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ASSESSMENT OF THE POTENTIAL DISTRIBUTION OF *SHOREA ROBUSTA* IN RANCHI DISTRICT, JHARKHAND (INDIA) USING ECOLOGICAL NICHE MODELLING

Obaidullah Ehrar[1*], Pankaj Kumar Singh[1], Kishore Kumar[1], TaposhiSharma[2], Immanual Gilwax Prabhu[1], Bijoy Krishna Handique[2], HanamantGadad[1], Niranjan Kumar[1] and Sathyanarayana Kutala[1]
[1]Central Tasar Research and Training Centre, Ranchi – 835303, Jharkhand, India
[2]North-Eastern Space Applications Centre, Umiam – 793103, Meghalaya, India
[*]Correspondence may be addressed. Email: ehrar.obaidullah@gmail.com

ABSTRACT

Shorea robusta Gaertn. f. (Sal) is one of the primary food plants of tropical tasar silkworm. *S. robusta* forests are the most disturbed forest type in Southeast Asia. In India, Sal forests form a major source of timber and for the past decades there was massive deforestation and their eventual clearance for expanding agriculture, human settlements, etc. In the present study, the present (2020) and future (2040) distribution of the *S. robusta* ecological niche has been forecasted using MAXENT method. In order to examine the distribution of the target species, nineteen bioclimatic variables were employed. The data were analysed from the jack-knife test after running the 19 variables in the MAXENT. Nine bioclimatic factors were eliminated in accordance with their contribution to the *S. robusta* distribution. Ten bioclimatic variables are used to provide the actual contribution of the model and the present distribution contribute to temperature seasonality 17%, Precipitation of driest period 14.6%, precipitation of wettest period 14.2%, precipitation of driest quarter 13.4%, precipitation seasonality 13.3%, Isothermality 13.2%, Minimum temperature of the coldest month 5.8%, Mean temperature of driest quarter 4.1%, precipitation of warmest quarter 2.9%, temperature annual range 1.5%. The average test area under the receiver operating curve AUC is 0.939, and SD is 0.015. The future prediction ssp 126 and the contribution of the bioclimatic variables are temperature seasonality 26%, Precipitation of driest period 13.5%, Isothermality 12.7%, precipitation seasonality 11%, precipitation of warmest quarter 10.9%, precipitation of driest quarter 10.2%, precipitation of wettest period 9.3%, Minimum temperature of the coldest month 2.9%, Mean temperature of driest quarter 1.8%, temperature annual range 1.7%. The approach presented here appears to be quite promising in predicting suitable habitat for *S. robusta* with the available records and can be an effective tool for biodiversity conservation planning, monitoring and management.

Keywords: *S. robusta*, deforestation, Maxent, Bioclimatic variables, Ecological Niche Modeling.

Introduction

Forest resources are a high-value commodity across the country, as most of the population relies on them for standard requirements such as food and fuelwood. Forests are critical to Jharkhand's economic, cultural, and social well-being, sustaining rural livelihoods and ensuring food safety. *Shorea robusta*, *Pterocarpus marsupium*, *Butea monosperma*, *Diospyros melanoxylon*, and *Madhuca longifolia* are found in Jharkhand's tropical humid deciduous and tropical dry deciduous forests. Wood, fuelwood, forest, and a variety of non-wood forest products are frequently harvested, including fruit, nuts, edible mushrooms, vegetables, medicinal plants, fish, animal products, essence products, resins, barks, and fibre products, as well as bamboos, rattans, palms, and grasses. The overview of valued species, lack of information and awareness about the present population condition of essential plants, habitat change, habitat specialisation, limited distribution, and overgrazing constitute some of the main difficulties facing crucial plant populations. Single plant animals in a particular region can have a significant influence on natural enemies like diseases, herbivores and predators of seed (Kumar and Saikia, 2020a).

Max Ent is a grid-based machine learning method that is motivated by the maximisation of entropy. It uses data on species existence alone to forecast a species' range (Elith *et al*., 2010). It is based on the maximum entropy method and is available for download from the following website: - (https://biodiversityinformatics.amnh.org/opensource/maxent).
It is quickly becoming one of the most famous pieces of software due to its ease of use (Warren and Seifert, 2011). It neatly and efficiently solves the problem of species distribution modelling. It creates an accurate model and outputs a table detailing the contribution of each environmental variable to the prediction model (Ortega-Huerta and Peterson, 2008). Additionally, it makes continuous predictions and incorporates delicate topography data to provide a more thorough prediction (Phillips *et al*., 2006). Tasar silkworm rising for cocoon manufacturing is also a tribal practice in Bihar, Andhra Pradesh, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, West Bengal, Maharashtra, Uttar Pradesh, and Telangana. Large-scale collection of naturally formed cocoons in various tasar producing locations. These states are renowned for their

traditional and one-of-a-kind Tasar silk weaving (Achary *et al*., 2019).

The Tasar silk industry has directly and indirectly engaged around 2.5 lakh households in rural and semi-urban regions. Indigenous peoples are mainly responsible for silk production. Nearly 30 million (77%) of the entire tribal population of over 38 million reside in tasar farming states in the tropical zone (25.67 million) and temperate zone (4.23 million). However, 13.2 million and 3.2 million indigenous people reside in tropical and temperate tasar growing districts. Thus, around 1.23 lakh families in a tropical zone are active in tasar silkworm raising (Achary *et al*., 2019). In the present study, the potential and future distribution of *S. robusta* in Ranchi district have been analysed through Maxent. We aimed for the identification of additional localities where *S. robusta* may exist and where it could potentially exist, eventually leads to targeted conservation strategies for tasar silkworm ecoraces.

Study Area

Ranchi is situated in the Chota Nagpur plateau; part of the Deccan plateau's eastern half. Ranchi, Jharkhand, India, is located at 23.344101 latitudes and 85.309563 longitudes. Ranchi, Jharkhand, India, is in the Cities location category and is located at 23° 20' 38.7636" N and 85° 18' 34.4268" E in the India country. Ranchi's mountainous geography and extensive tropical forests combine to provide a more temperate climate than the rest of the state. However, the average temperature has risen as a result of unchecked deforestation and urbanization. Ranchi, Jharkhand, India, has a 644-metre elevation, which is equal to 2,113 feet. Toposheet 73A, 73B, 73E, and 73F cover the area. The forest in the Ranchi district covers 3 25,603 acres, accounting for 17.38 % of the primary raw material used by various significant businesses such as furniture, matchboxes, paper, rayon, construction, railway footwear, and wooden poles. Forest produce has been classified into two categories:

1. Major Forest Products
2. Minor Forest Products

The major forest products comprise wood from timber, such as Sal, Bamboo, Kusum, Gamhar, Mahua, Jamun, Shisham, *Mangifera indica*.

Minor Forest Products are like Harada, Behara, Kendu leaves, Sal leaves, Karanj seeds, Mahua patta. These products have medicinal and commercial values in the market.

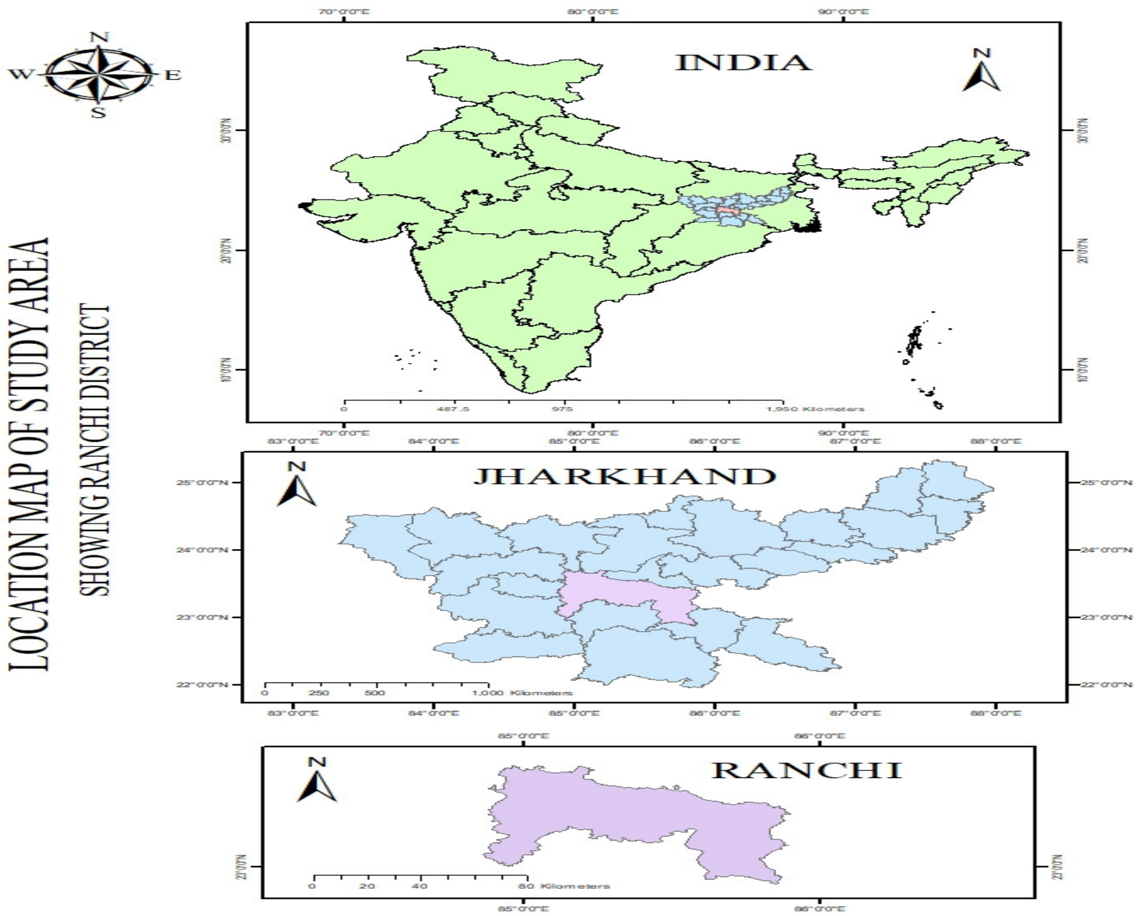


Fig. 1 : Map of the study area

Material and Methods

Satellite Data

The Landsat ETM+ and DEM were utilised in this research. Erdas Imagine 2014 and Arc GIS 10.4 were used for digital picture processing and geographic database. The boundary of the forest area was trimmed using the ASTER DEM data. A digital elevation utilising 30-meter ASTER data was generated. *S. robusta* Gaertn. f. areas of occurrence and GIS layers of elevation have been generated. Along with a topographic sheet of 1:50,000 from the Survey of India, this map were used to verify the ground truth based on the position of GPS.

MAXENT Model

MaxEnt is a grid-based machine learning approach using the highest level of entropy. It predicts the distribution of a species with just data on species existence (Elith *et al*., 2010). It is based on the maximum entropy algorithm (https:/ biodiversity informatics.amnh.org/open source/maxent/). It may be gotten here.

MaxEnt Modelling Procedure

S. robusta occurrence point data were divided into training data (90% of occurrence point data was used for model prediction) and test data (10 % of occurrence point data was used for model prediction) (25 % occurrence point data used for model validation). The model will be duplicated 20 times, with a sub-sample as the replicated run type. The regularisation multiplier will be set to 1 by default. The maximum number of background points be 10000. The maximum iterations were taken 500 with a 0.00001 convergence threshold. The replicated run type was set as 'Bootstrap'. The 'Adjust sample radius' is taken 'zero' and default prevalence as 0.5. The Log file was taken as ‘maxent log’. For reliable evaluation of model outputs, the area under the receiver operating curve (AUC) is used. It runs from 0 to 1, with an AUC of more than 0.8, indicating a good prediction.

DATA USED

In order to generate the bioclimatic indices, the best feasible spatial resolution requires reliable climatic records. Interpolated climate records were obtained from a global network of 4000 climate stations, using current 1970–2020 climate data (http://www.worldclim.org). More biologically relevant variables were produced using the BIOCLIM model implemented in DIVA-GIS (version 7.1.7.2), i.e. 19 bioclimatic indicators including precipitation and temperature data. Bioclimatic indices evaluate energy and water balances at a particular location as a substitute term. Annual trends (e.g., annual rainfall, average annual temperature), seasonality (e.g. precipitation ranges and annual temperature) and severe environmental circumstances (e.g., the temperature of the coldest and warmest month and precipitation of the wet and dry quarters).

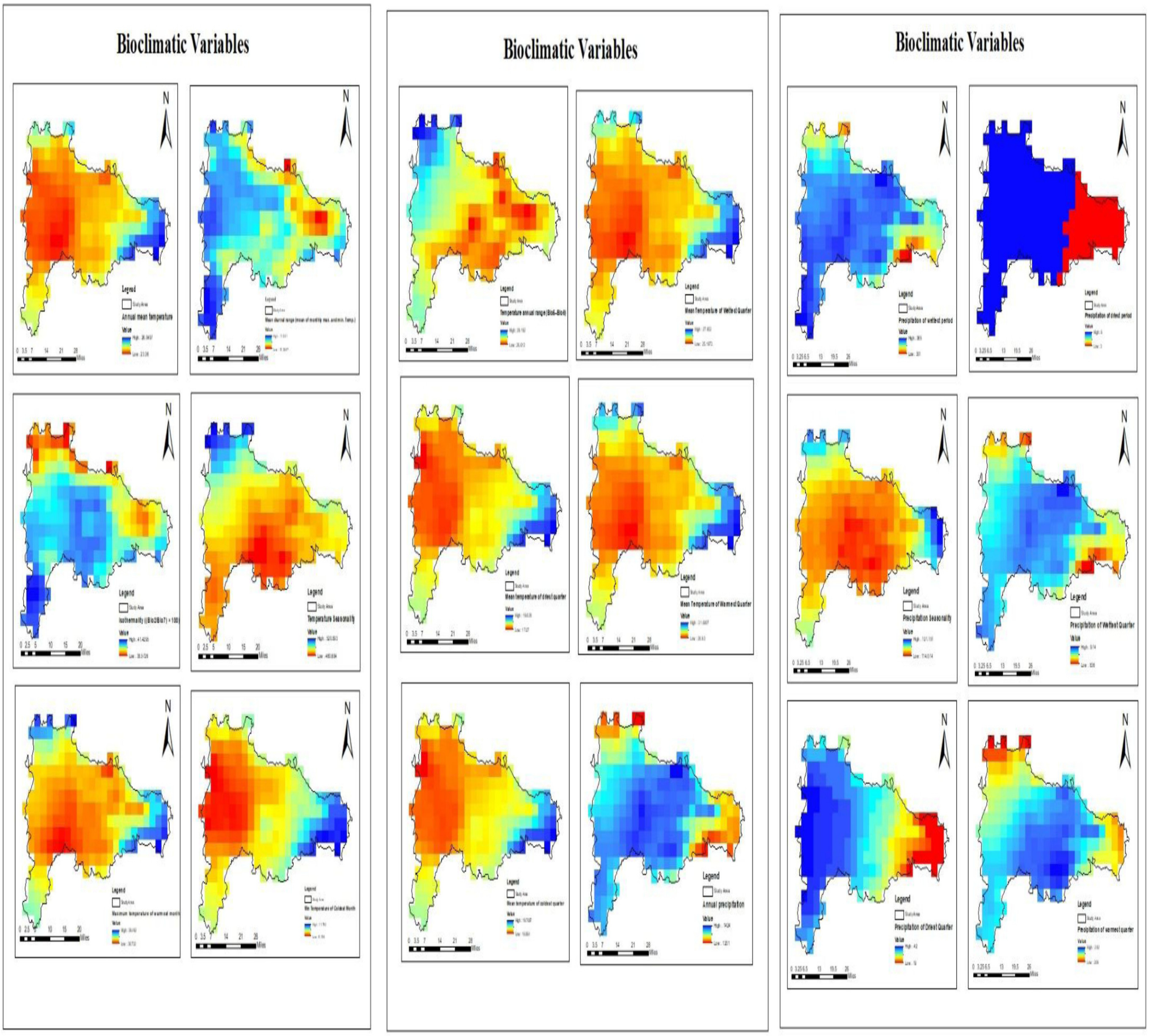


Fig. 2 : Bioclimatic variables used in the study area (Ranchi District)

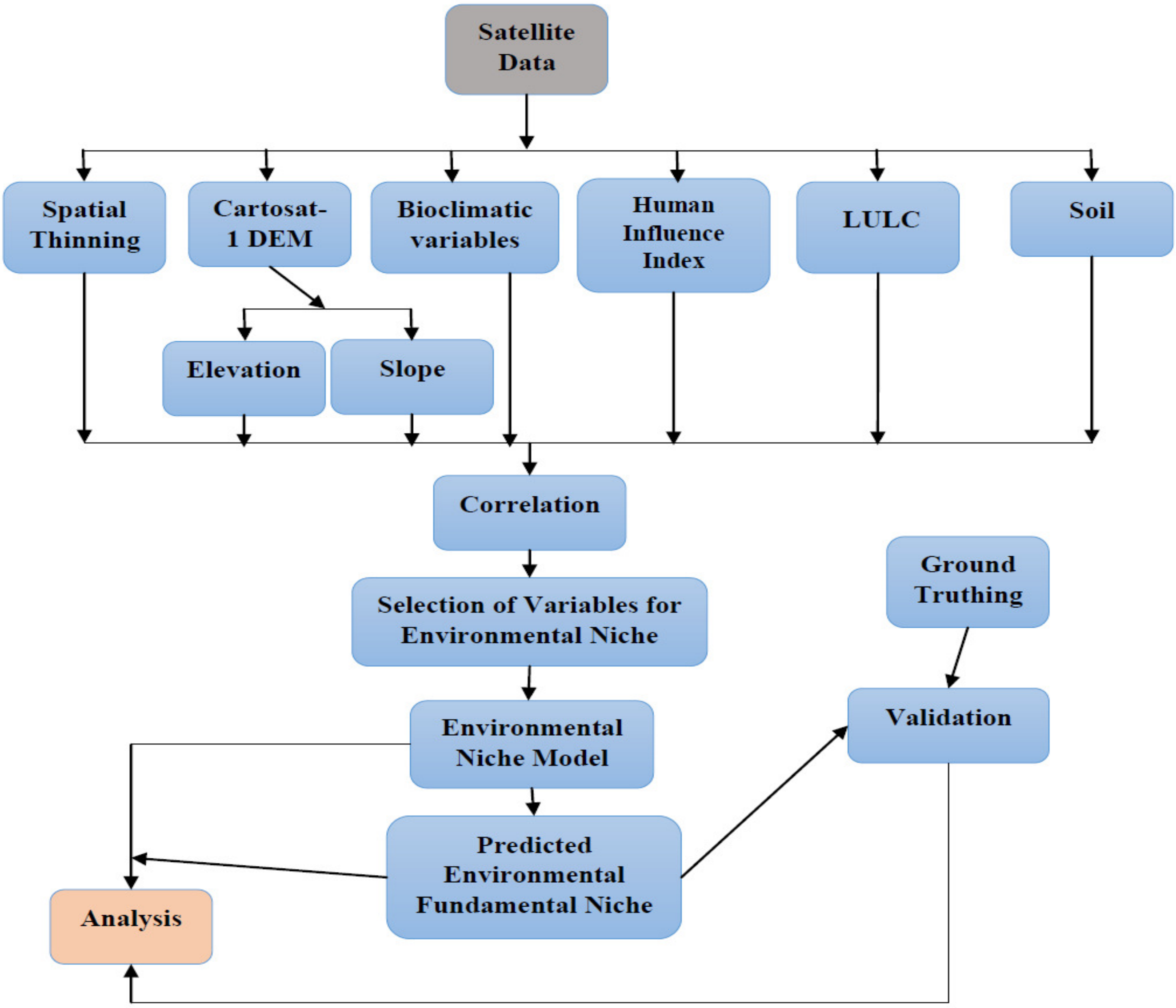


Fig. 3 : Flow Chart for assessing the present distribution of *S. robusta* in Ranchi District, Jharkhand

Results and Discussion

Assessment of the current potential distribution of *S. robusta* Gaertn. f. in Ranchi district.

Ecological niche modelling aids and improves endangered species research by enabling fast field surveys led by niche model projections to find additional populations of rare and poorly known species (Menon *et al.*, 2010). *S. robusta* was mostly found in tropical deciduous woods in Ranchi's northern and central sections, according to field data. Using a combination of bioclimatic parameters, relief, slope, land use/land cover, soil, and a human influence index, these field records were used to anticipate the current distribution pattern of *S. robusta* in Ranchi. The continuous and thick zones with high to very high likelihood (highest suited habitat niche) were the north-western parts linked with Ramgarh forests. In addition, the central parts also had probable high zones for *S. robusta* in a fragmented manner (Figure 4). The central-eastern parts have a shallow probable area for *S. robusta* and the western parts of the Ranchi district. Even with the high human influence index in the north-western and the central part of the Ranchi district, there was a potential occurrence of *S. robusta*.

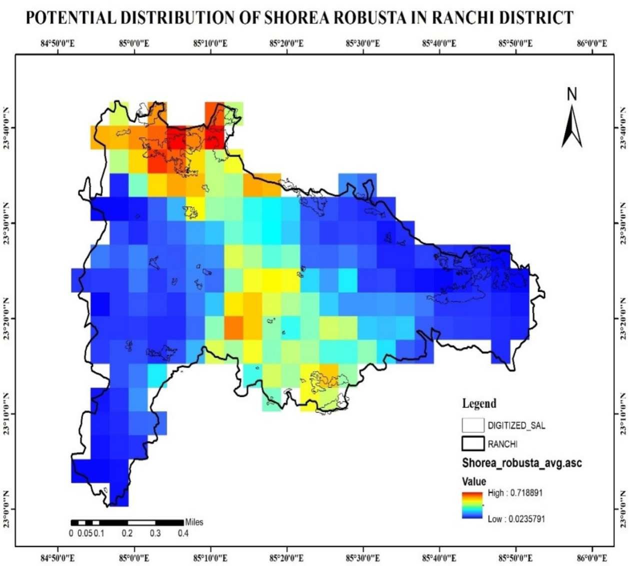


Fig. 4 : The potential distribution of *S. robusta* in Ranchi district

The standard deviation of the current potential distribution of the *S. robusta* in the Ranchi district of Jharkhand showed that the north-western parts towards the Ramgarh forest, a small portion have the high SD and some portion of central and south of central have high SD in the Ranchi district (Fig 5: SD of potential distribution of Sal in Ranchi District). The SD (Standard Deviation) here represents the variation of the occurrence data of the focus species in the study area. This means the occurrence data points in the study area, which was modelled in MaxEnt, vary in that region. Therefore, there might not be a concrete occurrence of the species (the locations fluctuate as per modelling).

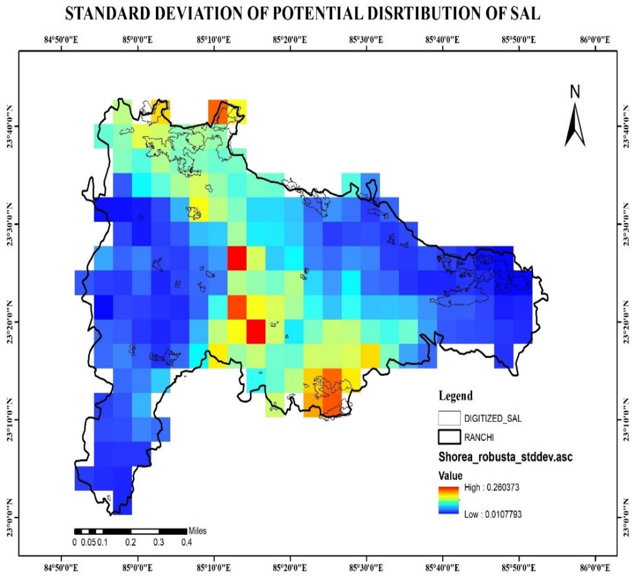


Fig. 5 : Standard deviation of potential distribution of *S. robusta* in Ranchi district

The following figure shows the training omission rate and predicted area as a function of the cumulative threshold, averaged over the replicate runs.

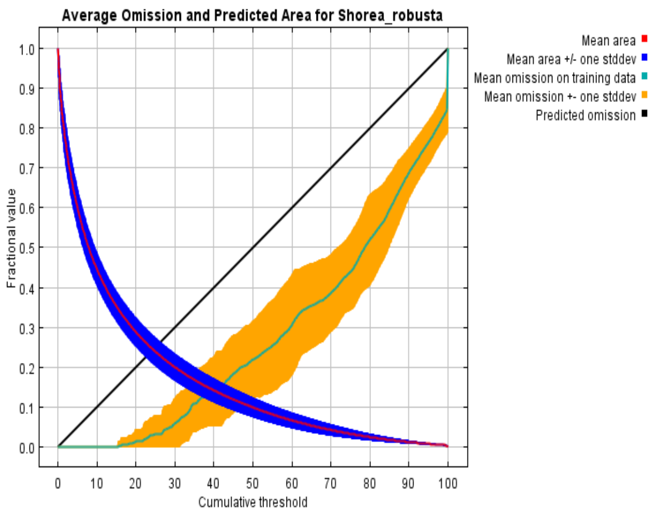


Fig. 6 : Average Omission and Predicted Area for *S. robusta* in Ranchi District

This is the same data's receiver operating characteristic (ROC) curve, averaged over the duplicate runs once more. It is worth noting that the specificity is calculated based on expected area rather than actual commission. The standard deviation (SD) for the replicate runs is 0.015, and the average training AUC is 0.941. (Fig. 7)

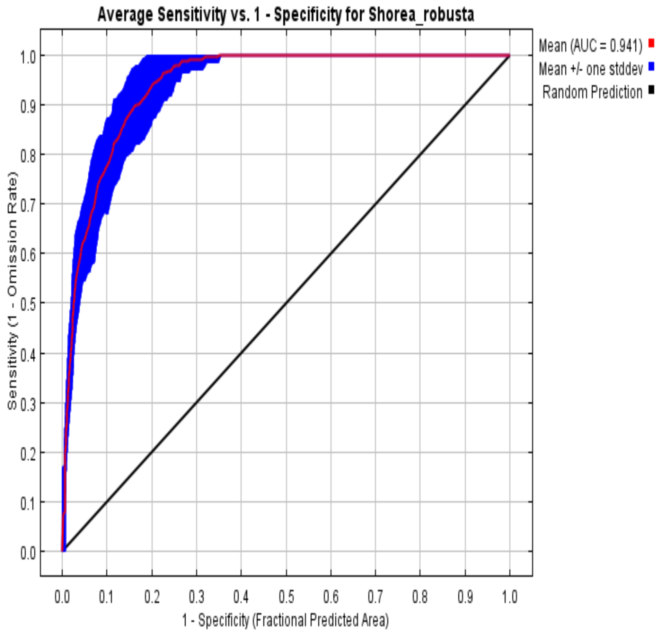


Fig. 7 : Average Sensitivity and Specificity for *S. robusta* in Ranchi District

Influence of Bioclimatic Variables

A variety of environmental conditions influences *S. robusta* distribution in the Ranchi district. The study found that Temperature Seasonality contributes the most (17%) to the current distribution of *S. robusta*, while Temperature Annual Range (Bio 7) contributes the least (1.5%). However, the jack-knife test found that the environmental variable with the highest gain, when employed in isolation, is Temperature seasonality (Bio 4), which thus looks to provide the most useful information by itself. On the other hand, precipitation of the wettest period (Bio 13) is the environmental variable that reduces the gain the greatest when excluded and looks to have the most information that is not present in the other variables. The figures depicted are averages of replicate runs.

Response curve

These graphs show the impact of each environmental variable on the Maxent forecast. The curves indicate how the anticipated probability of presence changes as each environmental variable changes while all other environmental variables remain constant. The mean response of the 20 replicate Maxent runs (red) and the mean +/- one standard deviation is shown in the graphs (blue, two shades for categorical variables).

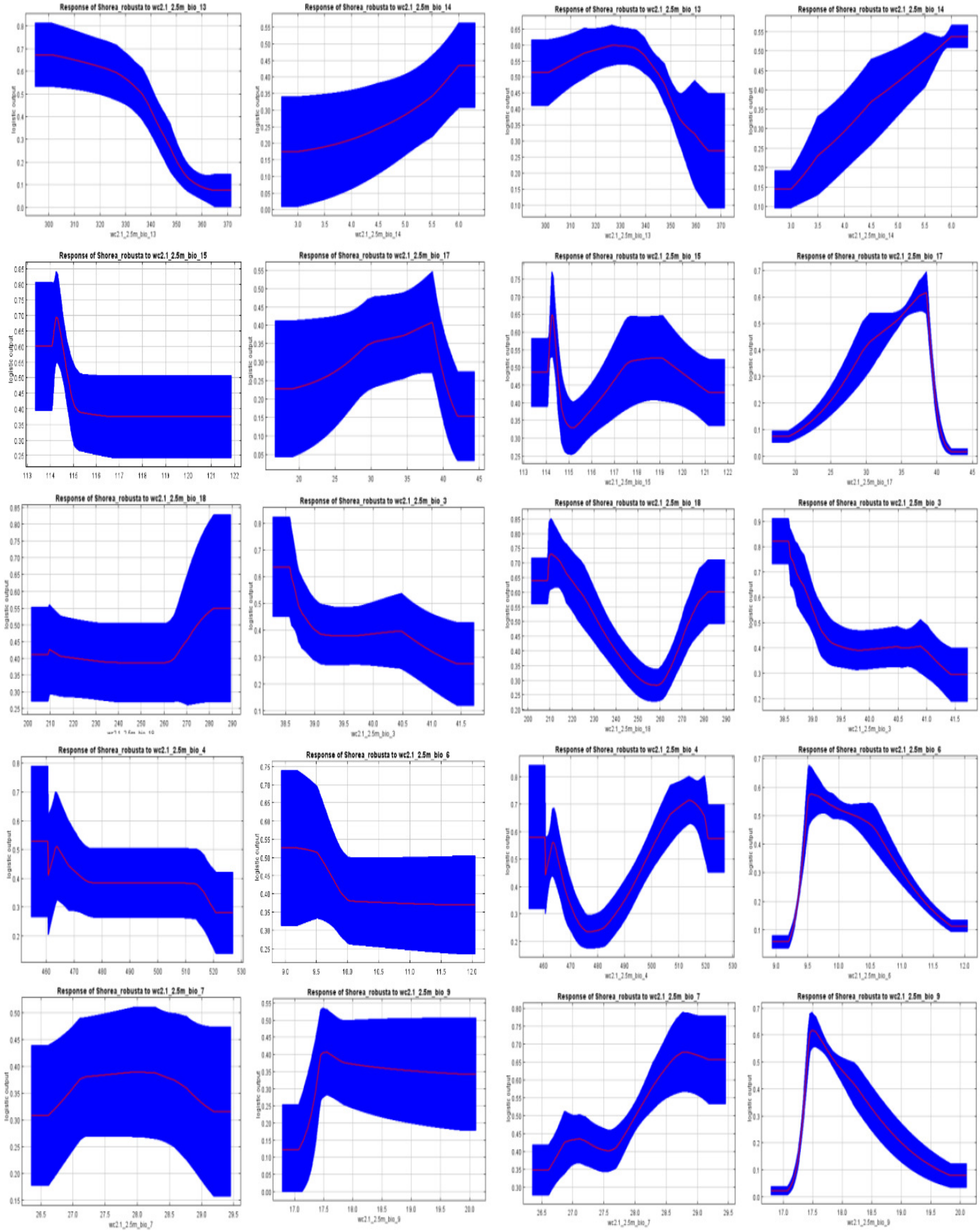


Fig. 8 : *S. robusta* response curves in relation to different bioclimatic variables.

Unlike the marginal response curves before, each of the curves below represents a new model; particularly a Maxent model generated using only the relevant variable. These graphs show how predicted suitability depends on the selected variable and dependencies generated by correlations between the selected variable and other factors. If there are high correlations between variables, they may be easier to interpret.

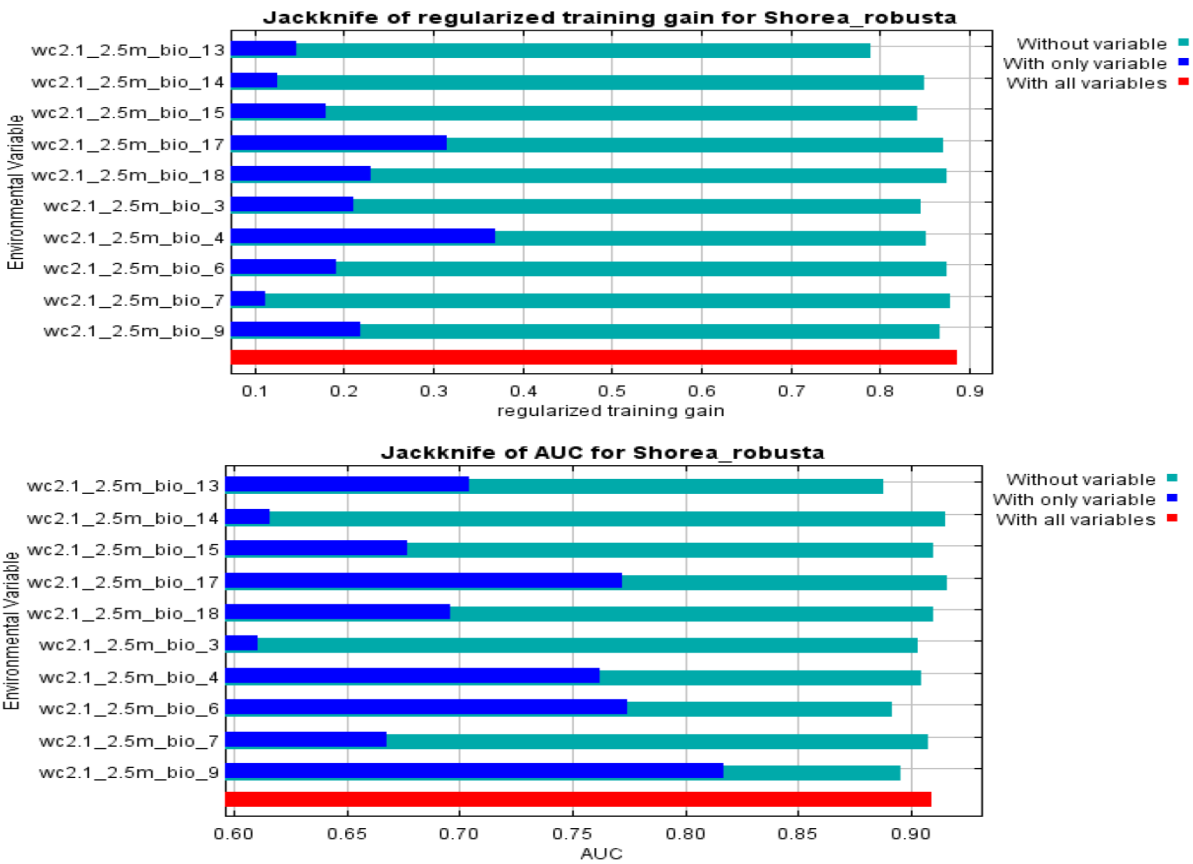


Fig. 9 : Jack-knife test of regularized training gain and AUC for *S. robusta*

Table 1: Environmental variables and their percentage contribution (Current Scenario: 2021)

S.No.	Environmental variables	Code	Unit	% Contribution
1	Temperature Seasonality	Bio_4	°C	17
2	Precipitation of driest period	Bio_14	mm	14.6
3	Precipitation of wettest period	Bio_13	mm	14.2
4	Precipitation of Driest Quarter	Bio_17	mm	13.4
5	Precipitation Seasonality	Bio_15	Fraction	13.3
6	Isothermality ((Bio2/Bio7) × 100)	Bio_3	Dimensionless	13.2
7	Min Temperature of Coldest Month	Bio_6	°C	5.8
8	Mean temperature of driest quarter	Bio_9	°C	4.1
9	Precipitation of warmest quarter	Bio_18	mm	2.9
10	Temperature annual range (Bio5-Bio6)	Bio_7	°C	1.5

Prediction of the future distribution of *S. robusta* Gaertn. f. in Ranchi district(Future Scenario: 2040)

S. robusta future prediction distribution using ssp126 for 2040 resulted in the future distribution map shown below (Fig. 10). If no external impact or factor affects the distribution, the ssp126 represents how the distribution will vary. As a result, in 2040, the distribution will disperse across the central, northern, and western parts of the Ranchi district, with the largest density in the central, slightly east-central, northern, north-western, and zone between the central and western regions. The moderate density will be found in Ranchi's eastern section and down to the inner side of the district's southern region. In the next 20 years, the western and south-eastern zones will have the lowest occurrence.

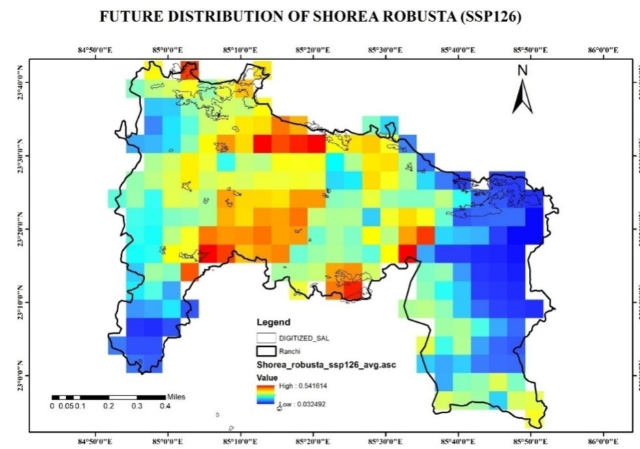


Fig. 10 : Showing the future distribution of *S. robusta* in Ranchi district

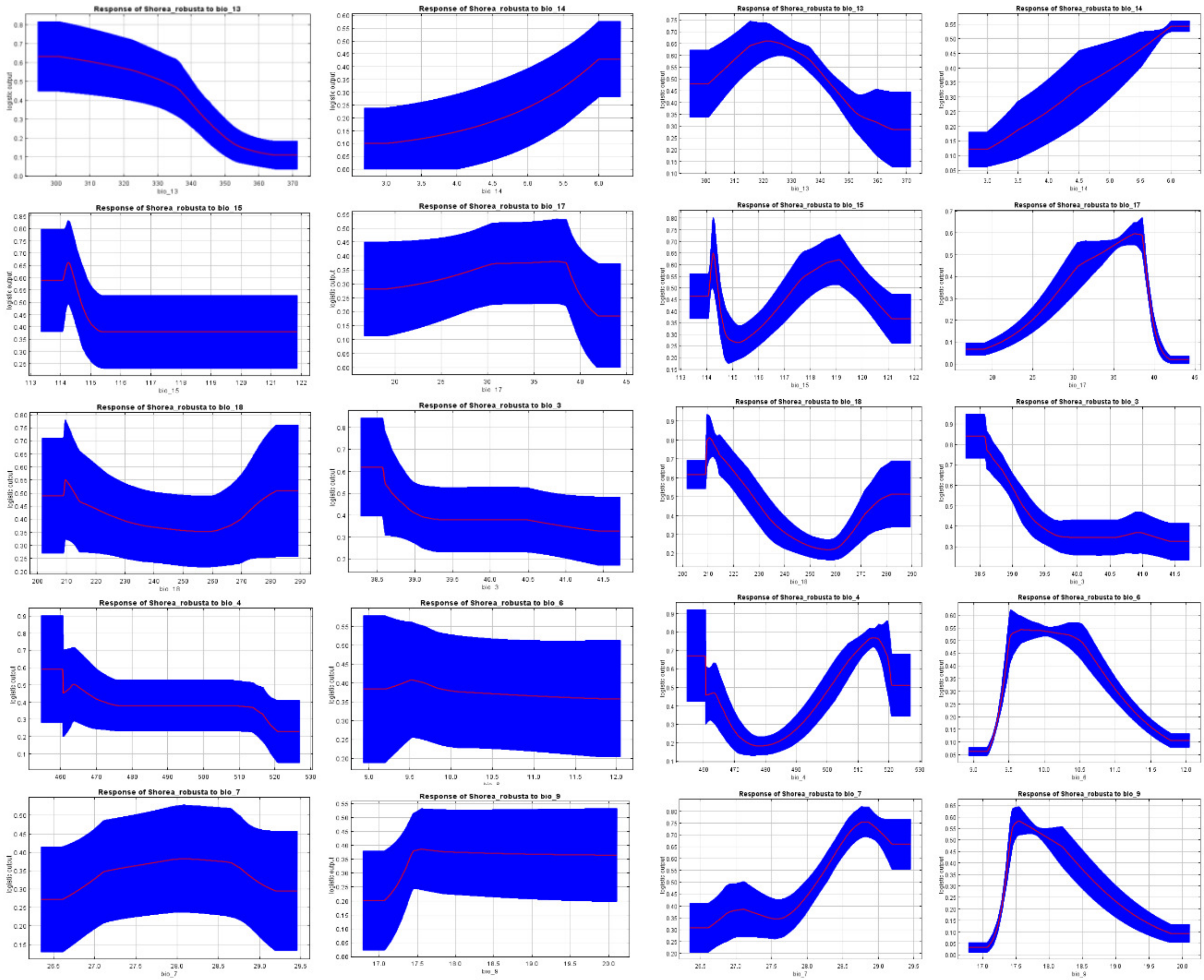


Fig. 11 : Response Curve of bioclimatic variables when other variables are not acting.

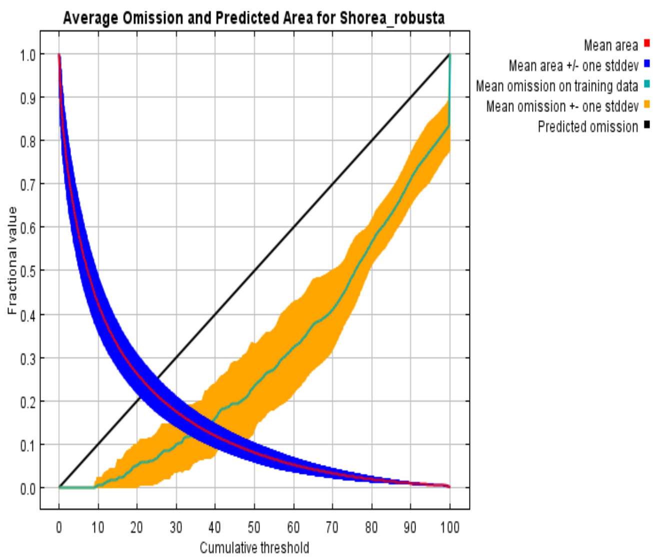


Fig. 12 : Average Omission and Predicted Area for *S. robusta* in Ranchi District (Future Scenario: 2040; ssp126) The average training AUC for the replicate runs is 0.939, and the standard deviation is 0.015.

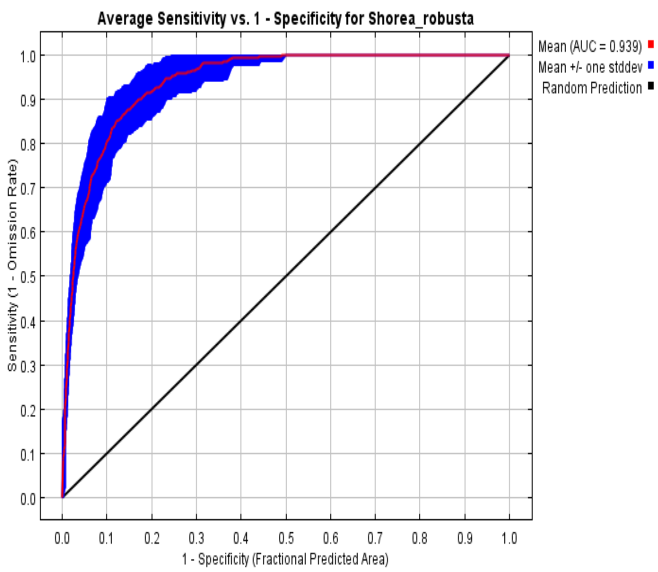
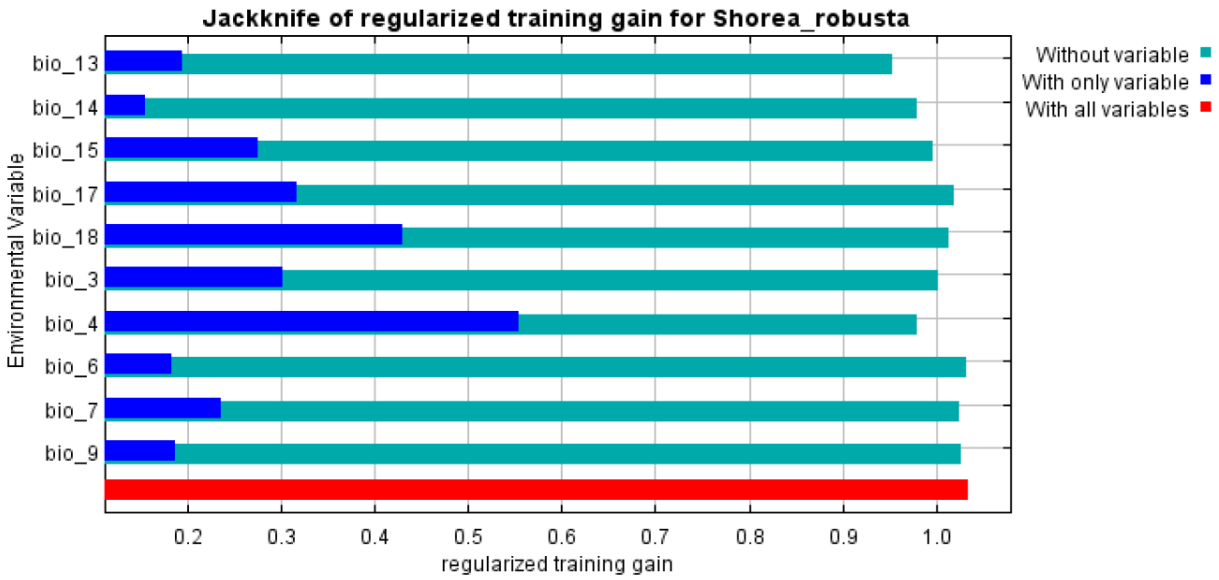


Fig. 13 : Average Sensitivity and Specificity for *S. robusta* in Ranchi District (Future Scenario: 2040; ssp126)



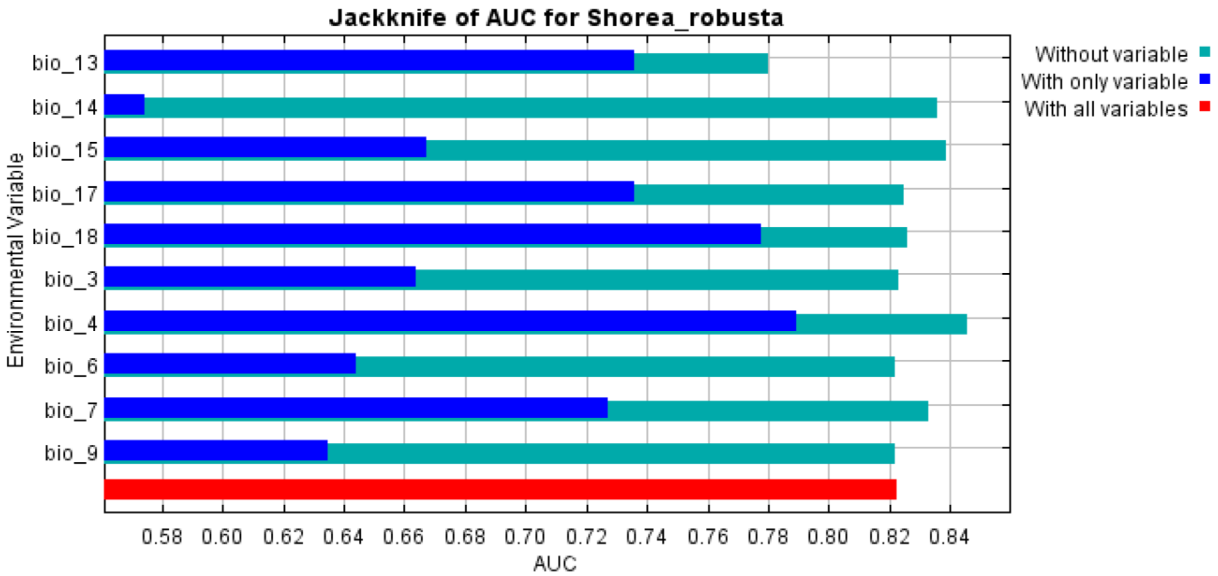


Fig. 14 : Jack-knife test for evaluating the relative importance of environmental variables of *S. robusta*in Ranchi.

The environmental variable with the highest gain, when used in isolation, is bio_4, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when omitted is bio_13, which therefore appears to have the most information that is not present in the other variables.

Table 2 : Environmental variables and their percentage contribution (Future Scenario: 2040)

S.No.	Environmental variables for ssp126	Code	Unit	% contribution
1	Temperature Seasonality	Bio_4	°C	26
2	Precipitation of driest period	Bio_14	mm	13.5
3	Isothermality ((Bio2/Bio7) × 100)	Bio_3	Dimensionless	12.7
4	Precipitation Seasonality	Bio_15	Fraction	11
5	Precipitation of warmest quarter	Bio_18	mm	10.9
6	Precipitation of Driest Quarter	Bio_17	mm	10.2
7	Precipitation of wettest period	Bio_13	mm	9.3
8	Min Temperature of Coldest Month	Bio_6	°C	2.9
9	Mean temperature of driest quarter	Bio_9	°C	1.8
10	Temperature annual range (Bio5-Bio6)	Bio_7	°C	1.7

The current IPCC estimate is to increase the mean annual temperature by (0.4 to 4.8) Celsius between 2046 and 2100. (IPCC 2014). Some plant and animal species may be threatened. The long-term trend of climate change and its impact on the distribution of diverse flora and fauna species is therefore vital to be understood.

Conclusion

The study was focused on the potential distribution of the *S. robusta* in the Ranchi district of Jharkhand using Ecological Niche modelling and the MAXENT algorithm. The north-western parts and the central parts of the Ranchi district were predicted to have the potential distribution of *S. robusta*. However, the north-western has a very high density, whereas the central regions have fragmented regions. The Jack-knife test was conducted for the current distribution of *S. robusta.* The model produced an AUC of 0.941 and SD of 0.015, which indicates that the model prediction is highly accurate.

The future prediction of *S. robusta* for the year 2040 was found that the eastern, central and northern regions are potential places for distribution of Sal in the future if no such external forces act on it. However, the western region does not show any occurrence in the future. The main reasons for the decrease of the forest area are overexploitation, encroachment, natural hazards, illegal felling of forest trees. In addition, Sal is illegally traded for its high market value; also, abiotic factors like soil erosion, temperature act as a barrier to the growth of the species.

References

Achary, S.N.; Nandi, D.; Kar, P.K. (2019). Status of Wild Tasar Silkworm Populations in Mayurbhanj Revealed Through GIS and Remote Sensing.

Behera, F.; Devi, R.S.; Sanghamitra, A. and Kumar, S. (2020). Food plants assessment of Asian elephant (Elephas maximus Linnaeus, 1758) in Dhenkanal district of Odisha, India: Tools for mitigation of Human-Elephant conflict. *NeBio*. 11(2): 117-124.

Elith, J.; Phillips, S.J.; Hastie, T.; Dudı´k, M.; Chee, Y.E. and Yates, C.J.; (2010). A statistical explanation of MaxEnt for ecologists. Diversity and Distributions. 1–15. DOI: 10.1111/j.1472-4642.2010.00725.x

Menon, S.; Choudhury, B.I.; Khan, M.L. and Peterson, A.T. (2010). Ecological niche modelling and local knowledge predict new populations of *Gymnocladus assamicus* a critically endangered tree species. *Endangered Species Research*, 11: 175–181.

Ortega-Huerta, M.A. and Peterson, A.T. (2008). Modeling ecological niches and predicting geographic distributions: a test of six presence-only methods. *Revista Mexicana de Biodiversidad*. 79: 205- 216

Phillips, S.J.; Anderson, R.P. and Schapire, R.E. (2006). Maximum Entropy Modeling of species geographic distributions. *Ecological Modeling*. 190: 231-259.

Warren, D.L. and Seifert, S.N. (2011). Ecological Niche Modelling in Maxent: the importance of model complexity and the performance of model selection criteria. *Ecological Applications*, 21(2): 335-342.