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Identification of potential future areas for sustainable cashew *(Anacardium occidentale* L.) nut production in Togo using the Maxent model

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Abstract

Understanding current and future potential habitats is crucial for designing sustainable management policies and cashew-growing practices that are more resilient to climate change. This study assessed the current distribution and predicted the potential effect of climate change on the habitat distribution of *Anacardium occidentale* L. in Togo under two global circulation models (HadGEM3-GC3.1-L and MIROC6) and two shared socio-economic pathways (SSP245 and SSP585) by 2050. The maximum entropy algorithm, 2538 species occurrence records and a combination of seventeen (17) climate and soil variables were used. The results showed that soil, followed respectively by the annual precipitation (bio12), and the temperature seasonality (bio4), are the most significant environmental factors affecting cashew distribution in Togo. Based on the current model, 78.92% of the Togolese landscape is highly favourable to sustainable cashew-growing practices. In 2050, according to the MOROC6 Model, the areas of sustainable cashew nut production will be reduced to 5.24% under the SSP 245 scenario and will completely disappear under the SSP585 scenario. However, for the HadGEM3-GC3.1-L model in 2050, the areas of sustainable cashew nut production in Togo will be reduced to 3.71% and 0.26% respectively for the SSP245 and 585 scenarios. In short, the results of this study, which was carried out for the first time in Togo, point out the need to put in place a strategy for the conservation and sustainable cultivation of cashew trees in Togo.

Keywords: *Anacardium occidentale* L., Climate Change, ecological niche modelling, sustainable agriculture.

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Introduction

Plant species have been employed for a variety of reasons throughout human history. They have been around for a long time and are still employed in scientific studies today. *Anarcardium occidentale* L., the cashew tree is a member of the Anacardiaceae plant family. The cashew tree is a Brazilian and Lower Amazonian native species (Kunjumon and Ashoka, 2022). The genus *Anacardium* contains eight native species from tropical America, among which A. *occidentale* is the most economically important (Some, 2014). This introduced tree species in Africa has become an essential source of income for rural populations (Ndiaye, 2021). It is mainly cultivated for its nut which is an important industrial and export raw material (Akinhanmi, 2008). Within Africa, the crop is booming and raw nut production has increased from 1 million tons to 1.8 million tons, with an annual growth of 5.8% between 2011 and 2018 (Hien, 2019). Cashew nuts are popular appetizers. They are also used in the food sector and as a component in a variety of

confectionary items. Humans benefit from the nutritional value of cashew nut kernels. They are high in vitamins (A, D, and E), as well as lipids and proteins (Kunjumon and Ashoka, 2022). The cashew plantations contribute to the efforts to address climate change through carbon sequestration (Ndiaye, 2019). It reduces atmospheric carbon levels and promotes a healthy environment for human development. The increase in the cultivated area of the cashew is due to its high hardness and low soil and climate requirements Atakpama *et al*. (2023). It is especially suitable for areas with a warm tropical climate with alternating wet and dry seasons. Climate change is now broadly recognized and accepted as evident and one of the world's most pressing environmental challenges. Global climate change, mostly driven by increases in atmospheric concentrations of anthropogenic greenhouse gases, has significant impacts on human health, socio-economic activities, and ecosystems as noted by Bogner *et al*. (2008). Under climate change, species may shift their ranges to cope with climate change (Walther *et al.,* 2002). Given the socio-economic and environmental importance of A. *occidentale,* it is necessary to know the impact that climate change will have on the spatial distribution of A. *occidentale.* For this reason, Atakpama *et al.* (2023) have decided to conduct a research study to assess the present-day distribution and predict the potential effect of climate change on the distribution of *Anacardium occidentale's* habitat in Togo under two Representative Concentration Pathways (RCP4.5 and RCP8.5). We decided to conduct this study using the Shared Socioeconomic Pathways (SSP) scenarios, which are new scenarios for predicting the impact of climate change on biodiversity. This study aims to assess the current distribution and predict the potential effect of climate change on the distribution of the habitat of *Anacardium occidentale* L. in Togo. Specifically, this study aims:

- To identify potential areas for sustainable cashew production in Togo;
- To determine the environmental factors affecting the success of cashew plantations in Togo;
- To predict the impact of climate change on potential cashew-growing areas in Togo.

Material and Methods

A country in West Africa, Togo, covers an area of 56,600 km² and is bordered by the Atlantic Ocean, Benin, Ghana, and Burkina-Faso to the South, East, West and North respectively. The climate is intertropical with significant variations from the south to the north.

Table 1: Sources and number of occurrence points used for modelling.

Source of occurrence points	Number of occurrence points
Atakpama *et al.* (2023)	705
Fieldwork	833
GBIF	1000

The soil data was collected from the Harmonized Soil database of FAO https://www.fao.org/soils-portal/data-hub/soil-maps-anddatabases/harmonized-world-soil-database-v12/en/ (accessed on 12 December 2023). The climate and elevation data were obtained from the WorldClim version 2.1 database (http://www.worldclim.org, accessed on 15 December 2023) and included the 19 bioclimatic variables.

Results and Discussion

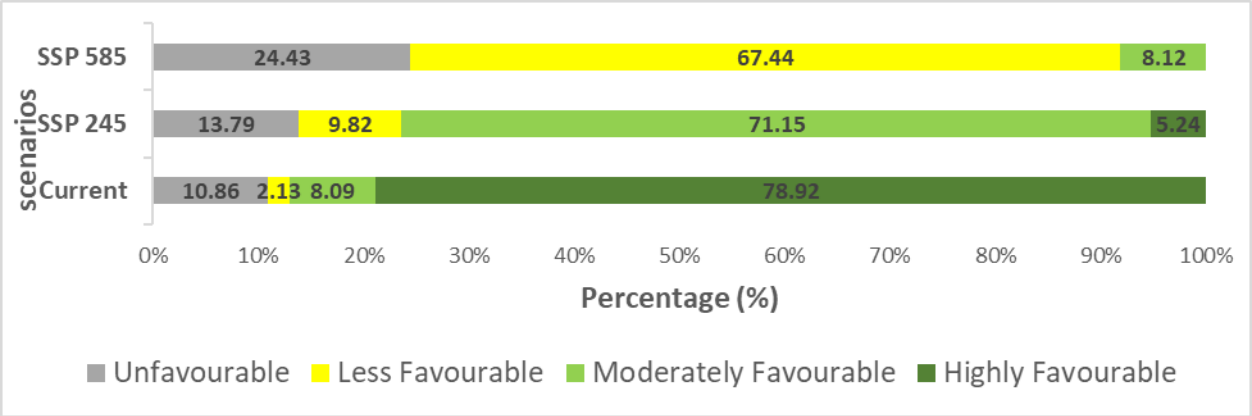

Figure 1: Proportion of current and potential future habitats according to MIROC6 under ssp245 and ssp585 scenarios of the cashew tree in Togo.

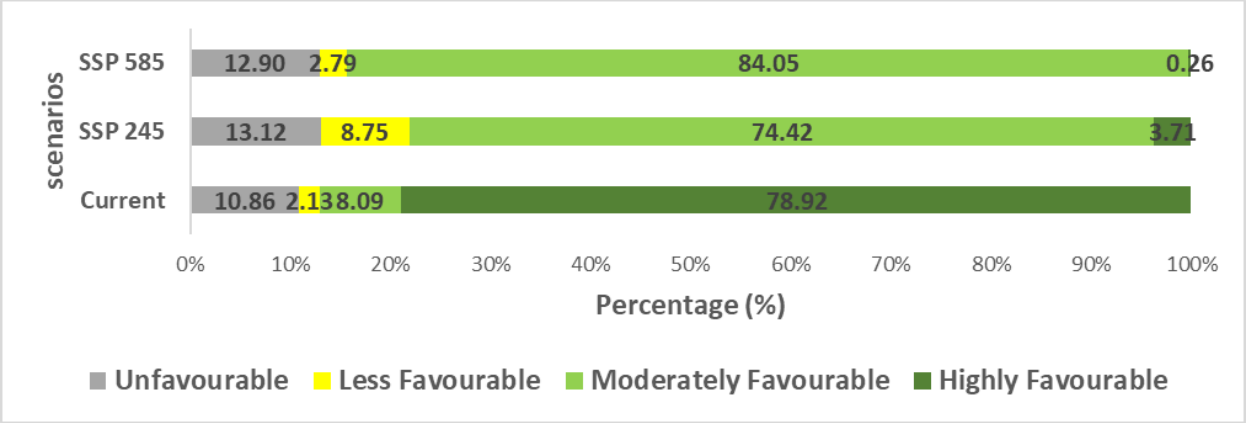

Figure 2: Proportion of current and potential future habitats according to HadGEM under ssp245 and ssp585 scenarios of the cashew tree in Togo.

Predicting how the species might respond to climate change is a fundamental component in designing biodiversity conservation and management policies and also in making cashew nut production climate-resilient. Climate projections indicate that the area of habitat currently favourable for cashew cropping in Togo is expected to change according to HadGEM and MIROC6 and under both scenarios (ssp245 and ssp585). This could be because the cashew tree is unable to develop the capacity to adapt to climate change. In addition, we can also say that climate change will reduce the geographical distribution of cashew trees. These results are contrary to those of Atakpama *et al.* (2023), who found that climate change would not reduce the geographical distribution of cashew trees in Togo This difference may be due to the fact that in our study we used the Shared Socio-economic Pathways (SSPs) scenarios, whereas Atakpama *et al*. (2023) used the Representative Concentration Pathways (RCPs) scenarios. The predictive models used for the 2050 horizon showed that habitats highly favourable to cashew development will decrease. Considering the evolution of habitats with HadGEM, MIROC6 and both scenarios ssp245 and ssp585, it is clear that climate change will be a threat to cashew cultivation in Togo. It is therefore a crop which is not resilient to climate change. In addition, biotic factors and anthropogenic disturbances can affect the species' niche distribution as indicated by Mod (2016). Including natural disturbances such as herbivory, human settlements and density in the SDMs should be an excellent predictor of understanding the impact of climate change on the species niche (Atakpama *et al*., 2023). This can lead to an understanding of how temperature and rainfall change patterns could affect vegetation distribution. According to the prediction of HadGEM under ssp245 and ssp585 scenarios; and MIROC6 under ssp245 more than 50% will be adequate for the conservation/sustainable cultivation of cashew trees in 2050. The model MIROC6 has

predicted that under the ssp585 scenario, the habitats currently highly favourable to the species in Togo will be more affected by climate change because they will become less favourable.

Conclusions and Outlook

This study assessed the effects of climate change in predicting the spatial distribution of potential cultivation area for cashew trees in Togo by 2050. The results show that soil is the most important predictor of the spatial distribution of cashew trees in Togo. Current climate conditions indicate that 78.92% of the country's land area is extremely suitable for cashew nut cultivation. For both models (HadGEM and MIROC6), the proportion of highly favourable habitats will decrease significantly by 2050 under two climate scenarios (ssp245 and ssp585). These findings will help cashew plantation farmers and the Ministry of Agriculture, Livestock and Rural Development to develop strong policies to increase the population's resilience to future climate conditions. Designating areas as potential sustainable growing areas for the cashew will also help improve the conservation status of A. *occidentale.*

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