Species Distribution modelling of Asian rice (*Oryza sativa*)

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Introduction

Asian rice (*Oryza sativa*), is among the most important and widespread crops globally, and is staple food source for about half the global population (1). Rice production will have to increase significantly over the coming decades in order to sustain the dietary needs of a growing global population, particularly in area with the highest population expansion; southern Asia, and sub-Saharan Africa.

Rice cultivation is positively influenced by increased humidity and high (seasonal) rainfall, because it requires standing water for growth. Rice is also a true (sub)tropical crop and requires relatively high temperatures between 20°C and 40°C (2). Rice agriculturalists are aware of the potential negative influence of anthropologically induced climate change (3,4). However, they are equally aware of the predicted higher demand for rice due to regional and global populations growth.

This study will provide predicted changes of viable habitat range for Asian rice (*Oryza sativa).* Based upon predictions of environmental conditions in 2050, and prediction of present-day distributions based on occurrences of Oryza sativa recorded in the Global Biogeographic information Facility database (GBIF)(5).

Methodology

Occurrences of Oryza Sativa were obtained from GBIF, and the data set was trimmed to exclude occurrences noted without coordinate data (4). A final dataset of 136506 occurrences were used in this analysis. Climate data explaining current global environmental variation and a prediction of climatic states in ~30 years' time was acquired from worldclim.org version 1.4 (6). The 2050 model used was greenhouse gas scenario RCP4.5, which simulates bio climatic conditions if greenhouse gas emissions peak in 2040, in line with the goals outlined in the Paris climate accord 2015.

The following temperature and moisture climatic variables were selected for this species distribution model, correlated variables were avoided, and selection was made based on biological arguments presented in (2,3,4):

Bioclimatic variable (ANUCLIM abbreviation)	**Bioclimatic variable description.**
Bio1	Annual mean temperature
Bio2	Mean diurnal range
Bio15	Precipitation seasonality
Bio16	Precipitation of wettest Quarter

Maxent software was used to acquire species distribution models (7). The maximum entropy method which Maxent uses was replicated 10 times and cross validated to create a consensus species distribution model. Max number of background points was increased to 200,000 to ensure more pseudo-absences than presences were included in the AUC model validation analysis. default setting was retained for other variables.

Model output

The predicted distribution of *Oryza sativa* in current climatic conditions is plotted in figure 1 along with the occurrences as recorded in the GBIF. This makes it possible to compare the predicted distribution with actual distributions. The prediction of future distribution based on environmental conditions as described in climate model RPC 4.5 is shown in figure 2. The distribution predictions show a widespread viable habitat for *Oryza sativa*. In particular, the widespread occurrence of *Oryza Sativa* in Asia concurs with recorded observations, although our model predicts suitable climatic conditions for North Africa and South America that are not reported occurrence data.

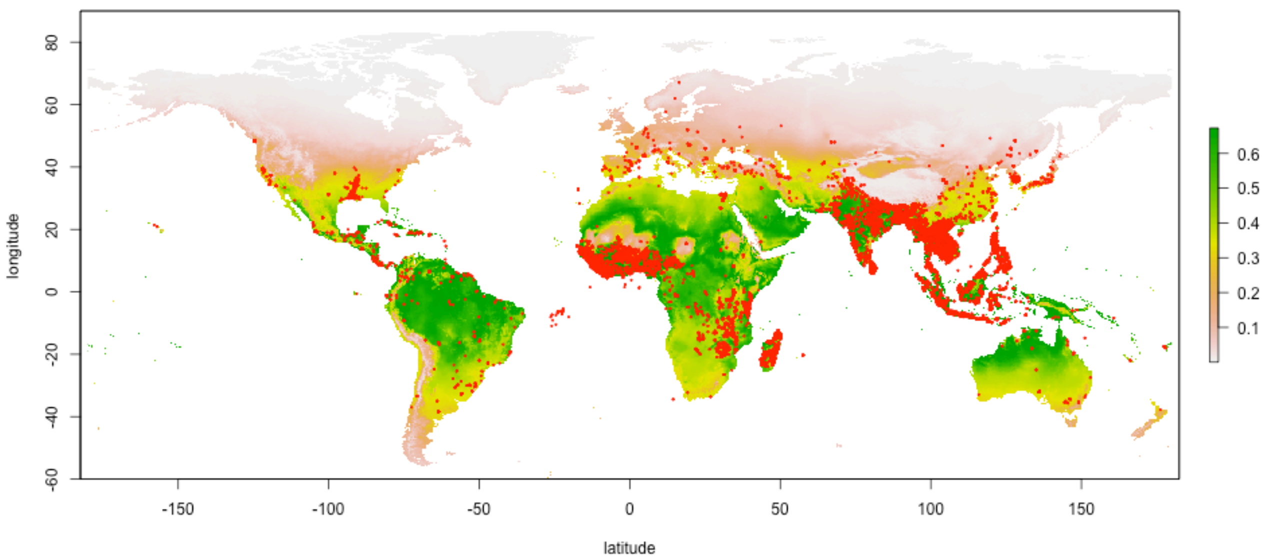

Figure 1: Predicted current global distributions based, and recorded occurrences of O. sativa. Recorded observations are plotted in red.

Model performance as indicated by the metric area under the curve (AUC) was 0.816. although this AUC value validates the model it should be treated with caution because it relies on pseudo-absence of occurrence rather than recorded absence (8).

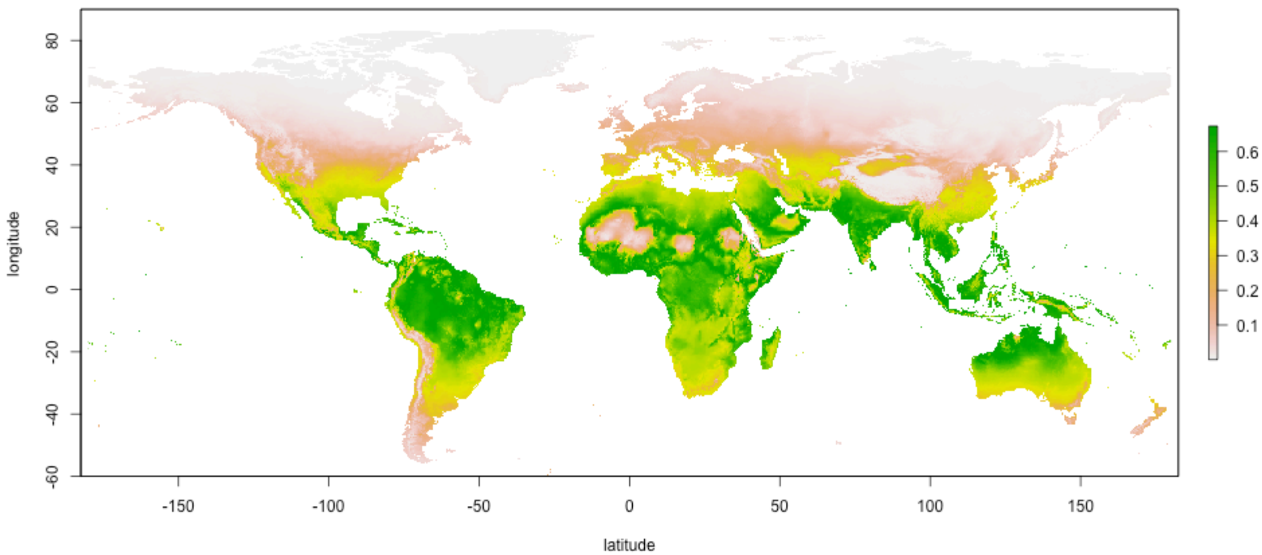

Figure 2: Predicted global distribution of O. sativa in 2050 according to climate model RCP 4.5.

The predicted change in viable habitat between current and future climatic conditions for *Oryza sativa* is shown in figure 3. The largest loss of potential distribution occurs in north western Africa, and a section in Arabian Peninsula, according to this model. Viable habitat is also lost at the most southern margins of the current viable distribution in South America and Australia. Additionally, the model predicts a small amount of viable habitat will be gained in North America and India.

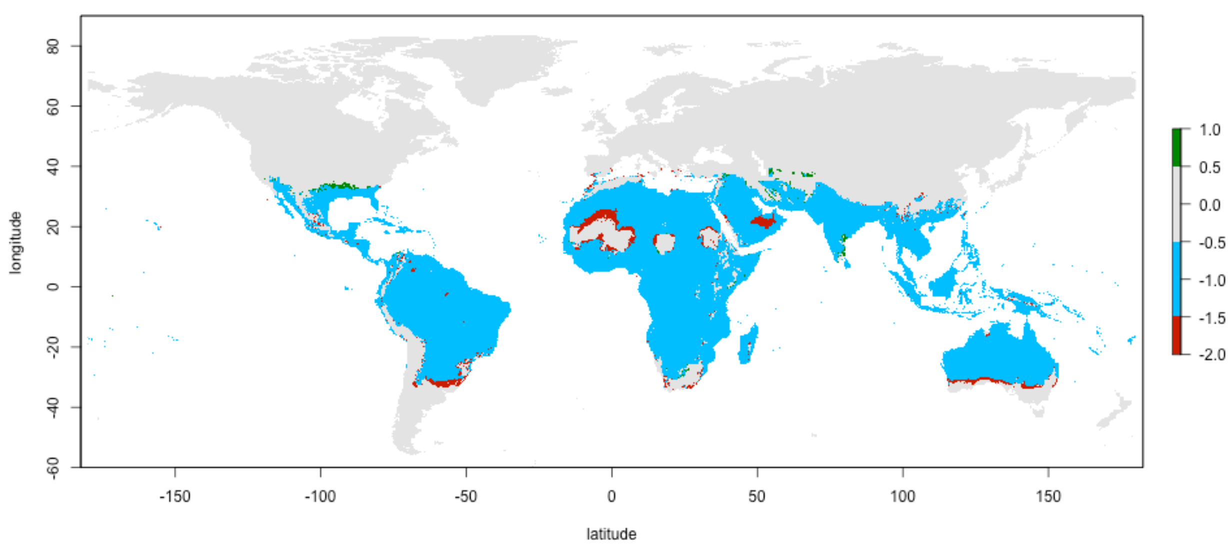

Figure 3: Predicted distribution shift of O. sativa. Comparison of current predicted distribution and predected distribution for 2050. Unchanged range is shaded blue, lost range is shaded red, gained range is shaded green.

Biological interpretation

Until 2050 global habitat viability for Asian rice (*Oryza sativa)* will be reduced at several margins of the present-day habitat viability current distribution. However, according to this model, much of the current possible distributional range of rice will be retained while some regions will make possible gains in range of habitat viability. The widespread viable habitat of *Oryza sativa* predicted in our species distribution model for present day and future climatic conditions, does not wholly describe the distribution of this cultivated crop for a number of reasons.
South America is one area where predicted and actual distribution do not concur. In particular the Amazonian basin, this may be due to land use deviation. Despite deforestation much of the Amazonian basin remains inappropriate for agricultural practices due to forest cover. our model does not take into account biotic conditions or competitions. Furthermore, my model over-predicted rice distribution in Northern Africa, this is likely due to sub optimal variable selection, my model relies heavily on mean temperature and precipitation seasonality. The drought season of North Africa and the monsoon season of South East Asia may have similar effects on precipitation seasonality coefficient despite having conflicting influences on habitat suitability for Asian rice.

O. sativa is a cultivated crop and for that reason, economic and cultural factors have a major influence on its current (and future) distribution. For example, Japan is the world's ninth largest agricultural producer of rice however our model predicts that climatic variables are not optimal for rice cultivation in japan. Regardless cultural tradition and economic support for rice agriculture results in a high resource investment in rice production and mechanical cultivation. Furthermore, unlike other Asian rice cultivars Japanese cultivar are particularly hardy towards colder temperature. This model does not account for variation in adaptability of rice cultivars. Economic and cultural influence on rice cultivation and distributions are not accounted for in this model other than through the influence these factors may have on the occurrences as recorded in the GBIF dataset, ultimately our model is weakened by the influence these cultural and economic occurrences have on the distribution dataset. Despite the shortcomings of this model in predicting actual or future distributions, the outputs indicate geographic areas where viable environmental conditions exist and could exist according to the climate change predictions defined in RCP 4.5. Further optimization of this model could play an effective role in averting food crises as we confront the predicted human population growth in sub-Saharan Africa and Asia, regions with the optimal environmental conditions for rice cultivation.

References

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