How Climate Change Affects Habitat Suitability for Crocodylus Siamensis

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Introduction:

Global climate change is the most troublesome hindrance our world is facing in its struggle for existence. Although it has been proven that over time, climate change is a completely natural process, the anthropogenic side can't be ignored as it is inducing numerous modifications in natural climatic processes. This can result in effects spanning extreme weather, reduction of biodiversity, depletion of biotic resources, the changing of geophysical features, etc. Climate change has largely modified climate conditions around the world, steadily increasing weather extremes and hence causing weather parameters to develop in different environments than before. Temperature, rainfall, and humidity immensely impact biodiversity, and many tropical species can't tolerate conditions beyond mild variations. Anything beyond these mild variations can result in species migrations, endangering the species and causing ecosystem niche gaps. Additionally, the loss of permafrost, glaciers, and ice sheets have caused sea levels to rise, which then has an adverse impact on many low-lying freshwater ecosystems through saltwater inundation. Crocodiles require freshwater habitats for nesting and saltwater inundation can make them lose their habitats and decrease their nesting range.

Climate change has proven to continue its devastating impact on apex predators, including crocodiles. Climate change can affect crocodiles habitat suitability, nesting locations, prey availability, etc. Scientists have deduced that the degree of impact climate change will have on crocodiles is dependent on the loss of nesting habitat and their ability to find new habitats. Species distribution modeling (SDM) can model these changes in suitable habitat range for a variety of plants and animals. SDM modeling specializes in predicting the spatial and temporal patterns of special occurrences. This can help us figure out how species' habitats can change over time.

It is important to understand the consequences climate change will have on crocodiles' habitat range and can help drive conservation efforts. It is imperative to understand the numerous ways the crocodiles will be affected if more meaningful and purposeful conservation efforts are to take place. There have been many conservation efforts to support these crocodiles however, their population numbers are still dwindling as the conservation efforts predominantly focus on a narrow species range and try to fix only one or two factors leading to the population decrease. The anthropogenic aspect of climate change must be addressed.

Methods:

I obtained occurrence records of Crocodylus Siamensis from Global Biodiversity Information Facility (GBIF) [GBIF]. The GBIF is database and data infrastructure supported by multiple national governments, aimed at providing open-access biodiversity data for the public and the science community. The total number of occurrences for C. Siamensis downloaded is 138,732. These occurrences are found mainly in Australia, Indonesia, Singapore, South Africa, India, Kenya, Mexico, etc. The timeline of the sightings for this species ranges from 1985 to 2024. I filtered to keep only occurrences with coordinates. The latitudes range from 80 to 120 and longitudes range from -5 to 30.

Environmental Variables

I acquired environmental variables representing the current climatic conditions from the WorldClim database (Fick and Hijmans, 2017) at the resolution of 2.5 arcmin. The environmental variables included: Bio1 = Annual mean temperature, Bio2 = Mean diurnal range (max temp – min temp) (monthly average), Bio3 = Isothermality (Bio1/Bio7) * 100, Bio4 = Temperature Seasonality (Coefficient of Variation), Bio5 = Max Temperature of Warmest Period, Bio6 = Min Temperature of Coldest Period, Bio7 = Temperature Annual Range (Bio5-Bio6), Bio8 = Mean Temperature of Wettest Quarter, Bio9 = Mean Temperature of Driest Quarter, Bio10 = Mean Temperature of Warmest Quarter, Bio11 = Mean Temperature of Coldest Quarter, Bio12 = Annual Precipitation, Bio13 = Precipitation of Wettest Period, Bio14 = Precipitation of Driest Period, Bio15 = Precipitation Seasonality (Coefficient of Variation), Bio16 = Precipitation of Wettest Quarter, Bio17 = Precipitation of Driest Quarter, Bio18 = Precipitation of Warmest Quarter, and Bio19 = Precipitation of Coldest Quarter. Using R software (R Core Team, 2023) and raster package (Hijmans, 2024), I trimmed the environmental variables so that the geographic range of environmental variables was contained with 120 degree latitudes and 30 degree longitudes. The extent of the environmental variables covers and extends beyond the latitudinal and longitudinal ranges of C. Siamensis.

In addition, to project species future suitable areas, I acquired environmental variables representing future climatic conditions for the years 2061- 2080 under the model MPI-ESM1-2-HR and CMIP6 (Gutjahr et al., 2019) The future climatic raster layers were also trimmed using the sampling extent mentioned above.

Modeling Strategy

To investigate the suitable habitat areas of C. Siamensis, we performed a multivariate generalized linear model (GLM). I randomly selected 10,000 pseudo-absence, or “background” points, within the range of the environmental variables (see section above). The number of 10,000 pseudo-absence points followed the recommendation by Barbet‐Massin et al. (2012). After running the GLM model, I converted the continuous probability of habitat suitability to a binary response output (suitable = TRUE or FALSE). The suitability cut-off was equal to the threshold at which the sum of the model sensitivity (true positive rate) and specificity (true negative rate) is highest (Field et al. 1997; Liu et al. 2011). I then used five-fold cross validation to evaluate the trained GLM; in each cross validation, 80% of the occurrence data were training data, leaving the remaining 20% as testing data. We evaluated the performance of GLM by calculating the Area Under the ROC Curve (AUC). We then projected future suitable habitat areas for Crocodylus Siamensis in 2061-2080.

Results:

The final GBIF dataset of Crocodylus Siamensis contains 20 records with coordinates. The GLM species distribution model shows an AUC value of 0.935, which indicates that this model has a high accuracy and can distinguish the suitable habitat from the non-suitable habitats (Figure 1). The GLM model output shows that variables 2, 17 and 18 show significant positive correlation to predicting species presence, and variables 4, 8, and 19 show significant negative correlation to species presence (Table 1). The comparison between current and future suitable habitat area reveals that due to climate change, the suitable habitat for C. Siamensis will greatly decrease (Figure 2).

Discussion:

The results have shown us that the suitable habitat range of C. Siamensis will greatly decrease in the coming years. Climate change is progressing and its consequences are only increasing in severity. Climate change can best be solved if adequate-informed and lasting conservation efforts are placed to target all of its aspects. Information regarding climate change must be spread, people have to start changing harmful products and stop harmful practices. Decisions need to be reached in international meetings and everyone on this planet must help to mitigate climate change. What climate change holds in stock for us in the future is devastating, we can solve it by acting now. To be skeptical of this proven fact will harm us all and we must use science and informed choices to make the world a better place.

Figures:

Table 1

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	5.362488e+01	3.392516e+01	1.5806819	0.113950800
wc2.1_2.5m_bio_1	2.130884e+01	7.465946e+00	2.8541383	0.004315374
wc2.1_2.5m_bio_2	6.392653e+00	3.481642e+00	1.8361031	0.066342409
wc2.1_2.5m_bio_3	-9.946674e-01	5.769211e-01	-1.7240960	0.084690520
wc2.1_2.5m_bio_4	-2.141161e-01	1.561799e-01	-1.3709582	0.170388000
wc2.1_2.5m_bio_5	-5.862398e+05	8.906478e+05	-0.6582173	0.510398509
wc2.1_2.5m_bio_6	5.862412e+05	8.906477e+05	0.6582189	0.510397504
wc2.1_2.5m_bio_7	5.862365e+05	8.906476e+05	0.6582138	0.510400780
wc2.1_2.5m_bio_8	-3.917003e+00	1.805283e+00	-2.1697446	0.030026199
wc2.1_2.5m_bio_9	3.876274e-01	8.641100e-01	0.4485857	0.653730573
wc2.1_2.5m_bio_10	-2.057788e+00	5.696715e+00	-0.3612235	0.717932351
wc2.1_2.5m_bio_11	-1.675536e+01	8.497026e+00	-1.9719091	0.048619988
wc2.1_2.5m_bio_12	-4.846318e-03	5.347829e-03	-0.9062216	0.364818594
wc2.1_2.5m_bio_13	-3.057946e-02	2.310211e-02	-1.3236650	0.185614315
wc2.1_2.5m_bio_14	-2.544320e-01	2.034970e-01	-1.2502985	0.211190530
wc2.1_2.5m_bio_15	7.632480e-02	1.023760e-01	0.7455343	0.455948759
wc2.1_2.5m_bio_16	1.146638e-02	1.213848e-02	0.9446300	0.344847785
wc2.1_2.5m_bio_17	1.717087e-01	7.133678e-02	2.4070145	0.016083532
wc2.1_2.5m_bio_18	9.058570e-03	4.761404e-03	1.9024997	0.057105853
wc2.1_2.5m_bio_19	-8.684402e-02	2.933579e-02	-2.9603432	0.003072965

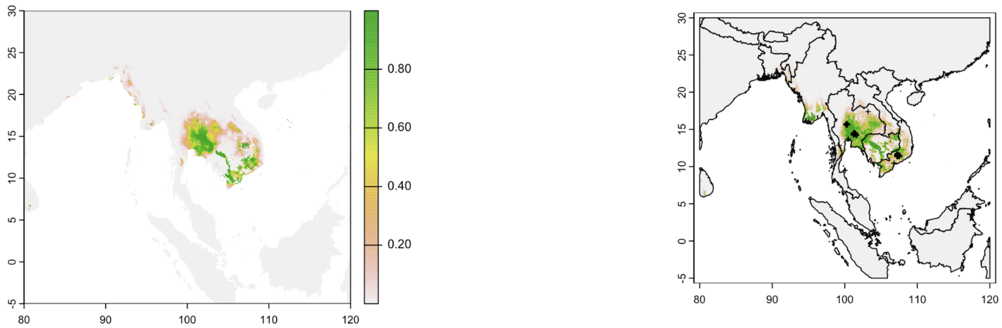
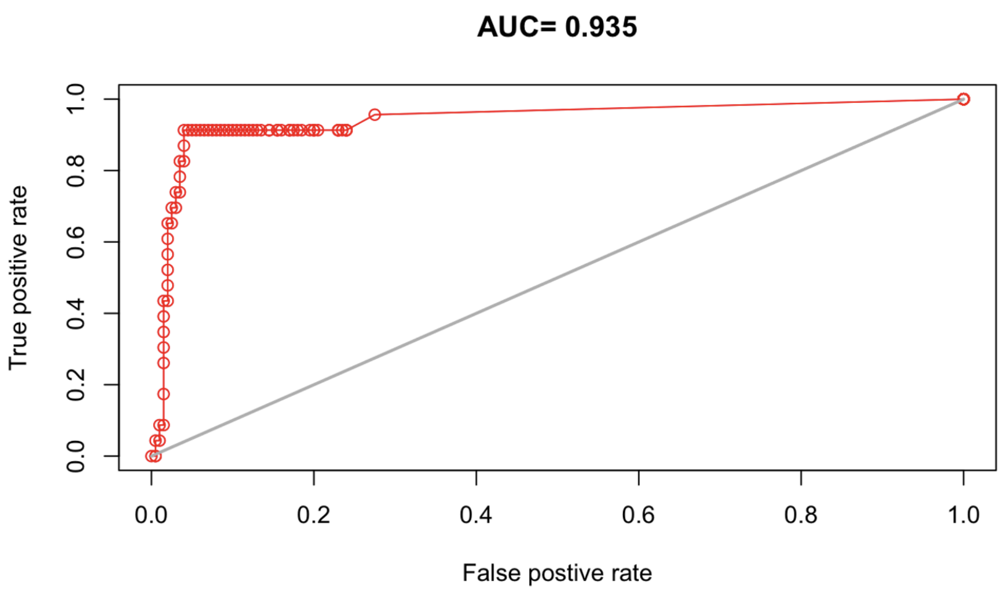


Figure 1

Figure 2



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