Project Interim Report 2

Project Title

Mapping rare and endangered species distribution of a protected area in Bangladesh under future climate scenarios: Implications for Conservation Planning

Project Site

Rema-Kalenga Wildlife Sanctuary, Bangladesh (GPS location: $24^{0}06^{/}$-$24^{0}14^{/}$ N & $91^{0}34^{/}$-$91^{0}41^{/}$ E)

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Summary

There is increasing evident that global climate change has significantly altered the forest vegetation, and will continue to do so in the future. Changes in temperature, rainfall and climate extremes such as drought, heavy rainfall, storms, and cyclones could fundamentally alter the species distribution and phenology which in turn, have impacts on forest ecosystems. Being a highly vulnerable country to climate change, it is more severe in the fragmented forests of Bangladesh. The total forest cover of Bangladesh is decreasing at an alarming rate and the biodiversity of the forest is under serious threat due to changing climate. A literature search revealed almost no work regarding this issue in Bangladesh. This project addresses this deficiency and identified the rare and endangered tree species from Rema-Kalenga Wildlife Sanctuary in Bangladesh. The spatial distribution of three rare medicinal tree species (*Terminalia chebula, Terminalia bellirica,* and *Phyllanthus emblica*) was modelled for current climatic condition and for the future climatic scenarios (for the years 2050 and 2070) using MaxEnt modelling algorithm. We used 11 environmental variables (10 bioclimatic variables and one altitude variable) for building the MaxEnt model. The key bioclimatic predictor variables were altitude (42.4%) following annual rainfall (16.6%) and precipitation of driest quarter (13.5%) in the model. The developed MaxEnt model indicates that, the habitat of the studied rare species in the central (deciduous forests) and north-eastern (evergreen forests) region of Bangladesh are more vulnerable to climate change compared to south-eastern (semi-evergreen forests) region. The outcomes of the project will be helpful for conservation planning of the protected areas of Bangladesh in changing climate scenarios.

Results

We identified 28 rare and endangered tree species belonging to 18 families in the study site. Table 1 describes the forest types, natural distribution and conservation status of those species in Bangladesh. The Rema-Kalenga Wildlife Sanctuary is very rich in rare tree species. However, the correlated process of habitat loss and increasing climate change are the greatest threat to the biodiversity of this forest. Figure 1 describes the locations of the rare species in the study site.

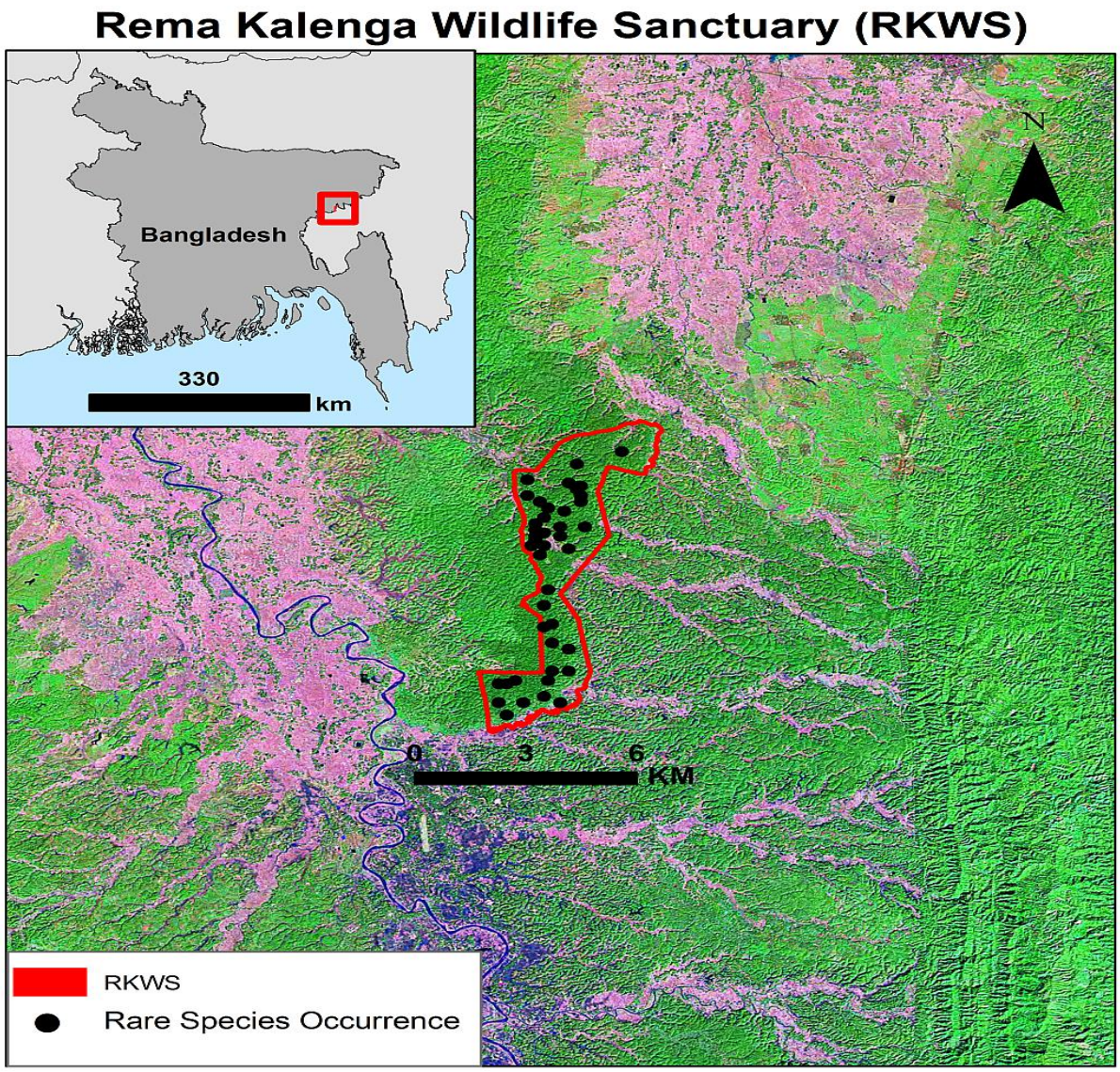

Figure 1: Rare and endangered tree species occurrences in the study area: the red mark inside the panel indicates the location of Rema-Kalenga Wildlife Sanctuary (RKWS) in Bangladesh, the black dot points are the positions of rare species occurrences in the study site.

Table 1: The list of rare and endangered tree species identified at Rema-Kalenga Wildlife Sanctuary and their natural distribution in Bangladesh

Species Name	Family	Forest types	Natural distribution	Conservation status
Buchanania lancifolia	Anacardiaceae	Tropical evergreen forests	Chittagong, Chittagong Hill Tracts	Not evaluated
Holigarna longifolia	Anacardiaceae	Rain forests	Chittagong, Rangamit and Sylhet districts	Data deficient
Mangifera sylvatica	Anacardiaceae	Hilly aeas, near streams and in valleys	Cox's Bazar, Chittagong and Sylhet districts	Not evaluated
Swintonia floribunda	Anacardiaceae	Rain forests	Chittagong, Cox's Bazar, Bandarban	Data deficient
Desmos longiflorus	Annonaceae	Hill forests	Chittagong, Sylhet	Not evaluated
Sageraea listeri	Annonaceae	Mixed evergreen forests	Chittagong Hill Tracts	Not evaluated
Bombax insigne	Bombacaceae	Mixed forests	Cox's Bazar districts	Data deficient
Balsamodendron roxburghii	Burseraceae	Semi-evergreen forests	Sylhet districts	Not evaluated
Canarium bengalense	Burseraceae	Mixed evergreen forests	Sylhet districts	Not evaluated
Canarium resiniferum	Burseraceae	Hill forests	Sylhet districts	Not evaluated
Terminalia chebula	Combretaceae	Moist deciduous to semi-evergreen forests	Cox's Bazar, Dhaka, Mymensingh and Sylhet districts	Data deficient
Cycas pectinata	Cycadaceae	Exposed slopes of hill	Chittagong, Mymensingh	Least concern
Anisoptera scaphula	Dipterocarpaceae	Tropical evergreen forests	Chittagong and Cox's Bazar districts	Data deficient
Elaeocarpus acuminatus	Elaeocarpaceae	Tropical evergreen forests	Sylhet districts	Not evaluated
Lithocarpus acuminata	Fagaceae	Rain forests	Chittagong and Bandarban districts	Not evaluated
Homalium schlichii	Flacourtiaceae	Top hills	Chittagong, Sylhet	Not evaluated
Hydnocarpus kurzii	Flacourtiaceae	Rain forests	Chittagong	Not evaluated
Litsea clarkei	Lauraceae	Mixed forests	Chittagong district	Not evaluated
Calliandra umbrosa	Leguminosae	Mixed evergreen forests	Chittagong and Sylhet districts	Not evaluated
Magnolia pterocarpa	Magnoliaceae	Hilly areas	Chittagong, Chittagong Hill Tracts	Not evaluated
Dysoxylum binectariferum	Meliaceae	Semi evergreen forests	Chittagong, Chittagong Hill Tracts	Not evaluated
Knema bengalensis	Myristicaceae	Mixed evergreen forests	Cox's Bazar districts	Vulnerable
Pterospermum semisagittatum	Sterculiaceae	Rain forests	Chittagong, Cox's Bazar, Chittagong Hill Tracts	Data deficient
Aquilaria agallocha	Thymelaeaceae	Semi evergreen forests	Sylhet districts	Data deficient
Dipterocarpus turbinatus	Dipterocarpaceae	Evergreen, semi-evergreen and mixed deciduous forests	Chittagong, Chittagong Hill Tracts, Sylhet and Cox's Bazar districts	Critically Endangered
Shorea robusta	Dipterocarpaceae	Moist deciduous to semi-evergreen forests	Mymensingh, Dhaka, Tangail and Sylhet districts	Least concern
Phyllanthus emblica	Euphorbiaceae	Moist deciduous to semi-evergreen forests	Cox's Bazar, Dhaka, Mymensingh and Sylhet districts	Data deficient
Terminalia bellirica	Combretaceae	Moist deciduous to semi-evergreen forests	Cox's Bazar, Dhaka, Mymensingh and Sylhet districts	Data deficient

Species distribution modelling

A literature search revealed no previous published work on species distribution modelling of rare tree species in Bangladesh. We selected three rare medicinal tree species namely *Terminalia chebula, Terminalia bellirica,* and *Phyllanthus emblica* in our study for spatial distribution modelling under future climate scenarios. We used presence only data of these three rare species from field survey and Bangladesh Forest Department (Figure 2). These three species are available in different forests in Bangladesh and their conservation status is still unknown due to data deficient (Table 1). We mapped the spatial distribution of these species in changing climate scenarios across the country for conservation planning. We used current and future climate (for the years 2050 and 2070) data from WorldClim database in our study. We selected only one Representative Concentration pathway (RCP) scenario (RCP8.5) in our study. At first, 20 bioclimatic variables were selected and after doing a multicollineraity test, 11 variables were finally selected for model building (Table 2). We used MaxEnt modelling algorithm for species distribution modelling. The description of three target rare species is given below with photographs.

Target rare species

(1) **Local name**: Haritaki

Scientific Name: *Terminalia chebula*

Family: Combretaceae

Description: A deciduous tree with straight trunk attaining a height of 20-30 m, and 1.5-2.7 m in girth. Leaves 9-17 × 4-7 cm, elliptic or oblong-elliptic, entire, acuminate or obtuse.

Habitat: Moist deciduous to semi-evergreen forests in Bangladesh.

Phenology: Flowering is March to July and fruiting is September to November.

Uses: The fruits have medicinal value. Wood is used for door-posts, beams, planks, boats and furniture. Tannin from fruits and bark produces a blue dye.

Conservation status: Data deficient

(2) **Local name**: Bahera

Scientific name: *Terminalia bellirica*

Family: Combretaceae

Description: A large deciduous tree reaching a height of 40 m, trunk with large buttresses and grey, longitudinally ridged bark. Leaves are petiolate, spiralled, crowded into pseudowhorls at apices of branchlets and 18-20 cm long.

Habitat: Moist deciduous to semi-evergreen forests in Bangladesh.

Phenology: Flowering is March to April and fruiting is May to July.

Uses: Its trunk is used for timber, leaves for fodder, and fruits for medicine. The bark is diuretic, useful in anaemia and leukoderma. Oil extract from the seed pulp is used in leucoderma and alopecia.

Conservation status: Data deficient

Photo 1: *Terminalia chebula*

Photo 2: *Terminalia bellirica*

(3) **Local name**: Amlaki

Scientific name: *Phyllanthus emblica*

Family: Euphorbiaceae

Description: A medium-sized deciduous tree reaching a height of 3-8 m. Leaves are linear-oblong and fruits are depressed globose.

Habitat: Moist deciduous to semi-evergreen forests in Bangladesh.

Phenology: Flowering is March to May and fruiting is October to February.

Uses: It is important for fodder, food and medicine. Fruits are eaten fresh or made into pickle. Barks, fruits and leaf are used as medicine. Tannins and dye are produced from bark and leaf.

Conservation status: Data deficient

Photo 3: *Phyllanthus emblica*

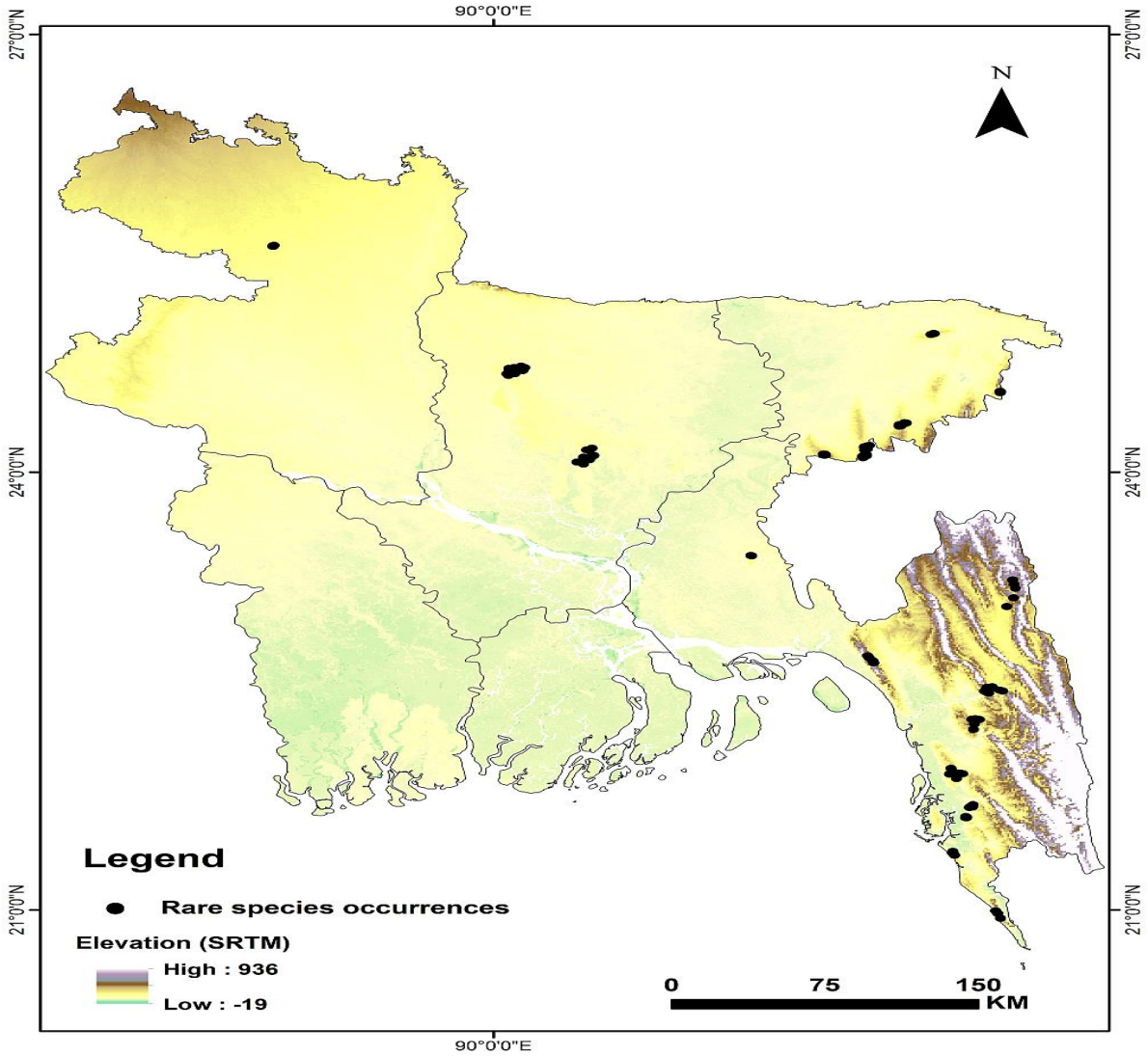

Figure 2: Presence only data of three rare medicinal tree species (i.e. *Terminalia chebula*, *Terminalia bellirica*, and *Phyllanthus emblica*) across Bangladesh (source: field survey and Bangladesh Forest Department).

Predictor variables

The key bioclimatic predictor variables were altitude (42.4%) following annual rainfall (16.6%) and precipitation of driest quarter (13.5%) in the model (Table 2). The precipitation of warmest quarter (10.6%) was also influential. Other bioclimatic variables did not contribute significantly to the model (Table 2).

Table 2: The percent contribution of the environmental variables for building the MaxEnt model of the rare species

Variables	Descriptions	Contribution (%)
BIO1	Annual Mean Temperature	0.7
BIO3	Isothermality (BIO2/BIO7) (* 100)	0.2
BIO6	Min Temperature of Coldest Month	3.9
BIO7	Temperature Annual Range (BIO5-BIO6)	2.4
BIO8	Mean Temperature of Wettest Quarter	2.4
BIO12	Annual Precipitation	16.6
BIO14	Precipitation of Driest Month	0.3
BIO15	Precipitation Seasonality (Coefficient of Variation)	7.1
BIO17	Precipitation of Driest Quarter	13.5
BIO18	Precipitation of Warmest Quarter	10.6
alt	altitude (elevation above sea level) (m) (SRTM)	42.4

Predicting distribution of rare tree species

Figure 3 explains the likely distribution of the studied rare species in Bangladesh forests. The values in the colour scale (0 to 1) denote the habitat suitability distribution of the rare species. The value 1 indicates the most habitat suitability of the species. The Rema-Kalenga Wildlife Sanctuary is situated in the north-eastern region of Bangladesh (Figure 1). It appeared that in the north-eastern region (evergreen forests) of Bangladesh, the likely distribution of rare species will be decreased continually at higher emission pathway RCP8.5 in 2050 and 2070 (Figure 3). The central part of the country where the rare species are found in the deciduous Sal (*Shorea robusta*) forests will experience same scenarios (Figure 3). The semi-evergreen forests located in the Southeast part of Bangladesh will be comparatively more suitable for the rare species in changing climate scenarios (Figure 3). The elevation of the Southeast part of Bangladesh is very high (Figure 2) which is the most controlling variable for rare species distribution (Table 2).

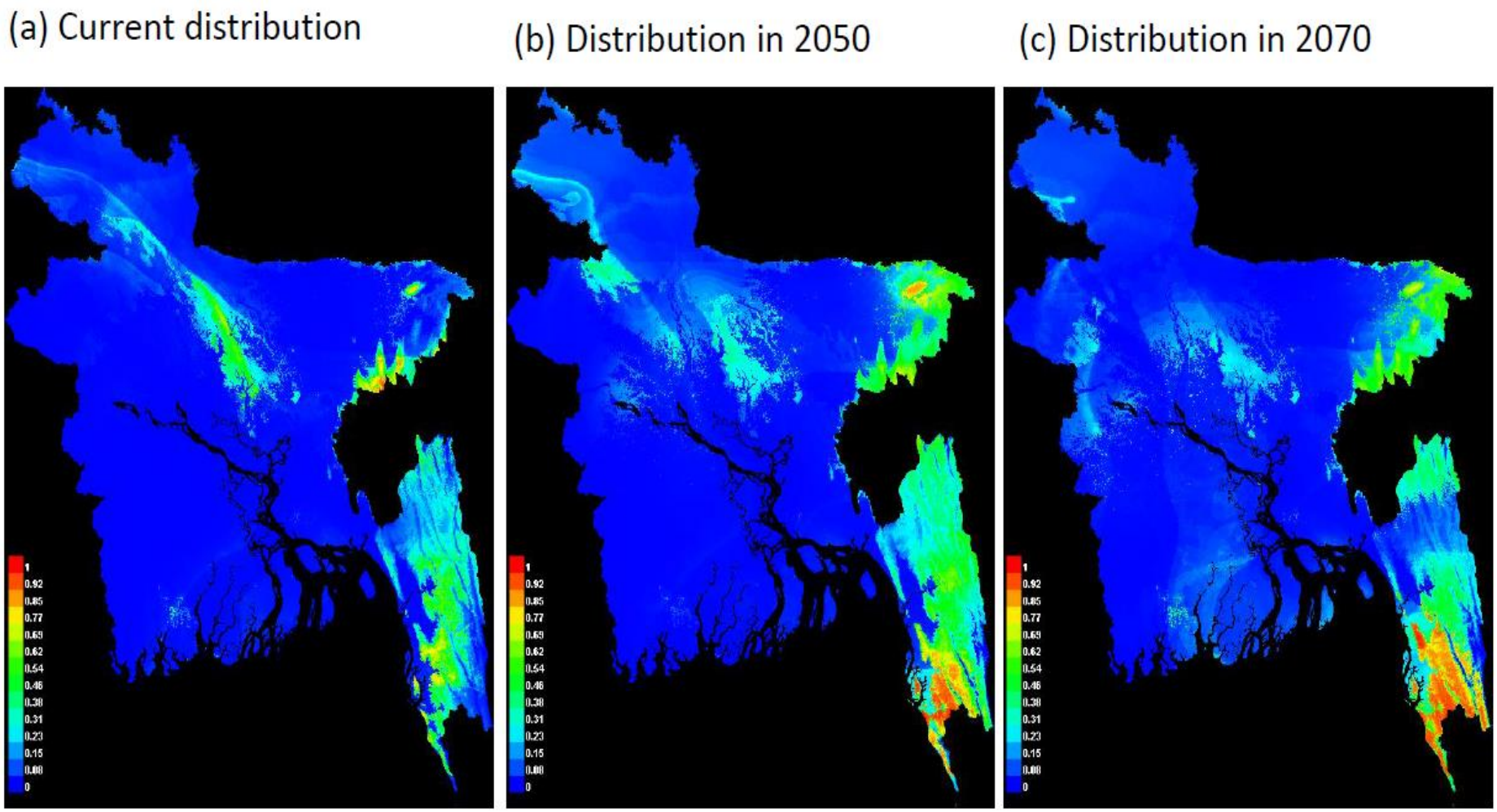

Figure 3: Prediction distribution of *Terminalia chebula*, *Terminalia bellirica*, and *Phyllanthus emblica* species: (a) current distribution; (b) distribution in 2050; and (c) distribution in 2070. The values in the colour scale (0 to 1) denote the habitat suitability distribution. The value 1 indicates the most habitat suitability of the species. The habitat of rare species in the central (deciduous forests) and north-eastern (evergreen forests) region of Bangladesh are more vulnerable to climate change compared to south-eastern (semi-evergreen forests) region.

Model performance

We used threshold independent AUC (area under curve) value of Receiver Operating Characteristic (ROC) statistical analysis for our model. The AUC value (0.974) indicates the excellent performance of the model for species distribution in changing climate scenarios (Figure 4).

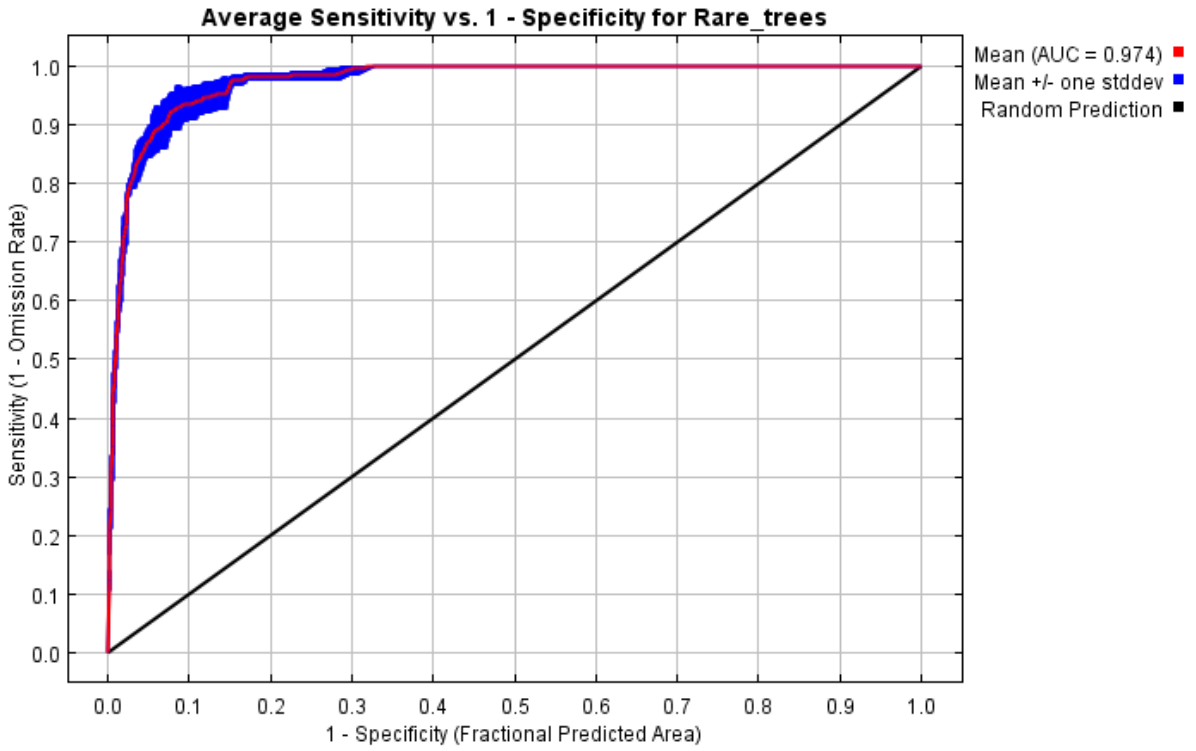

Figure 4: The AUC value of the model indicates the performance of the model.

Implications for conservation planning

The shifts in the distribution of the studied rare species will have major consequences for conservation of the forests and all related fauna and flora in north-eastern and central region of the country. Conservation planning focusing on those forests will have to consider the impact of climate change on the rare and endangered tree species and whether or not those species will persist in changing climate scenarios.

Next steps

Now we are preparing a manuscript from the project findings in order to submit it in a peer reviewed journal. We hope to come out with more results through publications.