Species distribution modelling (SDM): *Cocos Nucifera L.*

Report Methods in Biodiversity Analysis – Kiki Fontein (s1910183)

Introduction

Cocos Nucifera L. grows throughout the tropics with the highest production in south east Asia and the Pacific (*Fig.1*). Some records are found in temperate regions (e.g. United Kingdom) where temperatures in winter reaches far below the optimal outdoor temperature 21°C of *C.Nucifera*[1]. The coconut tree its seed is an ocean traveler and thrives in sandy and salty soil hence the coastal occurrence. Records found in temperate regions and more land inwards could represent green houses, plantations or errors throughout the process from observation to GBIF. In this report, species distributions models were made using climatic variables to indicate suitable habitats. From these models, an estimation about the distribution of *C.Nucifera* can be made with respect to global warming.

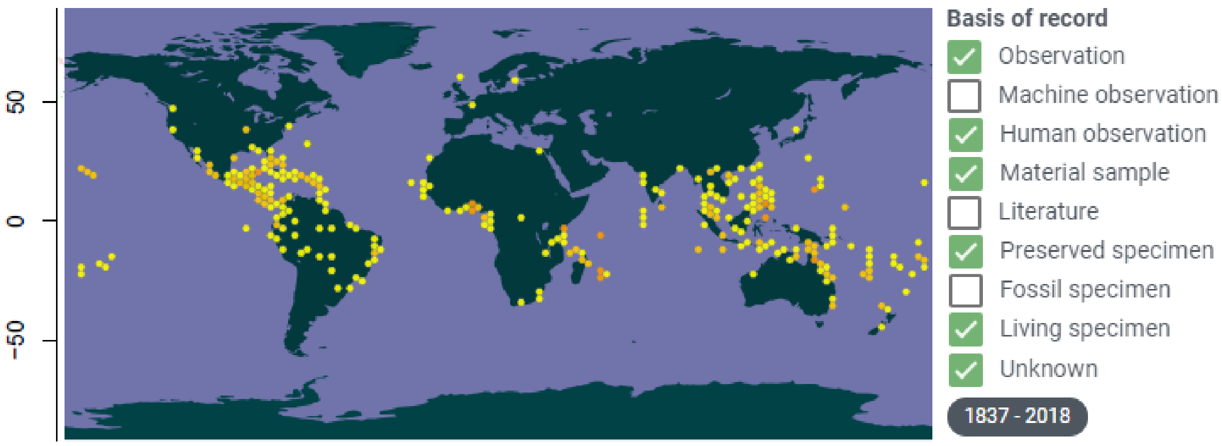

Fig.1: Present records of C.Nucifera extracted from GBIF[2] (1837-2018).

Method: species distribution modelling using climatic variables.

Occurrence data including the coordinates of *C.Nucifera* was extracted from GBIF. Hereafter, climate variables were downloaded from worldclim.org (version 1.4). At 5-minute resolution, current bioclimatic variables (1960-1990) and future 2050 HadGEM2-AO:RCP 4.5 bi (2041-2060) were downloaded. Climate change is currently happing, for this, future 2050 was chosen as it is nearest to the present. RCP 4.5 was selected as it is the medium emissions pathway. However, RCP 6 may be more representable based on the current emission rates. Both RStudio (version 3.5.1) and Maxent (version 3.4.1) were used for SDM. In RStudio, climatic variables: bio2, bio4, bio12 and bio15 were selected to be most important for the distribution of *C.Nucifera* and were found to be uncorrelated. The temperature variables bio 2 (mean diurnal range) and bio 4 (temperature seasonality) were selected as *C.Nucifera* is sensitive to diurnal variations and in general grows in tropical regions characterized by temperature above 18°C throughout the year[3]. Bio 12 (annual precipitation) and bio 15 (precipitation seasonality) are moisture variables and were selected as *C.Nucifera* requires evenly distributed precipitation throughout the year[3]. Subsequently, the R script of variable selection and the Maxent settings proposed in the handout (*Fig.2*) were used to create SDM in Maxent. From Maxent, the final product as 'HTML' file was used for further interpretation of the distribution. Additionally, the script in the '.asc' files were further used in RStudio to create similar additional SDM.

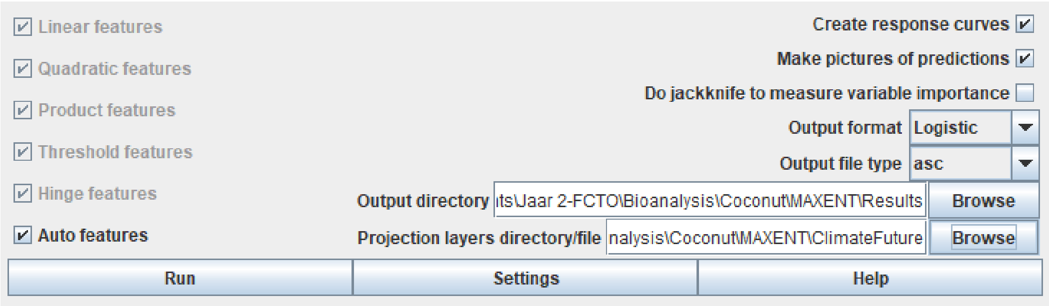

Fig.2: Maxent setting for creating a species distribution model for C.Nucifera.

Model output: possible distribution models based on selected climatic variables.

Minor differences (e.g. Greenland) between the possible present and future distribution of *C.Nucifera* can be observed (*Fig.3*). Distribution is estimated based on the suitability of habitat established by the selected climatic variables. An AUC value of 0.904 was generated from the Maxent model, which can be interpreted as a good model (*Fig.4*). However, caution must be taken when validating SDM with AUC values. Temperature seasonality (Bio4) was found to influence the distribution patterns the most (*Table.1*). This is reasonable as the coconut tree can not tolerate temperatures below 21°C.

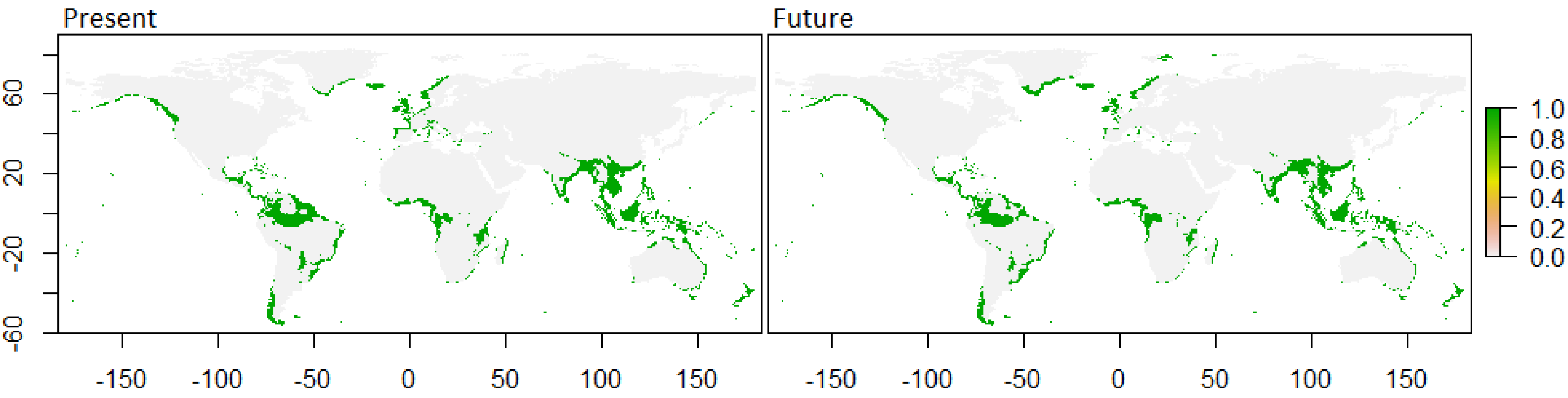

Fig.3: Possible present and future distribution of C.Nucifera (RStudio) based on suitable climatic conditions.

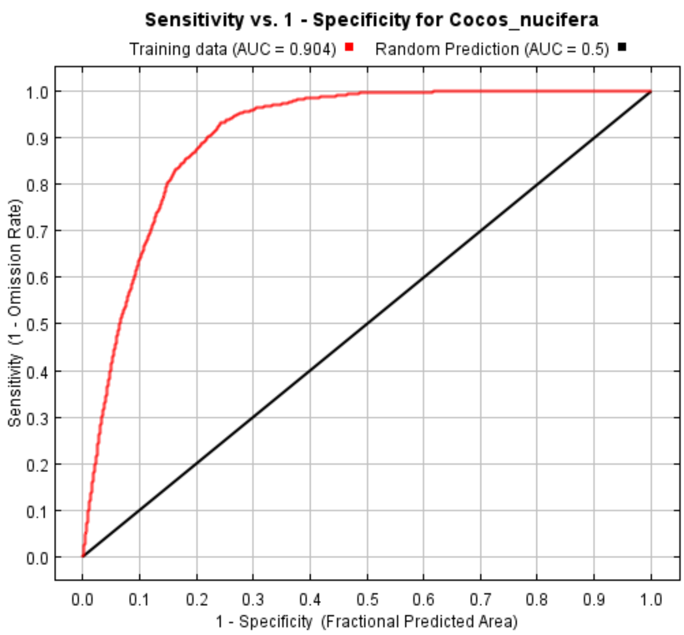

Fig.4: Receiver operator characteristic curve (Maxent). *Validation of Maxent model: AUC value.*

Table.1: Relative contribution of the selected climatic variable of the Maxent model.

Variable	Percent contribution	Permutation importance
bio4	43.7	63.9
bio12	33.9	7.6
bio2	21.5	27.4
bio15	0.9	1.1

Response to future scenario: distribution change between present and future

Overall, it appears that habitats will remain suitable for *C.Nucifera* (yellow color)(*Fig.5,6*).

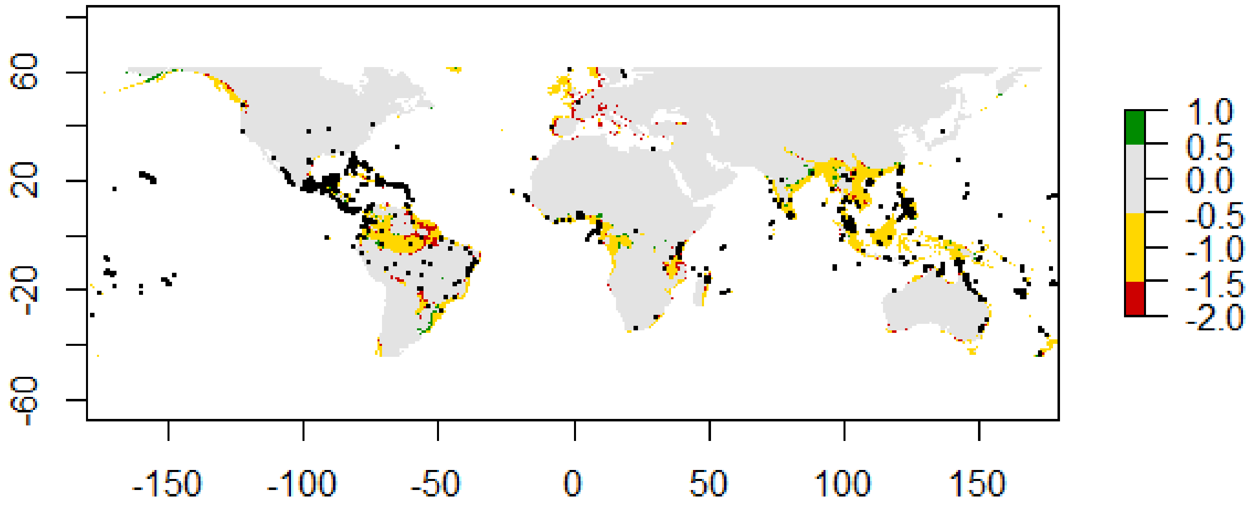

Fig.5: Future distribution change map with records (black dot) of C.Nucifera(RStudio). *The color gradient indicates: gained (green), never suitable (grey), remains suitable (yellow), and loss (red).*

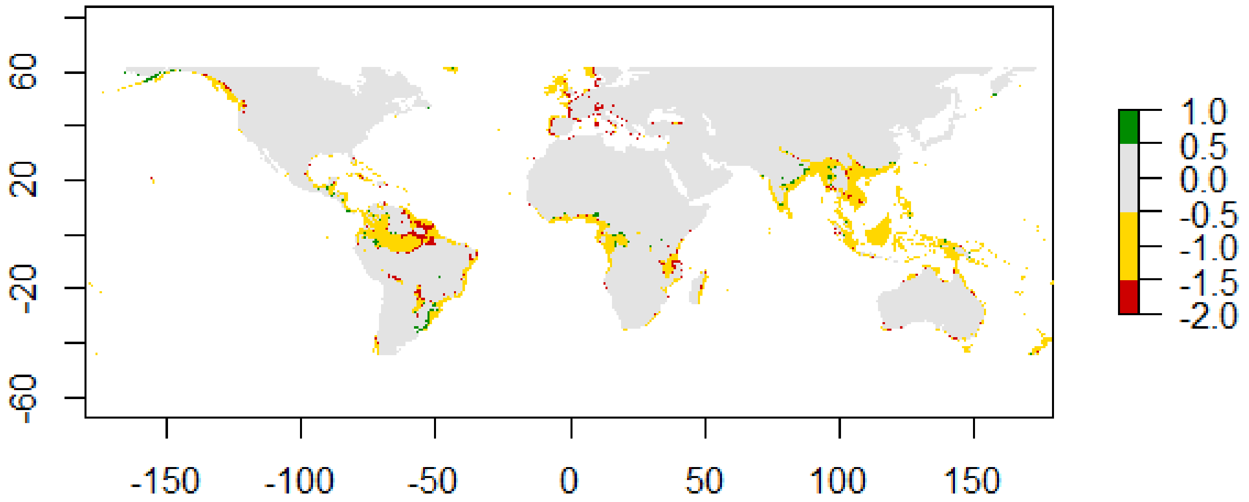

Fig.6: Future distribution change map of C.Nucifera (RStudio). *The color gradient indicates: gained (green), never suitable (grey), remains suitable (yellow), and loss (red).*

Biological interpretation

The model reveals that the distribution of *C.Nucifera* will mainly stay the same in 2050 with respect to climate. Climate alone will probably not affect the distribution as *C.Nucifera* as it prefers high temperatures. However, an indirect effect of rising temperatures is the rise of sea levels. This may reduce the habitat area in different ways, for instance, islands could disappear. The coconut tree may move more land inwards, however, as the current records reveal low occurrence in land centers, there must be a present constraint (e.g. altitude, soil) and is doubtful to become suitable. One reason that the coconut has established on a large scale is due to its adaption of the seed. Thus, further adaption may be in favor for the coconut tree. Luckily, the coconut is precious to humans as it is used for different products. Thus, it might be that humans will drive the ultimate distribution of *C.Nucifera* outdoor and indoor.

This model is not useful to estimate the future distribution of *C.Nucifera* on climatic level as well as model level. On climatic level, although most of the climatic model matches with the actual occurrence, the model is verified with an AUC value. It is better to include a null model for better model validation. Moreover, the model is performed once and should be simulated multiple times for higher reliability. Additionally, even within the climatic level the variables may not be enough or suitable. For instance, a suitable habitat was found in Greenland. More specifically, the moisture variables may be optimal in Greenland but the temperature not. In this model, both bio 4 (temperature) and bio 12 (moisture) showed high relative contribution values. On model level, important information is missing from this model. The 'realized niche' consists of three components. First, abiotic conditions, in this case climate was selected as it is informative, and it correlates with other abiotic conditions such as sunlight. However, altitude is area specific and would have given information about soil type (e.g. sand or rocks) and ocean current about dispersal opportunities. The second component, dispersal and movement limitations, the coconut carries a heavy seed and could never travel up a mountain by its own. The third component, biotic interactions, for instance seed predation by humans but replanting it because it is loved making this relationship quite complicated.

References

(1) *What Is the Climate for the Coconut Tree?.* https://www.hunker.com/12540918/what-is-the-climate-for-the-coconut-tree, retrieved on 11-12-18 from Hunker.

(2) https://doi.org/10.15468/dl.pvicfa, downloaded on 04-12-18 from GBIF

(3) *Coconut planting seasons and climate.* http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_planting_seasons.html, retrieved on 11-12-18 from Tamil Nadu Agricultural University – Expert System for Coconut.