Response of Species to impact of climate change in Gum Arabic Belt, Sudan: Case study *Acacia senegal*

.

ABSTRACT

Sustainable management strategies are imperative for numerous indigenous agroforestry plant species, such as *Acaciasenegal*, as they confront mounting challenges from rapid population growth, ~~explanation~~ explanationsin cultivated areas, and environmental threats like climate change. The goal of this study was to forecast the spatial distribution of *Acacia senegal* in the Gum Arabic belt in Sudan in the current (1985–2000) and for future climate scenarios (2021–2100). Bioclimatic data was employed for modeling purposes utilizing Maxent, with the assessment of model precision conducted through the utilization of the Area Under the Curve (AUC) and showed a high goodness-of-it (AUC=0.905±0.003). Significant differences were ~~showed~~ shownin species distribution between current and future periods under Shared Socioeconomic Pathways (SSPs) of SSP2-4.5 and SSP5-8.5 scenarios. Our findings indicated the main predictors ~~was~~ werebio16 and bio5 ~~with~~ with the highest percent of contribution (*56.3* % and *10.5 %*). Under the current potential distribution (25.4%), it is projected that Acacia Senegal would expand 36.2%-87.7% (SSP2-4.5) and 38.9-42.5 %(SSP5-8.5). It is expected that Acacia Senegal will create new environments suitable for it due to expected climate changes. Hence, the research necessitates the formulation of a strategic plan aimed to ~~rehabilitation~~ rehabilitateplantations of *Acacia senegal* and ~~cultivation~~ cultivatethese species within existing and prospective habitats conducive to their development. Whereas this plan seeks to enhance ecosystem functionalities and guarantee their sustained existence amidst shifting climatic conditions, owing to the economic, societal, and ecological advantage.

1. INTRODUCTION

Population growth, ~~expanding~~ expansionin Agricultural areas, and CO2 emission are crucial ~~threating~~ threatswhich are affecting direct or indirect on biodiversity especially within sub-saharan Africa. Which is most region threatened by climate change in Africa [1], [2]. Region of arid and semi-area importance of this region socially, environmentally, and economically, its biggest threat is climate change and land degradation is caused by unsustainable agriculture, overgrazing, desertification, and deforestation [3]. *Acacia senegal* holds higher significance as a prevalent species within the Sub-Saharan region [4]. *Acacia senegal* naturally occurrence either as a Common extensive pure stand or in mixed with other species in a good diversity , such as semi-desert grassland, Anogeissus woodland and rocky hill slopes, the species can grow on the different soil texture (sandy -light loamy soils) [5]. It is a species of trees and forests shrubs have multiple purposes for commercial uses, food industries, medicine, and cosmetics. it also support the dry-land ecosystem[6]–[9][10].

Geographic shift for species is caused to climate change especially in Africa[11], [12]. For instance there is some studies are actively focus to understand how the climate change effects on the geographic shift of various species by using predictive modeling's(Maxent) [13], [14][15]). Predictive modeling, which relies on environmental data sourced from documented occurrence sites, plays a pivotal role in analytical biology. It finds applications in different fields such as those related to the environment such as sustainable management programs of reserves, ecology, evolution, and epidemiology. This approach enables the prediction of species geographic distributions and plays a significant role in understanding and addressing biological phenomena [16]. Maxent is a proper method when dealing with insufficient or incomplete information to make prediction or extract inferences for species distribution at current potential area or new suitable area. It serves as a general-purpose tool for analyzing and estimating outcomes based on limited data availability. It's employ by estimating a target probability distribution through the identification of the probability distribution with maximum entropy. This corresponds for distribution that is most spread for species. It achieves this by considering a set of constraints that represent the limited information available regarding the target distribution [17]. Maxent offers several advantages and a few drawbacks, which will be compared to other modeling methods. Some of these benefits include leveraging presence data and environmental information across the entire study area, eliminating the need for absence data, Ability to handle both continuous and categorical data, allowing for the consideration the relationships among various variables. The presence of effective deterministic algorithms ensures convergence to the optimal probability distribution with maximum entropy. The Maxent probability distribution is defined concisely, simplifying analysis and interpretation [16], [17].

2. MATERIAL AND METHODS

2 METHODOLOGY

2.1Site Description

The location of Gum Arabic belt in the middle of Sudan , which is extended from western border of Sudan to the eastern border Sudan and cover an area about 520,000 Km2, Gum Arabic Belt in Sudan find in the area among 10° N and 14° N, which is covering 1/5 from the total area of Sudan (Eltohami, 2018). Sandy soils are predominant in the western (Darfur stats) and central (Kordofan's stats) with pockets of clay Soil (vertisol) in these area, while clay soils are commonly found in the eastern (Al-Gadarif stat) and (Blue Nile stat) in southern region [18], [19]. The mean annual rainfall in this region in range between 100-800 mm [20]. Specifically, the study area is diversified trees species dominated by many family like Fabaceae a, Apocynaceae, Poaceae, Balanitaceae[21]–[23]. The natural vegetation is woodland savannah dominated by various species for instance: *Dichrosta. Cortolaria senegalensis* (Al-Safari Plant) *Acacia seyal*, Sorghum happens (Adar), *A. polyacanthaWild.*, and*Combretum spp.*, [24] .Additionally in this region the common vegetation cover can describes like poor rangeland and scatter woody plants dominated by Acacia species, *Leptadenapyrotechnica* [25]. Recently, in the areas to the north of west Darfur is dominated by the low rainfall Woodland Savanna forest, which form vegetation cover. While the herbal species include different species:*Chloris gayana*, *Cassia obtusifolia*, and *Tribulus terrestris*, beside where the dominant tree species are Acacia species, whereas formerly Savanna woodland species predominated the area [26]. The southern geographical area holds a diverse array of species, encompassing fruit-bearing trees such as *Adansonia digitata*, *Balanites aegyptiaca*, and *Diospyros mespiliformis*, alongside gum-producing species like Acacia specie's and *Boswellia papyrifera*. Additionally, it features various other useful species like *Combretum aculeatum*, *Ficus sycomorus*, and , utilized locally for medicinal, fodder, and construction purposes, as well as for fuelwood production [27].

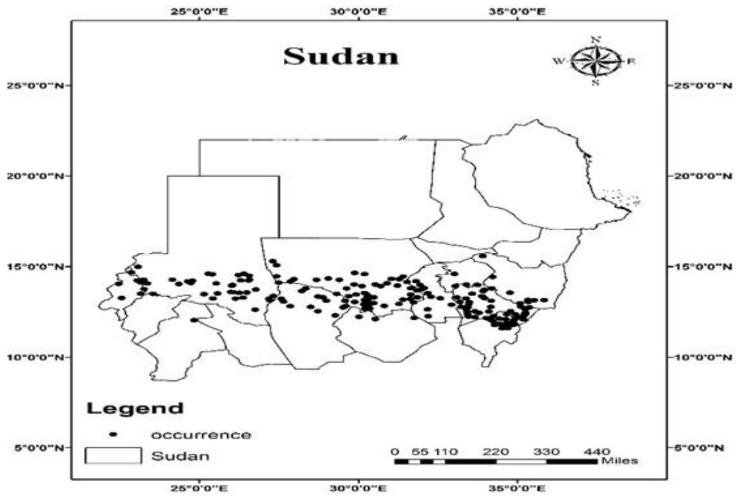

Fig. 1. Occurrence of *Acacia senegal*in Sudan

2.2 Data Collection

The input datasets from occurrence points and satellite image carried out in Sudan. A total of 164 geospatial coordinates (longitude and latitude) were obtained from fieldwork, National Research Center, and previous research carried out in Sudan (Figure 5).Bioclimate data was extracted for current data (1985- 2000) and future data (2021-2100) from Coupled Model Intercomparison Project Phase 6 (CMIP6) worldClim version 2.1. For future climate data for different periods, they were used by using general distribution models (GCMs), adopting a clustering approach to reduce model uncertainty. These datasets were also used to predict the distribution of *Acaciasenegal* under current and projected climate conditions using the maximum entropy model. (Maxent 3.4)

The research utilized version 3.4.4 of the Maxent Model, an ecological niche modeling method, to predict the potential distribution of *Acaciasenegal* under current and projected climatic conditions. Future climate data were obtained from three General Circulation Models (GCMs) covering time periods: 2021-2040, 2041-2060, and 2061-2080. An ensemble of climate models was employed, including the Goddard Institute for Space Studies (GISS-EC-1G), Max Planck Institute Earth System Model 1-2-High Resolution (MPI-ESM1-2-HR), and Institute Pierre-Simon Laplace (IPSL) GCMs. These models were chosen for ensemble integration based on their demonstrated efficacy in previous research conducted in Sudan: GISS-EC-1G , MPI-ESM1-2-HR, and IPSL-CM6A-LR, like other East Africa countries, Sudan, lacks especial calibrated General Circulation Model(GCM).For that were applied different models in the study[28], [29].

Table 1. Variables contributing to prediction

Code	Bioclimatic variables	Code	Bioclimatic variables
Bio01	Annual Mean Temperature	Bio13	Precipitation of Wettest Month
Bio02	Mean Diurnal Range	Bio14	Precipitation of Driest Month

Bio03	Isothermality	Bio15	Precipitation Seasonality
Bio04	Temperature Seasonality	Bio16	Precipitation of Wettest Quarter
Bio05	Max Temperature of Warmest Month	Bio17	Precipitation of Driest Quarter
Bio06	Min Temperature of Coldest Month	Bio18	Precipitation of Warmest Quarter
Bio07	Temperature Annual Range	Bio19	Precipitation of Coldest Quarter
Bio08	Mean Temperature of Wettest Quarter	Altitude	Elevation
Bio09	Mean Temperature of Driest Quarter		
Bio10	Mean Temperature of Warmest Quarter		
Bio11	Mean Temperature of Coldest Quarter		
Bio12	Annual Precipitation		

This ensemble of four global climate models was used to processing the limitations, unsureness, that is related by one global climate model in strictly predicting for future climate trend [30]. Several studies have reported the remarkable development of utilizing the multi-model group technique emerges as the foremost strategy for reducing model uncertain [31].To combine GCMs with equal weight, ArcGIS was used, and arithmetic mean arithmetic was commonly applied to combine multiple models. Regarding of the arithmetic average, Arithmetic mean has been commonly applied to utilize multiple models such as, ArcGIS was ensemble, incorporating the General Circulation Models (GCMs) with uniform weighting [10].

The current climatic data was obtained from WorldClim version 2.1. This dataset comprises climate information spanning the temporal range from 1970 to 2000, while future projections extend from 2021 to 2100[32]. The datasets for both the present and future climatic conditions were acquired with a spatial resolution of 30 seconds, equivalent to approximately (km)2 and accessed from the WorldClim database. Future climate data were sourced from CMIP6, demonstrating both qualitative and quantitative advancements over prior phases such as CMIP5. These improvements encompass a more precise representation of physical phenomena, simulated variables, and enhanced spatial granularity[10]. Furthermore, comparative analyses with CMIP5 indicate superior performance in terms of resolution in CMIP6[33]. The refined resolution in CMIP6 contributes to more substantial scientific insights[34].

The CMIP6 utilizes scenarios based on the Shared Socioeconomic Pathways (SSPs),these can be broadly classified into two categories: challenges to mitigation efforts and barriers to adaptation initiatives. SSP1 exhibits minimal impediments to both mitigation and adaptation, emphasizing policies focused on improving human welfare and promoting the advancement of clean energy technologies, and safeguarding natural ecosystems. Conversely, Regional Rivalry (SSP3) is marked by significant challenges to both mitigation and adaptation, prioritizing nationalist policies that address local and regional concerns over global priorities. Inequality (SSP4) is characterized with considerable challenges to adaptation but fewer hurdles to mitigation, whereas Fossil-fueled Development (SSP5) faces substantial challenges in mitigation but fewer obstacles in adaptation efforts. [35].

Particularly, SSP2 (Middle of the Road) delineates a situation characterized by moderate hurdles concerning both mitigation and adaptation efforts, for trend analysis, two SSPs were chosen for scrutiny: SSP2-4.5 and SSP5-8.5 [36][36].These scenarios were chosen to simulate the distribution patterns of three species under expected future climate circumstances. The choice of these SSPs was informed by their depiction of both moderate and extreme emission trajectories, along with a range of mitigation and adaptation approaches. This intentional selection enables the analysis of a "Middle of the Road" scenario and a "Fossil-fueled Development" scenario, covering a broad spectrum of extremes in contrast to existing adaptation and mitigation efforts [11].

2.3 Data analysis

Previous studies stated the decision to utilize the Maxent model for the analysis was driven by its strong in ~~establishing~~ establishrelationships between environmental variables and species presence records, as ~~demonstrated~~[demonstrated [15]. The machine learning method employs species presence data and environmental factors to generate estimations of species distribution [37], particularly suited for presence-only records[16]. Maxent has showed superior predictive efficacy in comparison to alternative structured decision-making models[13].

An important advantage of Maxent is its robustness to mitigate collinearity issues during model training, highly correlated predictor variables are removed having negligible effects on its performance[38]. Maxent adeptly manages complexity by downplaying the significance of redundant variables, effectively addressing collinearity issues [15], [16]. Maxent achieves an optimal balance between model fitting and complexity through regularization techniques [15], indications propose that the extent of collinearity among predictors is unlikely to notably influence the outcomes of Maxent.

3 RESULTS

3.1 Model Accuracy

The Maxent model exhibited excellent performance, and the outcome of the model are acceptable~~,~~ because the outcome ~~reflect~~ reflectsexcellent performance in faithfully delineating the distributional profile of *Acacia senegal*, manifesting mean training and test AUC metrics of 0.905 (Figure 4.). Run for Aciacasenegal generated AUC value more than 0.9, showed performance greatly accuracy.

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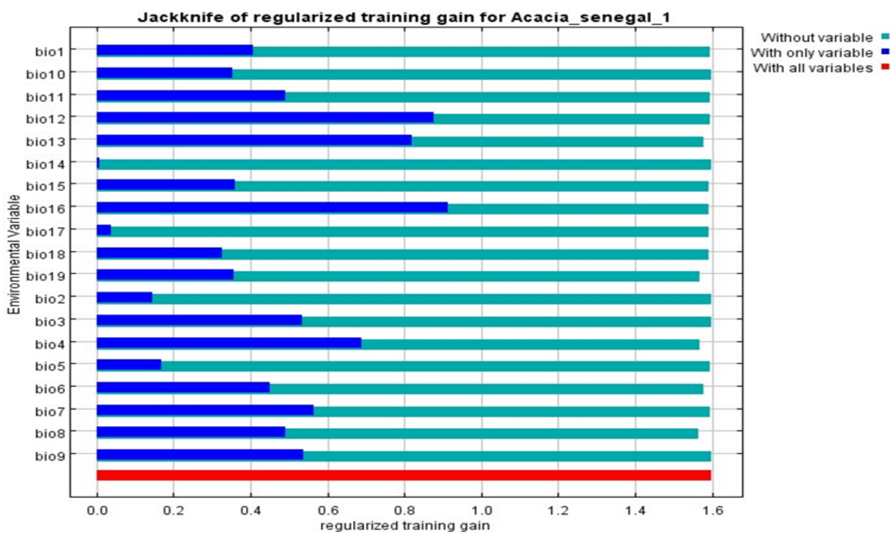


Fig. 2 Jackknife of regularized training gain for *Acacia senegal*

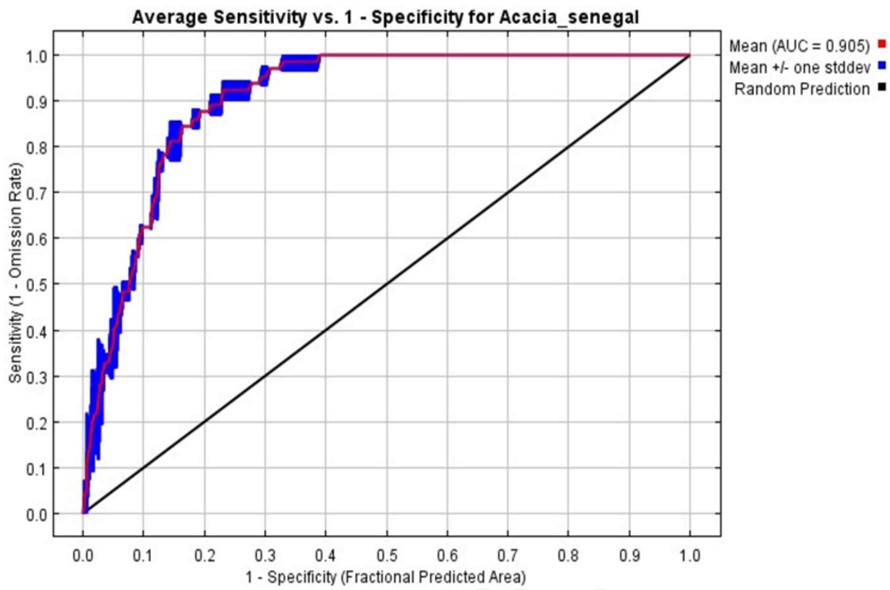


Fig .3 Cross-validated AUC (Area under the receiver operating characteristic curve)

3.2 Thresholds and suitability

The study established suitability thresholds for *Acacia senegal*, indicating it as suitable when $0.36 < P < 0.54$, unsuitable when $0 < P < 0.18$, and extremely suitable when $0.72 < P < 1$. These thresholds demonstrated statistical significance for species distribution classification at a significance level of $P < 0.05$, by utilizing the ~~tenths~~ tenthpercentile of training presence, the study evaluated suitability percentages and their effects on habitat suitability throughout the entire research area, covering 520,000 km². Additionally, a notable discrepancy ($p < 0.05$) was noted in suitability values between present and future time frames under both SSP scenarios (Table 2). The average suitability value under SSP2-4.5 exhibited a reduced magnitude compared to the present value. In contrast, the average suitability value for SSP5-8.5 showed a significantly greater magnitude in the future, surpassing current suitability thresholds.

Table 2. Distribution Threshold Magnitudes across Various Time Slices and SSPs.

Period	Mean±SD	Maximum
Current	0.095 ± 0.164	0.903
2021-2040 SSP2-4.5	0.17 ± 0.25	0.988

2021-2040SSP5-8.5	0.22 ± 0.29	0.983
2041-2060SSP2-4.5	0.25 ± 0.33	0.997
2041-2060SSP5-8.5	0.29 ± 0.35	0.994
2061-2080SSP2-4.5	0.21 ± 0.30	0.993
2061-2080SSP5-8.5	0.27 ± 0.34	0.997
2081-2100SSP2-4.5	0.22 ± 0.30	0.995
2081-2100SSP5-8.5	0.26 ± 0.34	0.98

3.3 Contribution of variables

The major predictors making excellent contribution of the species distribution were Precipitation of Wettest Quarter (bio 16) by percent contribution 56.3%, second one predictor is Max Temperature of Warmest Month (bio5) by 10.5%, the following predictors it presented less than 10%, are Temperature Annual Range(bio7), Mean Temperature of Driest Quarter (bio 9), Precipitation of Coldest Quarter (bio 19), and Temperature Seasonality (bio 4) (Table .3), the environmental variable with highest gain when used in isolation is bio16, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is bio4, which therefore appears to have the most information that isn't present in the other variables. Values shown are averages over replicate runs figure.

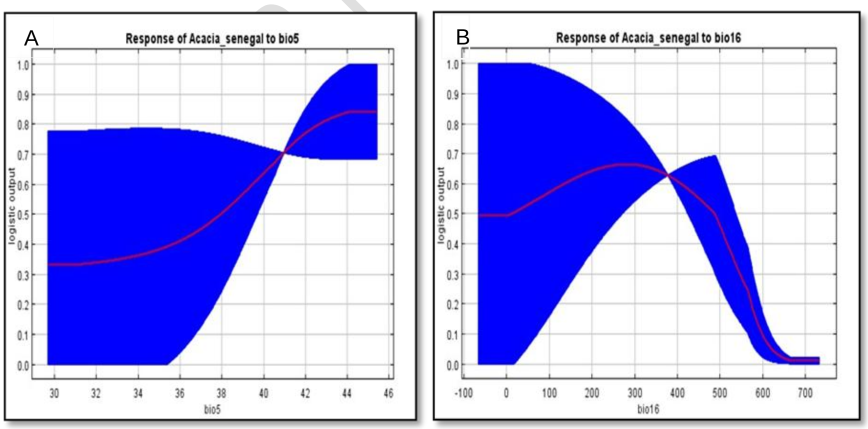
Table .3Variables contribution and permutation importance

Variable	Definition	Percent contribution (%)	Permutation importance (%)
bio16	Precipitation of Wettest Quarter	56.3	3.4
Bio 5	Max Temperature of Warmest Month	10.5	3.2
Bio 7	Temperature Annual Range	9.5	1.5
Bio 19	Precipitation of Coldest Quarter	5.2	3.5
Bio 4	Temperature Seasonality	4.7	13.3
Bio13	Precipitation of Wettest Month	2.3	24.2
Bio 8	Mean Temperature of Wettest Quarter	2.2	12.2
Bio6	Min Temperature of Coldest Month	2.1	20.8

Bio15	Precipitation Seasonality	1.9	2.8
Bio1	Annual Mean Temperature	1.8	0.6
Bio3	Isothermality	1.2	0.6
Bio17	Precipitation of Driest Quarter	0.5	0.6
Bio18	Precipitation of Warmest Quarter	0.5	0.6
Bio10	Mean Temperature of Warmest Quarter	0.3	0
Bio12	Annual Precipitation	0.3	7.3
Bio11	Mean Temperature of Coldest Quarter	0.2	4.2
Bio 2	Mean Diurnal Range	0.2	1.3
Bio 9	Mean Temperature of Driest Quarter	0.2	0.1
Bio14	Precipitation of Driest Month	0	0

3.4 Response of *Acacia senegal* to bioclimatic predictors

The *Acacia senegal*significantly toPrecipitation of Wettest Quarterwith peak in it**s** occurrence probability in area with precipitation between 200-300 mm (Fig .4 A). According to Bioclimatic variable 5 (Bio5), occurrence probability of species was highest level at 44 °C (Fig.4 B). Generally, the suitability of the species increased with Temperature Annual Range (Fig .4 C). But it decreased with the Precipitation of Coldest Quarter (Fig .4 D).



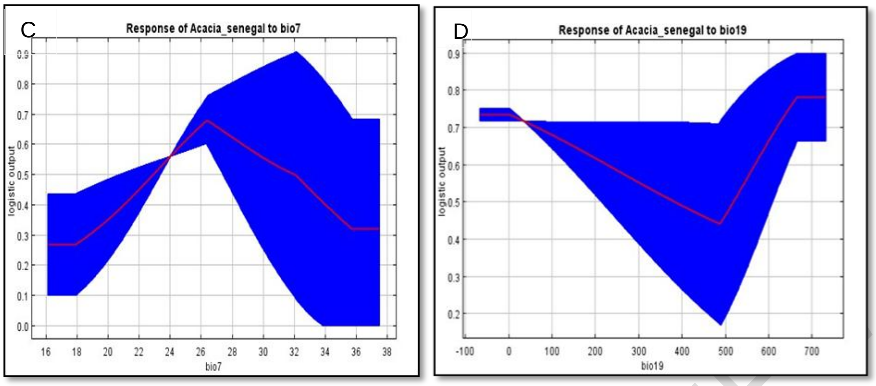


Fig4. Response curves of Acacia senegal to bioclimatic predictors in the habitat suitability modeling

Logistic output.A- Precipitation of Wettest Quarter (bio16, mm);B- Max Temperature of Warmest Month(bio5, °C);C- Temperature Annual Range(bio7, mm);D- Precipitation of Coldest Quarter (bio19,mm).

3.5 DISTRIBUTION OF *A. SENEGAL* SPECIES AND SUITABLE AREA ACROSS PRESENT AND FUTURE CONDITIONS

The Acacia Senegalese plant has been discovered across various regions in central Sudan within the Gum Arabic Belt, spanning from extreme west to extreme east, and has been identified in all study areas. This presence accounts for approximately one-fifth of Sudan's total area, encompassing both ongoing and prospective projects. The observed expansion in geographic distribution is attributed to the plant's adaptation to a more favorable climate, characterized by increased rainfall during the wetter quarter (bio 16). Notably, the impacts of climate change have played a significant role, with Acacia Senegalese exhibiting pronounced shifts in distribution due to these effects (bio 16).

Table .4*Acacia senegal*Distribution in SSP2-4.5 (% and km^2) as a proportion of the total Study Area (520000 km^2)

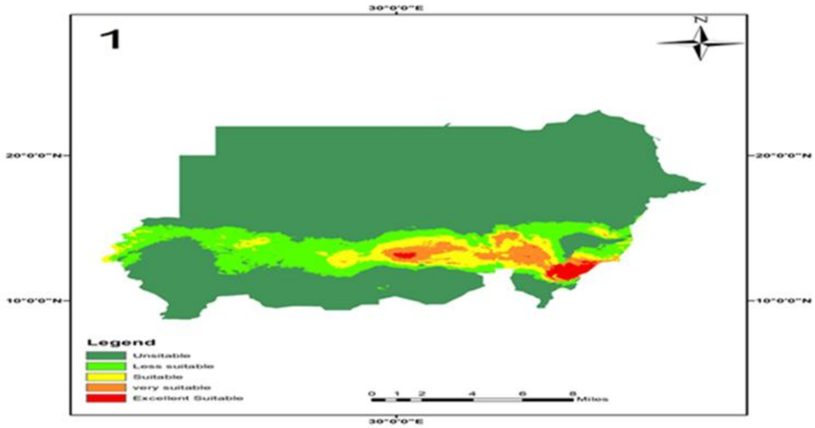
	Potential distribution SSP2-4.5		**New suitable area SSP2-4.5**	
Period	Area (Km^2)	Area (%)	Area (Km^2)	Area(%)
Current	132219.6	25.4	------	------
2020-2040	456001.6	87.7	323782	62.3
2041-2069	208998.0	40.2	76778.4	14.8
2061-2080	188166.6	36.2	55947	10.8
2081-2100	195271.6	37.6	63052	12.3

The current extent of *Acacia senegal* distribution encompasses 132219.6 km2 within a total area of 520000 km2. Projections indicate an expansion of its range to 456001.6 km2, encompassing a span of 25.4% to 87.7% under SSP2-4.5 for the period 2021–2100 (Table .4). This expansion could result in a potential increase in suitable area ranging from 46% to 62.3%. Conversely, under SSP5-8.5 conditions for the same period, the potential distribution may expand to a range of 25.4% - 42.5%, with prospective new suitable area in range between 13.5% - 17.1% (Table .5).

Table .5 *Acacia senegal* distribution in SSP5-8.5 (% and km^2) as a proportion of the total study area (369 km^2)

	Potential distribution SSP5-8.5		New suitable area SSP5-8.5	
Period	Area (Km^2)	Area (%)	Area (Km^2)	Area (%)
Current	132219.6	25.4	------	------
2020-2040	202098.8	38.9	69879.2	13.5
2041-2069	220322.4	42.4	88102.8	17
2061-2080	220921.6	42.5	88702	17.1
2081-2100	216306.74	41.6	84087.14	16.2

The model's predictive maps displayed significant shifts in the anticipated distribution of *Acacia sensgal* in the current distribution to future compared. This study highlights a notable significant rise ($p<0.05$) in the distribution of *Acacia sengal* under projected future climatic conditions, particularly especially evident in the SSP2-4.5 scenario, in comparison to their current extent. (Fig. 1to 6).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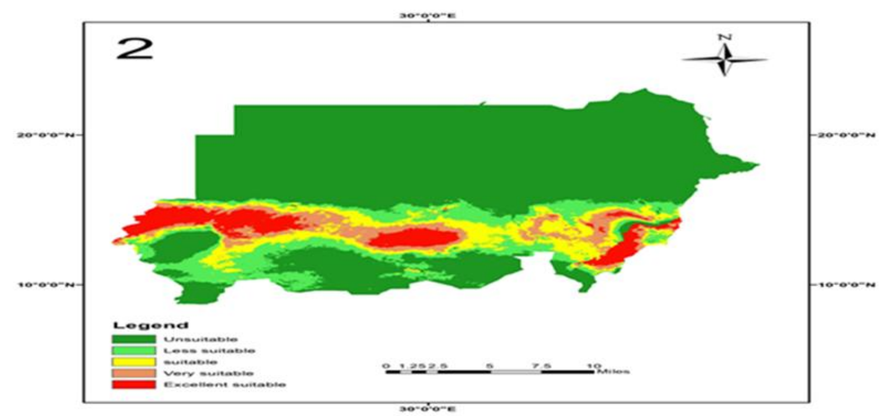
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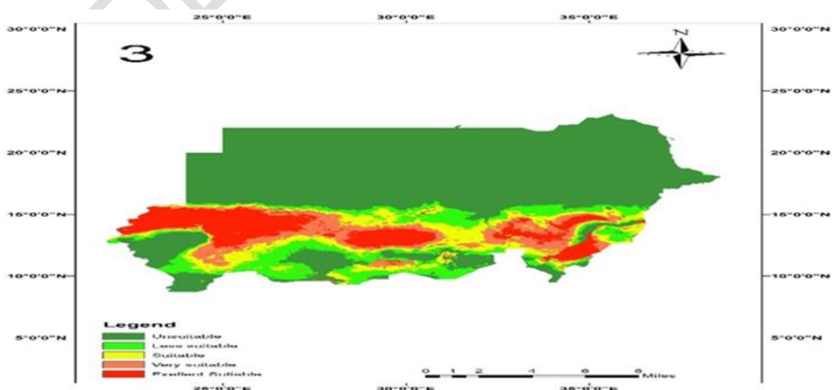
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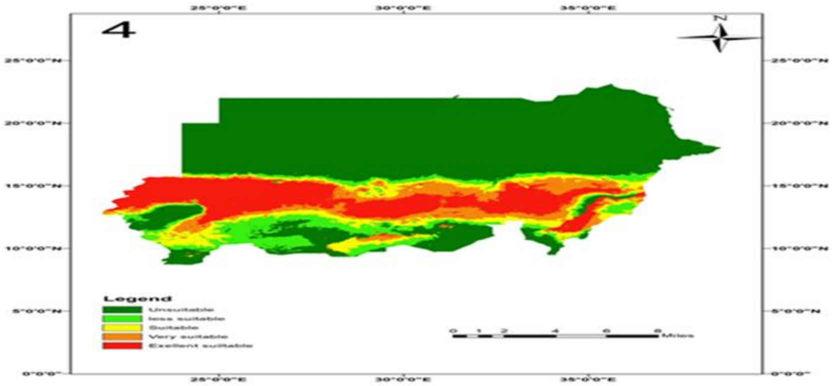
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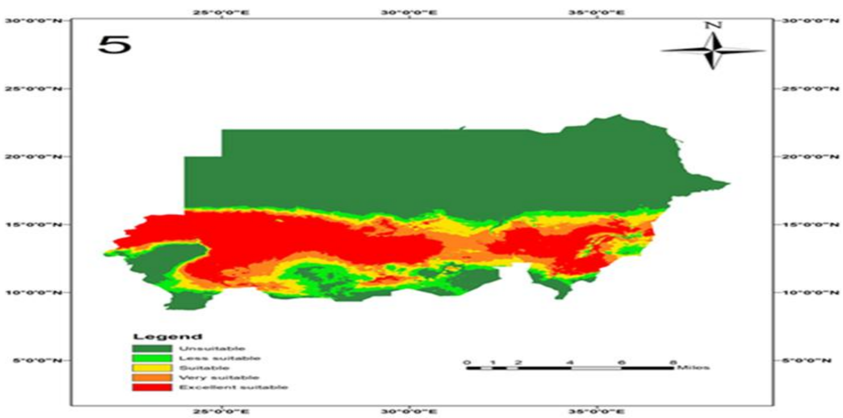
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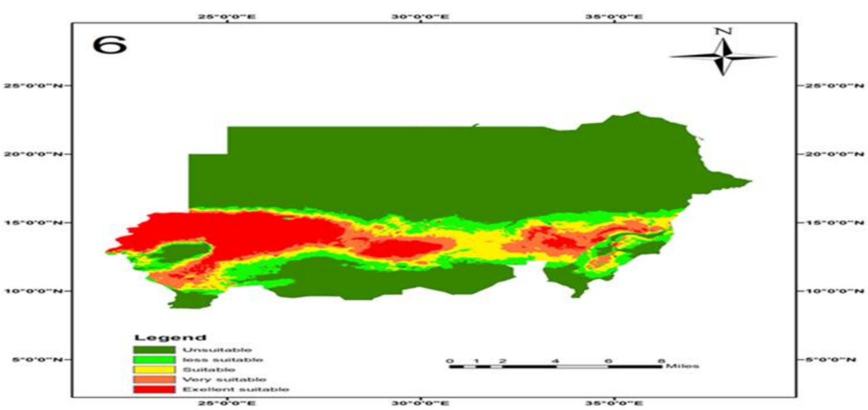
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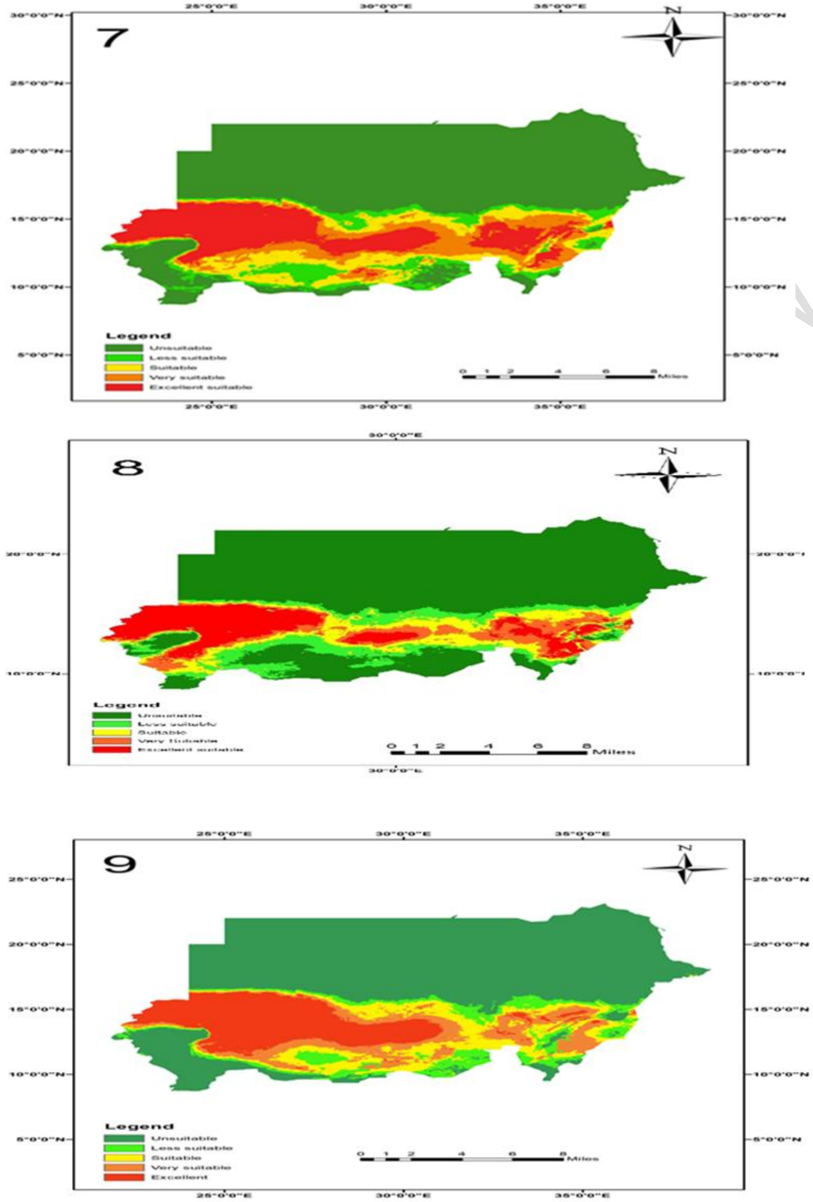

Fig .5 ***Acacia senegal*** **distribution (1) Current; (2) 2020-2040 SSP2-4.5;(3) 2020-2040 SSP5-8.5;(4) 2041-2060 SSP2-4.5;(5) 2041-2060 SSP5-8.5;(6) 2061-2080 SSP2-4.5;(7) 2061-2080 SSP5-8.5;(8) 2081-2100 SSP2-4.5;(9) 2081-2100 SSP5-8.5.**

4 DISCUSSION and CONCLUSION

4.1 Discussion

Previous studies have shown that biotic and abiotic factors have impacts on potential species distributions, and climate change plays a crucial role in determining these patterns[39]. There is ample evidence suggesting that climate change will significantly effect on the distribution of numerous species[40]. Species distribution modeling (SDM) is extensively employed to assess habitat suitability patterns on a broad spatial scale. These models generate detailed maps that are invaluable for pinpointing areas where conservation efforts are particularly crucial or likely to be effective.

In general, species distribution modeling (SDM) techniques utilize data on habitat requirements obtained from known occurrence sites to forecast the potential habitat of species under existing or potential future conditions. While these models may not precisely indicate the realized niche, they do offer pertinent information on habitat suitability for a particular species. This information can be instrumental in guiding the development of sustainable management plans[16]

This data from the derived distribution map is valuable for pinpointing suitable areas for cultivation and assessing the conservation status of target species within reserved forests. It aids in identifying appropriate locations for cultivation while also evaluating the conservation needs of specific species within protected forest areas.

In this study, the Maximum Entropy algorithm (MaxEnt), a widely utilized Species Distribution Modeling (SDM) technique, was employed to evaluate habitat suitability for both cultivation and in situ conservation of *Acaciasenegal* by different subpopulations under present and future (2100) climatic conditions. The study incorporated projections of future climate data obtained from three Global Climate Models (GCMs): GISS-EC-1G, MPI-ESM1-2-HR, and IPSL, under SSPs 2-4.5 and 5-8.5. These climate models indicated notable changes anticipated in the study area (Table4 and Table 5).

The results revealed that bio 16 and bio 5) were identified as most significant predictors influencing the distribution of *Acaciasenegal*, as shown in Table 3(Pramani. 2021; Zhang et al. 2023).

Following our findings, approximately 25.4 of Sudan's Gum Arabic area is potentially suitable for Acacia senegal and for the period 2021–2100 about 46% to 62 % for potential suitable area with SSP2-4.5, whereas the new suitable area ranging from 13.5 % to 17.1 %. Significant increases were projected under future climatic 2100 scenarios with several currently unsuitable areas becoming suitable under all the climatic models. This findings can explain by the significant change projected for magnitude in the future, surpassing the existing suitability thresholds (Table2). Indeed, according to the climatic model used in this study, the precipitation of wettest quarter with peak in its occurrence probability in area with precipitation between 200-300 mm and maximum temperature of warmest month, occurrence probability of species was highest level at 44 °C are projected to be). The *Acacia senegal* significantly to Precipitation of Wettest Quarter with peak in its occurrence probability in area with precipitation between 200-300 mm (Figure4 A). According to the Max Temperature of Warmest Month, occurrence probability of species was highest level at 44 °C (Figure 5. B)

The impact of climate change is evident in various species, as they undergo alterations in cover, distribution, and genetic makeup within their respective climatic zones [43]. Research suggests that plants predominantly thrive in areas with suitable climatic conditions and subsequently adapt their distribution in response to changes in the climate. This phenomenon implies that as climatic conditions continue to shift, species, including *Acacia senegal*, will likely experience more pronounced changes in distribution over time [44]. Global warming may magnify these changes, particularly arid and semi-arid regions as fragile ecosystems [45]. The study area, known as the Gum Arabic Belt, exhibits diverse climatic conditions conducive to plant species with high drought tolerance. Predominantly found in dry and semi-arid regions, especially in sandy soils, *Acacia senegal* is a prime example of a species well-adapted to such environments, in react to climatic changes, species may shift their distribution range towards the western part of the Gum Arabic Belt in look for suitable climatic conditions to adaptation. The current study of *Acacia senegal* are mainly located in the Gum Arabic Belt represents a significant chance suitable area in the future.

5.3 Conclusion

This study conclude that strategically planting and protecting these species is essential due to their significant environmental and economic contributions in both present and anticipated suitable areas. This action aims to enhance ecosystem services and guarantee the continued survival of these species amidst changing climates, the study showed that, under the current climatic conditions, it is possible to grow the Acacia Senegalese plant and expand its cultivation in large areas of Sudan within the Gum Arabic Belt. In addition, suitable environmental conditions include a wide range of areas potentially favorable for this species in situ and that future climate (2100) will increase the suitability of this habitat. With such a clear positive effect of climate on its suitable habitats, Acacia Senegal can be considered a good candidate for an ecosystem service and ecosystem-based adaptation approach to addressing climate change.

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