Niang et al., 2025. WCA / T.A. #9 Contribution of Agroforestry in a changing climate

Drone thermography enhanced by Deep Learning reveals a large buffering effect of *Faidherbia albida* tree crowns on soil temperature in an extremely hot agroforestry system.

Niang A.H.[a,b], Audebert A.[c,d], Diouf A.A.[e], Do F.C.[f,g], Roupsard O.[h,f,g], Irvine M.[i], Clermont-Dauphin C.[f,g], Cournac L.[f], Dia M.[j], Diack I.[j], Diene S.M.[k], Leroux L.[l,m,n], Demarty J.[o], Oliver-Soulayrol M.[o], Etchanchu, J.[o], Mbissane Faye P.F.[b], Sall O.[a].

[a]Universite Numerique Cheikh Hamidou Kane, Senegal
[b]Universite du Sine Saloum El-Hadj Ibrahima Niass, Senegal
[c]CIRAD, UMR AGAP Institut, 34398 Montpellier, France
[d]UMR AGAP Institut, Univ Montpellier, CIRAD, INRAE, Institut Agro, Montpellier, France
[e]Centre de Suivi Ecologique, Dakar, Senegal
[f]Eco&Sols, Univ Montpellier, CIRAD, INRAE, Institut Agro, IRD, Montpellier, France
[g]LMI IESOL, Centre IRD-ISRA de Bel Air, Dakar, Senegal
[h]CIRAD, UMR Eco&Sols, Dakar, Senegal
[i]INRAE, Bordeaux Sciences Agro, ISPA, 33140 Villenave-d'Ornon, France
[j]Universite Cheikh Anta DIOP, Dakar, Senegal
[k]Ecole Polytechnique de Thies, Senegal
[l]CIRAD, UPR AIDA, Nairobi, Kenya
[m]AIDA, Univ Montpellier, CIRAD, Montpellier, France
[n]IITA, Nairobi, Kenya
[o]HydroSciences Montpellier (HSM), Univ Montpellier, CNRS, IRD, Montpellier, France

It is often assumed that agroforestry is an effective nature-based solution for adapting to climate change and buffering temperature extremes within ecosystems. However, there is a critical lack of experimental data.
How can we effectively quantify the microclimatic effect of shade trees on the temperature of highly heterogeneous surfaces in an agroforestry ecosystem ? How do temperature of tree crowns, of soil under shade and soil in full sunlight vary, depending on the season, the time of day or night, or even between trees ?
We studied the effect of isolated trees in an extremely hot Sahelian ecosystem (soil surface temperature peaking at 58°C) in an agroforestry parkland in Senegal dominated by the emblematic species with reverse phenology *Faidherbia albida*. The experiment took place within a highly instrumented site (https://lped.info/wikiObsSN/?Faidherbia-Flux), with a tree density of approximately 6 trees per hectare and a dry season lasting more than 8 months.
A thermal drone (Evo II Dual 640 RTK) flew over 4 hectares for a full year, every month and at all hours of the day and night. Reference sensors (thermocouples, TOMST-TMS4) were used to calibrate the conversion between radiative measurements taken by the drone camera, or by a 4-component net radiometer, and absolute temperatures of the crown of seven trees and their surrounding soil, all revisited during each flight. An automated AI image processing chain was developed using deep learning to detect and segment each surface of the ecosystem. A large database was thus created to reveal the temperature dynamics by compartment.
The AI tool showed pixel classification accuracy of 0.84 with a recall of 0.88, and the complete thermal processing chain showed a confidence index for temperatures > 0.9. Monthly comparisons of daytime temperatures (all hours of the day combined) showed that *F. albida* tree crown

temperatures were approximately 5°C higher than air temperatures, indicating that their transpiration remained limited despite their phreatophytic nature. The soil temperature in the shade was 6 to 8°C higher than the crowns. Finally, and most importantly, the soil temperature in full sunlight exceeded that in the shade by 10 to 13°C, depending on the season. We found significant crown temperature variability among the seven trees studied, indicating likely differences in transpiration between trees. At night, however, the crowns remained warmer than the soil and thermally insulated the soil under the canopy, which therefore cooled more quickly away from the trees.

The trees in this extremely hot Sahelian environment demonstrated their highly effective thermal buffer role, which probably slows down surface soil evaporation and protects the microfauna and organic matter in the soil nearby, at least during the dry season. This buffer effect could contribute to the overall ‘fertility island’ effect already reported elsewhere.