation gradient

changes in Eucalyptus cover over time and to evaluate the effects of these changes on the composition and functioning of natural ecosystems.

Species occurrence records

Eucalyptus species records were collected from online databases and on-site surveys. We compiled records of Eucalyptus occurrences from the online Global Biodiversity Information Facility (GBIF) (www.gbif.org) database, and from field observation point data record. Through a comprehensive field survey conducted across Ethiopia, focusing on state plantation forest areas and farmlands, researchers meticulously recorded the presence data of the target species. Employing a systematic transect approach, we traversed varied landscapes, precisely recording geographic coordinates (longitude, latitude) and elevation of presence samples at 100-meter intervals using a handheld Global Positioning System (GPS). Although the target species was abundant between 1200 and 2640 m across the study area, our understanding of its distribution above this range remains limited due to the inaccessibility of higher mountains. While state plantation forests offered a controlled environment for sampling, the majority of presence records were unexpectedly clustered around homesteads, roadsides, and sacred sites. However, the locality record data was taken following the transect regardless of the level of patchiness or clustering of the species. Finally, the species occurrence data were standardized to remove records that were repeated. After cleaning and geo-referencing, 874 distribution localities were available for use in the subsequent analyse.

Predictor variables

Climate change is expected to have a complex effect on species, so it is important to include intricate ecological variables in species distribution models (Andriamasimanana and Cameron 2013). Three environmental variables were considered for their potential to predict the species distribution: terrain, climate, and soil. After careful consideration, 19 variables were selected for the analysis (Table 1). Three topographic variables, six edaphic factors, and two potential incoming solar radiation variables were used to model the distribution of the species. A total of 19 bioclimatic variables were acquired, but only eight were found to be significant to species distribution after multi-collinearity testing using Pearson correlation co-efficient ($r > 0.8$), and were therefore retained for further analysis. The raster grids of terrain, climate, and soil were resampled using ArcGIS 10.8 to a 200-meter resolution to ensure that all of the data were consistent. These variables include historical climate data from 1970 to 2000 and future climate data from 2021 to 2040 (2030) and from 2041 to 2060 (2050). The model structural framework is shown in Fig. 2.

Table 1 Environmental variables considered for the distribution model

Category	Short name	Long name	Unit	Source
Terrain	elevation	Elevation	m	www.worldclim.org
	slope	Slope	m/m	www.fao.org
	aspect	Aspect	Degree	
Soil	sq1	Nutrient availability	kg/ha	www.fao.org
	sq2	Nutrient retention capacity	meq/100 g	
	sq3	Rooting conditions	m	
	sq5	Excess salts	dS/m	
	sq6	Toxicity		
	sq7	Workability		
Solar radiation	srad1	Direct normal irradiation	kWh/m^2	www.globalsolaratlas.info
	srad2	Global horizontal irradiation	kWh/m^2	
Climate	bio2	Mean diurnal range	°C	www.worldclim.org
	bio3	Isothemality	°C	
	bio4	Temperature seasonality	°C	
	bio7	Temperature annual range	°C	
	bio14	Precipitation of driest month	mm	
	bio15	Precipitation seasonality	mm	
	bio18	Precipitation of warmest quarter	mm	
	bio19	Precipitation of coldest quarter	mm	

Climate scenarios

They are becoming increasingly pivotal in predicting climate change, conducting related research, and informing climate policy decisions. The data were retrieved at the same spatial resolution as the current climate variables (30 arc-seconds), and were then resampled to a resolution of 200 m.

The Hadley Centre Global Environment Model (HadGEM) (Roberts 2017) is a widely used climate model in Africa due to its highest Effective Climate Sensitivity (ECS) of all Coupled Model Intercomparison Project Phase 6 (CMIP6) models (Andrews et al. 2020; Kuhlbrodt et al. 2018; Williams et al. 2021), and its best coverage of Africa (Davis et al. 2012). This GCM has a good match between the atmospheric and oceanic components; and has been run to produce simulations for many hundred years, showing little drift in its surface climate. The HadGEM3-GC3.1 was used to extract future climate data from the WorldClim2.1 database. The prediction of species habitat suitability and distribution took into account three of four climate change scenarios (Table 2). The Intergovernmental Panel on Climate Change (IPCC) launched the shared socioeconomic pathways (SSPs) in 2010, which are a more comprehensive set of future climate change scenarios than those used in past studies. SSPs have been used to quantify the relationship between climate change and socio-economic development pathways.

Maximum entropy modeling

The potential distribution of eucalyptus in Ethiopia has not yet been studied using SDMs. The MaxEnt model was deemed the optimal technique for modeling the suitable habitat of eucalypts in Ethiopia. This non-parametric classification method is popular because it can use presence-only data from random subsets of predicted and predictor variables (Fitzpatrick et al. 2013; Phillips et al. 2006). The method has therefore been recommended for use in ecological and species distribution modeling applications (Elith et al. 2011; Guillera-Arroita et al. 2014; Merow et al. 2013; Phillips and Dudı´k 2008). Additionally, it is also the best technique for some comparative analyses in species distribution modeling, and has been chosen to model and map species habitat suitability as a function of environmental variables (Merow et al. 2013; Phillips et al. 2017).

Although there is no consensus on the best set of parameter values to use in MaxEnt, the user still needs to specify a set of parameters, such as the percentage of test data, the number of background points, the type of feature, the clamp, and the regularization multiplier before fitting. The model was run 10 times using a subsampling technique. In a strategic compromise between precision and practicality, the MaxEnt model's default configuration strikes a balance with a convergence threshold of 5,000 iterations and a maximum of 10,000 background points, enabling accurate predictions without excessive computational demands. A default regularization value of 1 was used to prevent the model from overfitting and to strike a balance between model complexity and simplicity (Phillips and Dudı´k 2008; Warren and Seifert 2011). Finally, the data was split into a 75% and 25% set to train and validate the model's predictions, respectively.

The performance of the model was evaluated by calculating the area under the curve (AUC) of the receiver operating characteristic (ROC) curve. AUC is a measure

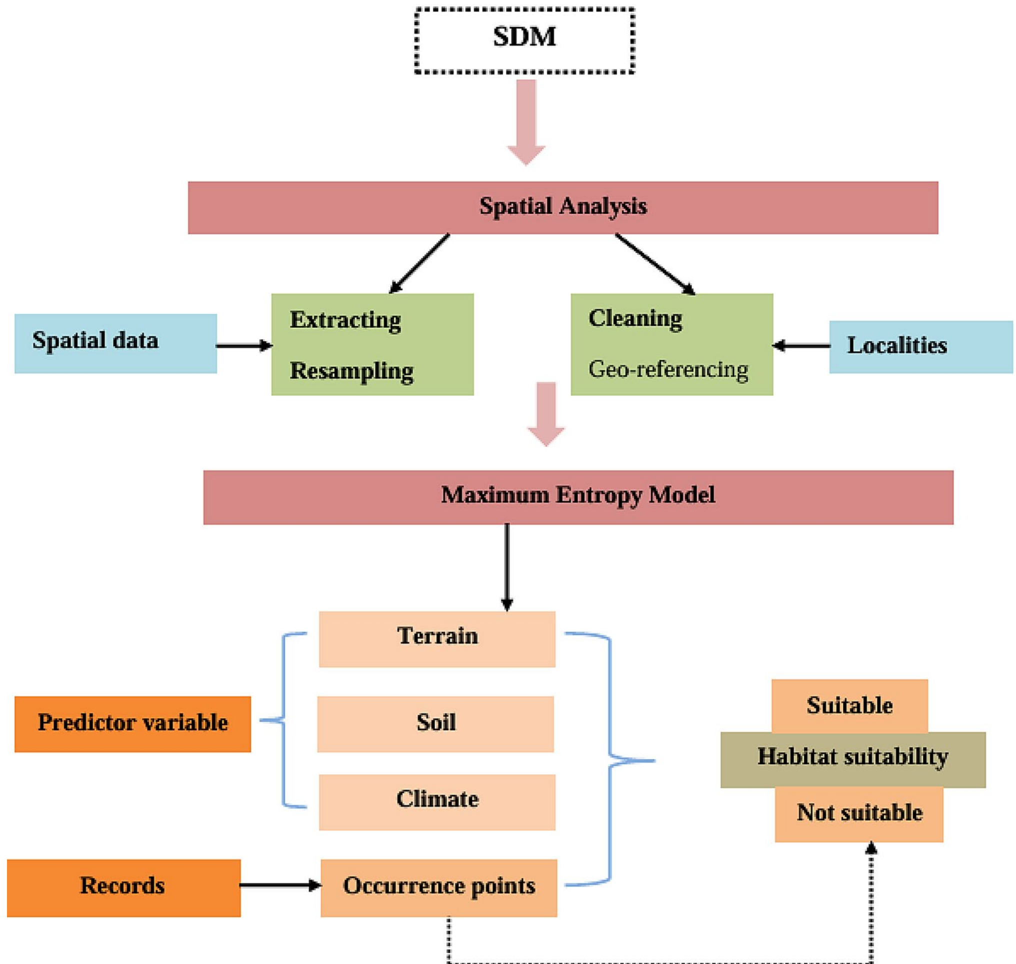

Fig. 2 The model structural framework

Table 2 The four emission scenarios

Emission	Description
SSP1–2.6	SSP1 (Low forcing scenario) Upgrade to RCP2.6 scenario based on (Radiative forcing reaches 2.6 W/m2 in 2100)
SSP2–4.5	SSP2 (Medium forcing scenario) Upgrade to RCP4.5 scenario based on (Radiative forcing reaches 4.5 W/m2 in 2100)
SSP3–7.0	SSP3 (Medium forcing scenario) New RCP7.0 emission path based on (Radiative forcing will reach 7.0 W/m2 in 2100)
SSP5–8.5	SSP5 (High forcing scenario) Upgrade to RCP8.5 scenario based on (SSP5 is the only SSP scenario that can achieve radiative forcing to 8.5 W/m2 in 2100)

of model performance that ranges from 0 to 1. An AUC of 1 indicates perfect performance, while an AUC of less than 0.5 indicates a model that performs worse than random chance. Model performance is classified into five categories, from failing to excellent, based on the AUC value: failing (AUC < 0.6), poor (0.6 ≤ AUC < 0.7), fair (0.7 ≤ AUC < 0.8), good (0.8 ≤ AUC < 0.9), and excellent (AUC ≥ 0.9) (Gebrewahid et al. 2020). The jackknife test was used to determine the importance of each variable in affecting the suitable growth area of the eucalyptus tree.

Spatial and statistical analysis

ArcGIS 10.8 was used to calculate the areas of different potential suitable zones over time. The grid values of the suitable and non-suitable zones predicted for Eucalypts in each period were reclassified in ArcGIS 10.8. The classes above the threshold value were classified as suitable zones and assigned a value of 1, while the classes below the threshold value were classified as non-suitable zones and assigned a value of 0. The distribution changes of the eucalyptus tree were calculated, and the area variation range of the potential distribution areas in each period (2030 (2021–2040): SSPs1–2.6, SSPs 2–4.5, SSPs 5–8.5, 2050 (2041–2060): SSPs1–2.6, SSPs 2–4.5, and SSPs 5–8.5) was obtained. We prioritized 2030 and 2050 for their insights into near- and mid-term impacts, offering crucial timing for policy interventions based on projected eucalyptus distribution changes.

Table 3 Model's prediction accuracy and major predictor variables relative importance

AUC values	Predictor variable	Percentage contribution
Mean (0.935)	Elevation	53.5
Training data (0.946)	Rooting conditions	10.6
Test data (0.934)	Slope	6.8
Random prediction (0.5)	Precipitation of driest month	3.8
	Temperature seasonality	3.7

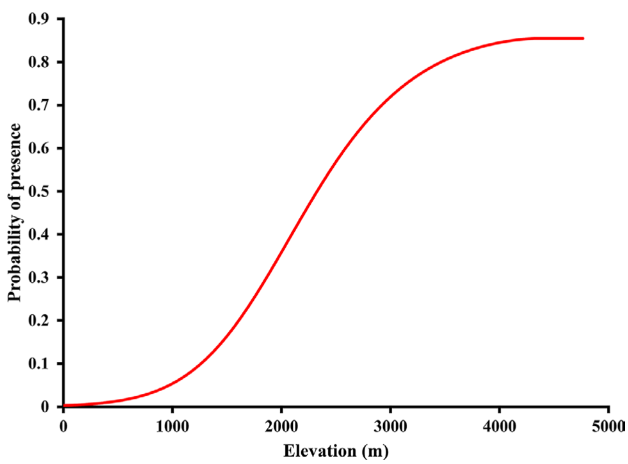

Fig. 3 The effect of elevation on the predicted distribution of Eucalyptus

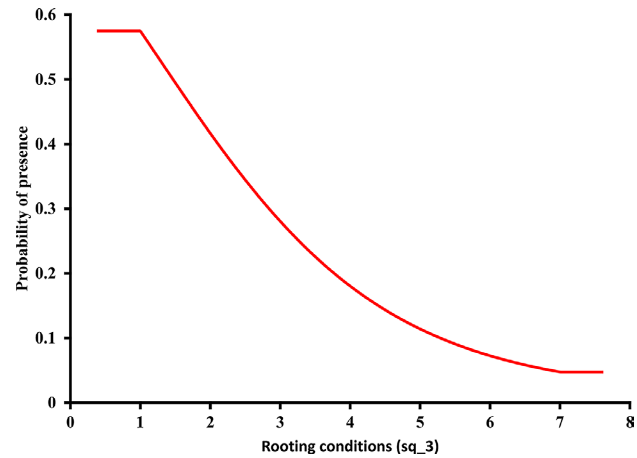

Fig. 4 The effect of rooting conditions on the predicted distribution of Eucalyptus

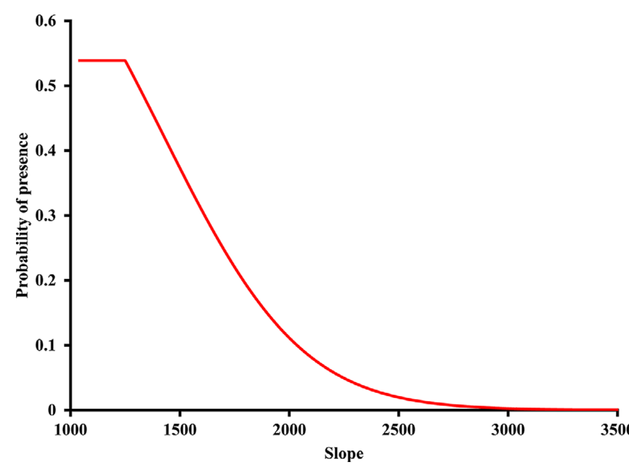

Fig. 5 The effect of slope on the predicted distribution of Eucalyptus

To systematically examine the data's key characteristics and patterns, descriptive statistical techniques were employed. These methods, adept at summarizing and organizing essential numerical information, painted a comprehensive portrait of the dataset. The resulting insights, meticulously presented through a tapestry of well-structured tables and visually compelling figures, facilitated clear comprehension and interpretation of the data's salient features, fostering a deeper understanding of the underlying phenomena under investigation.

Results

MaxEnt model prediction accuracy evaluation

The receiver operating characteristic (ROC) curve showed that the area under the curve (AUC) values for the training and test datasets were 0.946 and 0.934, respectively (Table 3). This indicates that the MaxEnt model developed to predict areas of suitability for Eucalyptus has a high degree of agreement between the training and test data.

The jackknife test results for the contributions of the predictor variables to the MaxEnt model are shown in Table 3. Elevation and rooting conditions were the most important variables, with contributions of 53.5% and 10.6%, respectively. The other variables with moderate contributions to the MaxEnt model were slope (6.8%), precipitation of driest month (3.8%), and temperature seasonality (3.7%). These above five variables accounted for 78.4% of the total contribution, making them the dominant environmental factors affecting the potential distribution of Eucalyptus in Ethiopia.

Key environmental factors influencing species distribution

The results show that altitude, rooting conditions, slope, precipitation of the driest month, and temperature seasonality were identified as the most determinant environmental factors governing the potential distribution of Eucalyptus in the region. Figures 3–7 shows the response curves for the main environmental factors affecting Eucalyptus distribution. When the probability of Eucalyptus distribution is greater than or equal to 0.5 and the suitability condition is considered to be suitable distribution, the following environmental conditions are met: Elevation is 2000–3000 m, rooting conditions is 2–4 m (medium root system), slope is >1500 m/m, precipitation of driest month is 100–150 mm, and temperature seasonality is 3–10 °C. Similarly, at the optimal

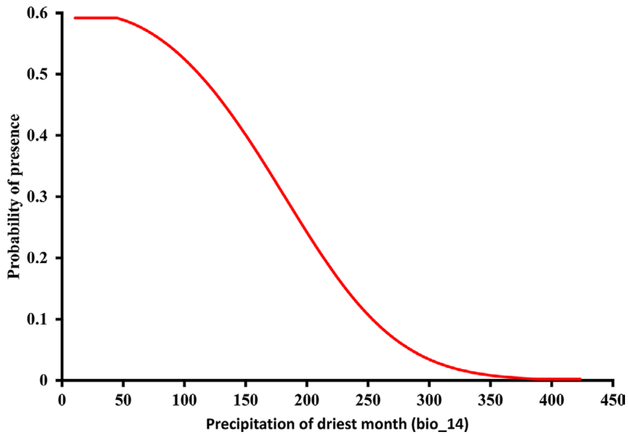

Fig. 6 The effect of precipitation of driest month on the predicted distribution of Eucalyptus

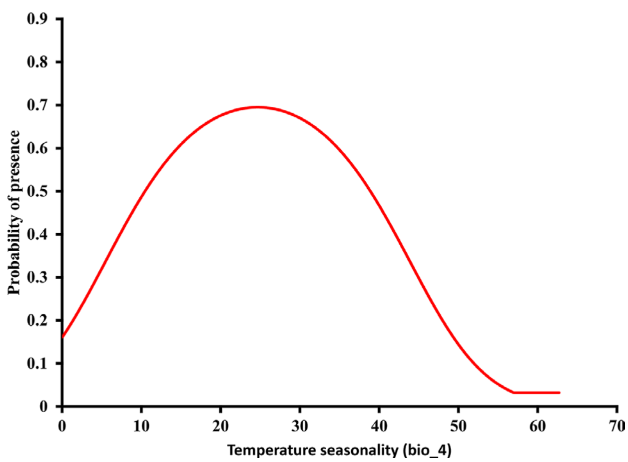

Fig. 7 The effect of temperature seasonality on the predicted distribution of Eucalyptus

Table 4 Predicted changes in Eucalypts expansion and cover for the specified period and scenarios

Period	Area (ha)	Change (ha)	Loss (%)	Gain (%)
Current	5359378.85	-	-	-
2030s, SSPs1-2.6	5564658.29	205279.44		3.83
2030s, SSPs2-4.5	4383356.37	976022.48	18.21	
2030s, SSPs5-8.5	4240131.05	1119247.8	20.88	
2050s, SSPs1-2.6	7826645.39	2467266.54		46.04
2050s, SSPs2-4.5	8309965.66	2950586.81		55.06
2050s, SSPs5-8.5	3866925.09	1492453.76	27.85	

environmental conditions for Eucalyptus distribution, the corresponding elevation, rooting conditions, slope, precipitation of driest month, and temperature seasonality are 4000–5000 m, 0.5–1.5 m (shallow root system), 1000–1300 m/m, 1– 50 mm, and 15 –35 °C, respectively.

Predicted effects of climate change on Eucalyptus distribution

Ethiopia has currently 5359378.85 hectares of suitable habitat for eucalypt, which is about 5% of its total land area (Table 4; Fig. 8). These areas are mainly distributed in the northern, central, southern, and western highlands and plateaus. Under three different future scenarios of greenhouse gas emissions, MaxEnt model projections show a potential decrease in net area cover and expansion by the 2030s, followed by an increase in the 2050s (Table 4; Figs. 9 and 10). The decrease in net area cover and expansion by 2030 varied between 18.21% and 20.88%, depending on the climate change scenario. Under the moderate and high forcing scenarios, the decrease was greater. Under the low and moderate forcing scenarios, the increase in net area cover and expansion by 2050 varied between 46.04% and 55.06%, with the higher increase occurring under the moderate forcing scenario. Despite the overall increase, climate change scenarios still showed clear differences in their impact on the species. By the 2030 and 2050 s, the net area cover and expansion of Eucalyptus is expected to increase by 3.83% under SSPs1-2.6 and decrease by 27.85% under SSPs5-8.5, respectively.

The high-forcing climate change scenario (SSPs5-8.5) has a significantly greater impact (around 49% higher) on the decrease in surface area cover between 2030 and 2050 than the low-forcing scenario (SSPs1-2.6). Most importantly, the low and moderate forcing climate change scenarios are expected to cause a nearly 105% increase in surface area cover between 2030 and 2050.

Discussion

The study findings revealed that topographic variables are the environmental features that most strongly influence the distribution of eucalypts in Ethiopia. The species is most likely to be found in areas with high elevation and gentle slopes. In this study, the first variable refers to areas with an altitude of more than 2,500 m above sea level, and the second variable implies areas with a relatively slight incline. This finding is consistent with recent studies on the autecology of this species in China (Ouyang et al. 2021) and Spain (Lázaro-Lobo et al. 2022), which showed that topographic variables are more important than other environmental variables in determining its distribution. Altitude, the most important factor in this study, was also the second most important factor in aforesaid study in China. Therefore, *Eucalyptus globulus* has succeeded in the Ethiopian highlands (the hotspots) since its introduction, adapting to the local climate and soil conditions (Pohjonen and Pukkala 1990).

The second most important variable is rooting conditions, an edaphic factor. Trees may develop deep and wide root systems that reach into cracks in the bedrock

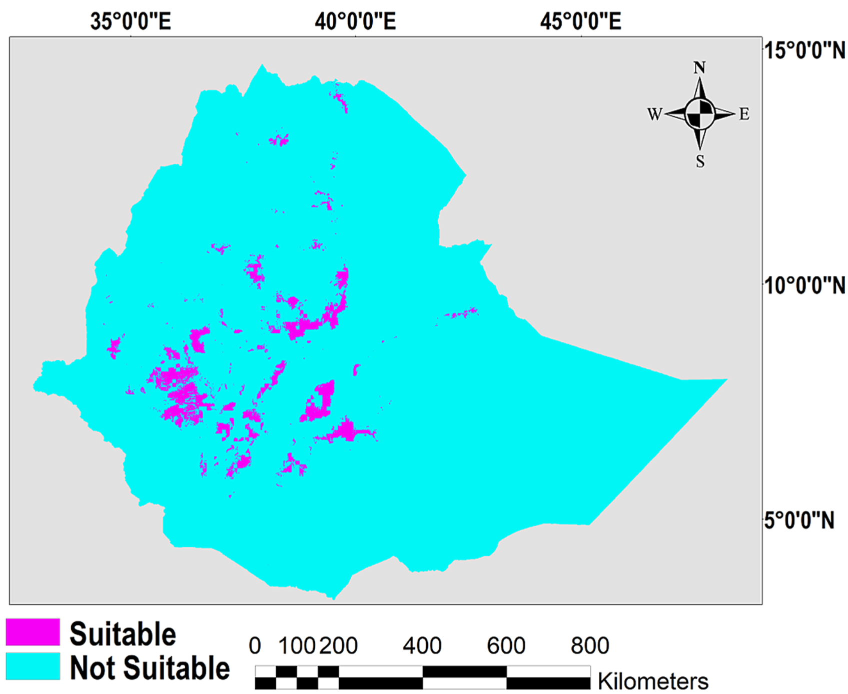

Fig. 8 Current potential expansion of Eucalyptus in Ethiopia

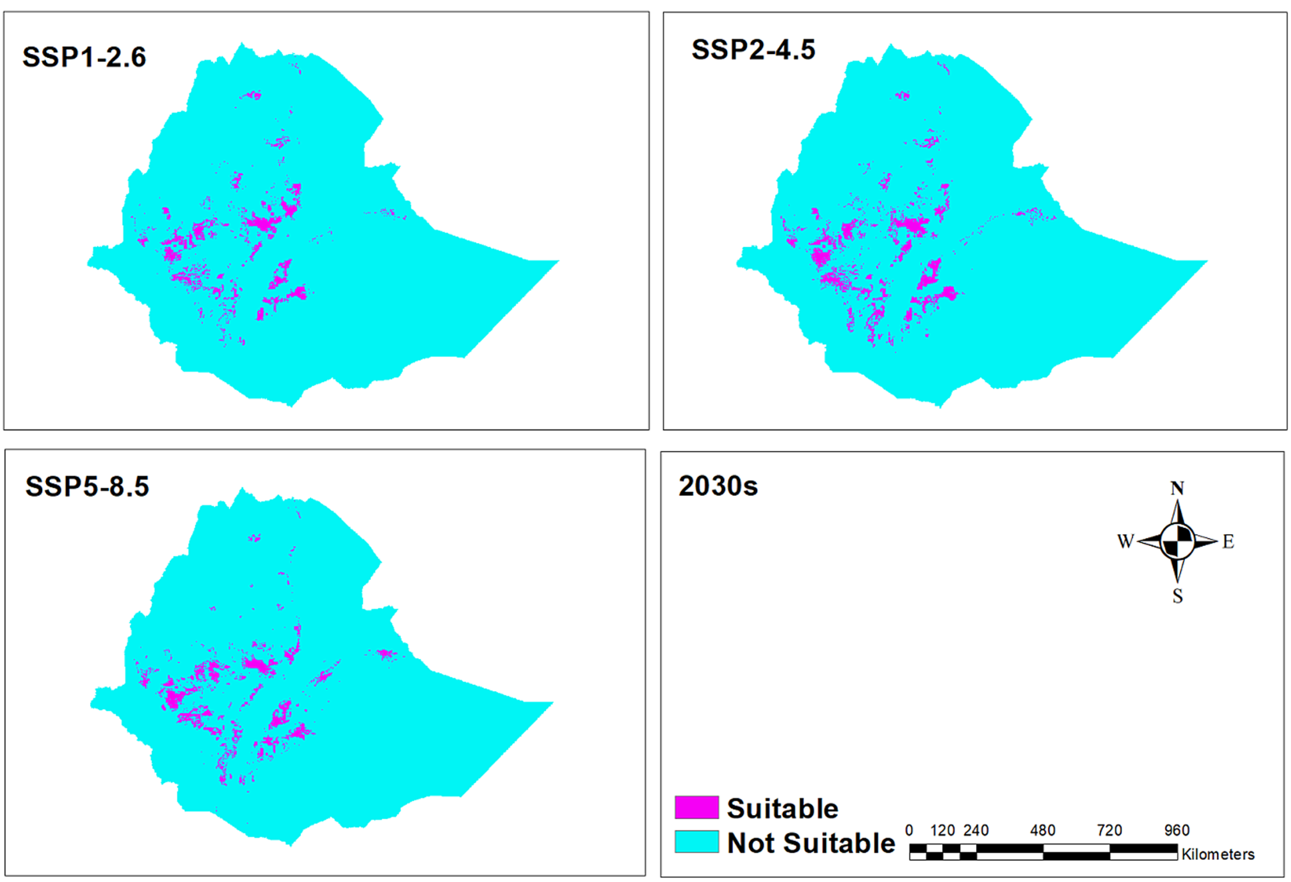

Fig. 9 MaxEnt model predictions of future potential expansion of eucalypt under different climate change scenarios

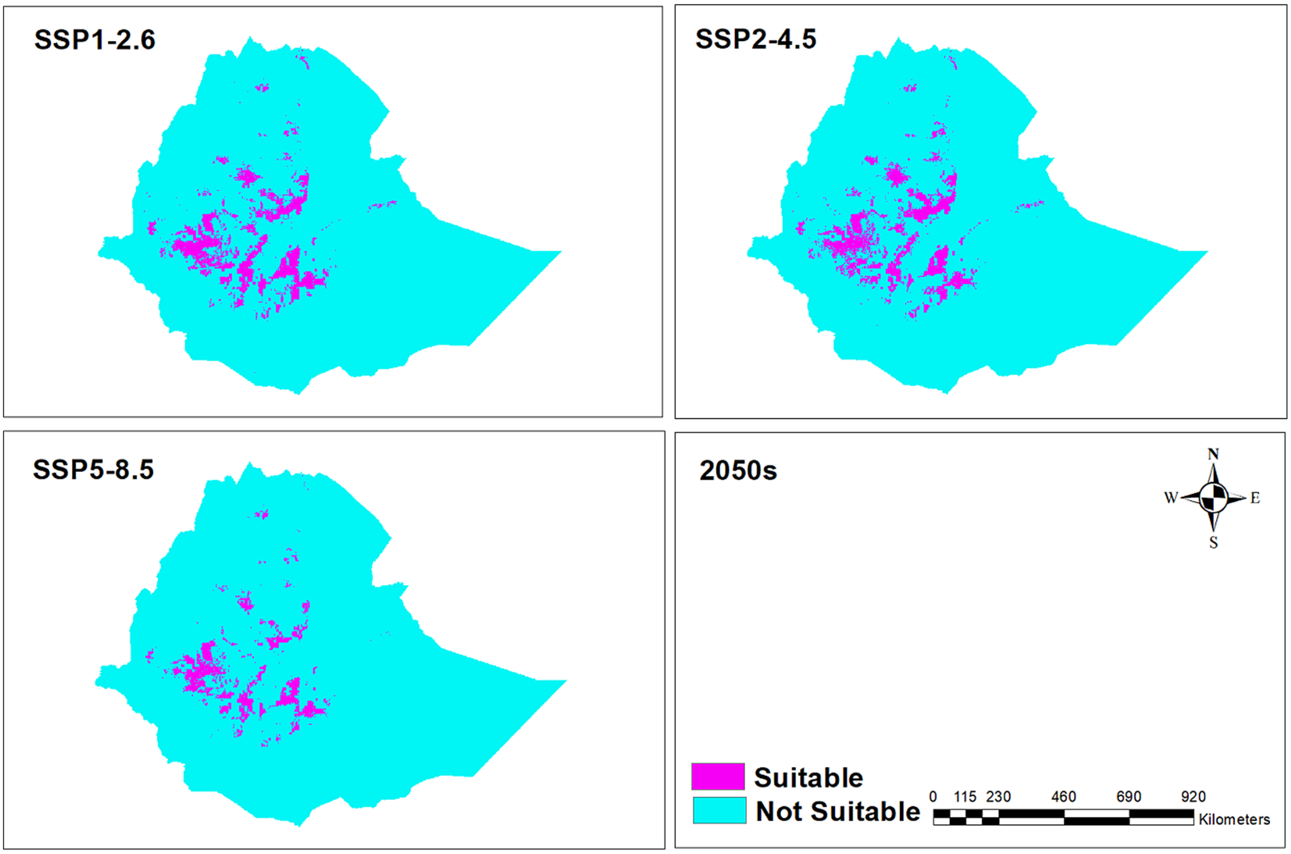

Fig. 10 MaxEnt model predictions of future potential expansion of eucalypt under different climate change scenarios

below the soil to find water when it is scarce (Nepstad et al. 1994). Nevertheless, they need less extensive root systems when water is abundant (Matthes-sears and Larson 1995). Thus, the abundant water availability in the Ethiopian highlands, the species' hotspots (Tesfaw et al. 2023), allows the species to develop a shallow rooting system. Most of Ethiopia's surface water resources are in the highlands, where 78% of the country's renewable surface water is generated by river basins (Berhanu et al. 2014; FAO 2016).

The fourth and fifth most important variables are related to the precipitation of driest month and temperature seasonality. Eucalyptus globulus is typically found in areas with 600–1100 mm of annual rainfall in its native range, and is not present in areas with less than 500 mm of annual precipitation (Bean and Russo 1989). The high average annual precipitation of 2000 mm in the study area (Ashkriz 2015) may entail why pluviometry variables are less important than topographic variables. The positive effect of precipitation of the driest month on the distribution of eucalyptus suggests that the soil water storage was insufficient, leading to rapid depletion of soil water during the summer. Moreover, this study shows that thermal variables, especially temperature seasonality, have a moderate impact on the distribution of eucalyptus in Ethiopia. The species is most likely to be found in areas with low to medium temperature variability, which is consistent with its autecological records (Cerasoli et al. 2016).

Despite the large area currently occupied by eucalypts in Ethiopia, the developed SDM indicates that there is potential for their range to continue to expand. Our model predicts a significant expansion of suitable habitat for eucalypts in the highlands under both low and moderate forcing climate change scenarios. Tesfaw et al. (2023) recently found that eucalyptus coverage and expansion increased by 69% in the northern part of Ethiopian highlands over the past two decades.

Eucalyptus plantations expanded rapidly throughout the Ethiopian highlands, primarily motivated by economic need driven factors (Gizachew 2017; Yitaferu et al. 2013). Farmers and growers in the study area primarily establish eucalyptus woodlots as a livelihood strategy, both to meet household wood consumption needs and generate cash income (Bajigo et al. 2019). The preferred species is also fast-growing and highly tolerant of difficult environmental stresses (Demel 2000). Furthermore, Eucalyptus species have evolved a variety of adaptations to survive in diverse environmental conditions, including severe droughts, poor soil, fire, and insect damage

(Davidso, 1989). The species succeeded in Ethiopian highland climates and soil conditions because they coppice vigorously and are not palatable to livestock (Pohjonen and Pukkala 1990).

The retraction of suitable habitat in the high forcing scenario between 2030 and 2050 is likely due to temperature-related variables, particularly temperature seasonality. The probability of eucalyptus occurrence reaches its maximum when temperature seasonality peaks between 20 and 30 °C, and then rapidly decreases to near zero as temperature seasonality continues to increase (Fig. 7). As average temperatures in Ethiopia are projected to increase by 4.1 °C by 2070 under high forcing climate scenario (Tassie 2016), significant declines in the amount of suitable habitat for eucalyptus species can be expected, as observed in this study.

Conclusions

The central, northern, southern, and western highlands of Ethiopia are expected to experience a substantial increase in suitable habitat for eucalyptus, favored by topographic factors and increased precipitation in the region. However, the expected increase in temperature seasonality is likely to reduce suitable habitat for eucalyptus by 2030 and 2050 under the high-forcing climate change scenario. Despite the apparent expansion of suitable habitat for eucalyptus under future climatic conditions, the establishment of new plantations is not guaranteed. National government legislation and socioeconomic changes, including environmental policy reforms, could play a crucial role in mitigating or even reversing the expansion of eucalyptus species.

Abbreviations

AUC Area under the Curve
GBIF Global Biodiversity Information Facility
IOM Institute of Medicine
SDMs Species Distribution Models

Author contributions

GBM conceived the work, designed methods, collected data, and wrote the draft; NT and MAR designed study, analyzed data, wrote and revised the manuscript. The authors read and approved the final manuscript.

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Data availability

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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