Mapping the abundance of Faidherbia albida trees in Senegal with Sentinel-2 time series

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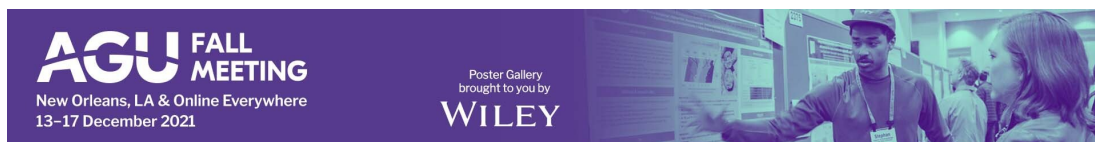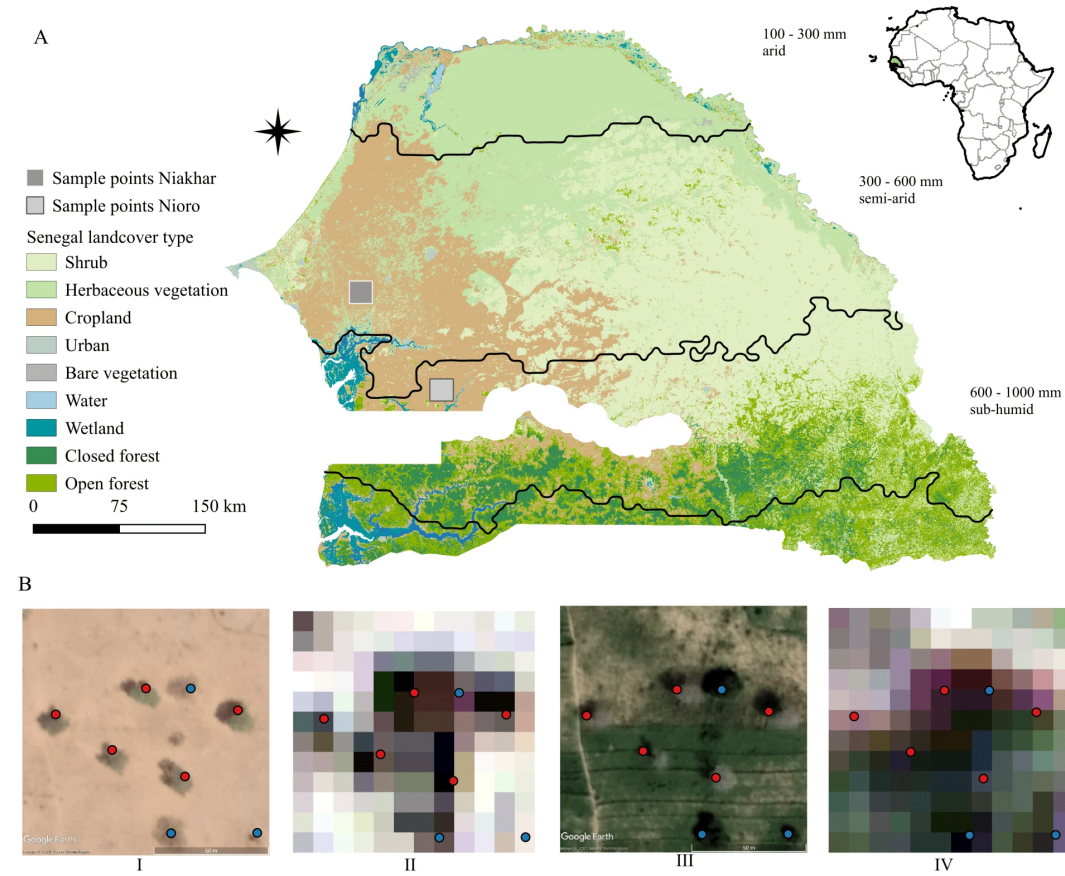
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BACKGROUND AND AIM

Multi-purpose *Faidherbia albida* trees represent a vital component of agroforestry systems in West Africa. It is characterized by reverse phenology, thereby providing growth and fodder especially during the dry season, and shedding leaves during the wet season, minimizing competition with pastures and crops for resources.

Here we aim to (1) use a Multi-Layer Perception(MLP) artificial neural network fed with a number of Sentinel-2 features to generate a 10 m resolution Faidherbia albida explicit distribution map, and (2) to compare the remote sensing-based method map and the occurrence map derived from Species Distribution Model to bridge the gap between the theory and reality.
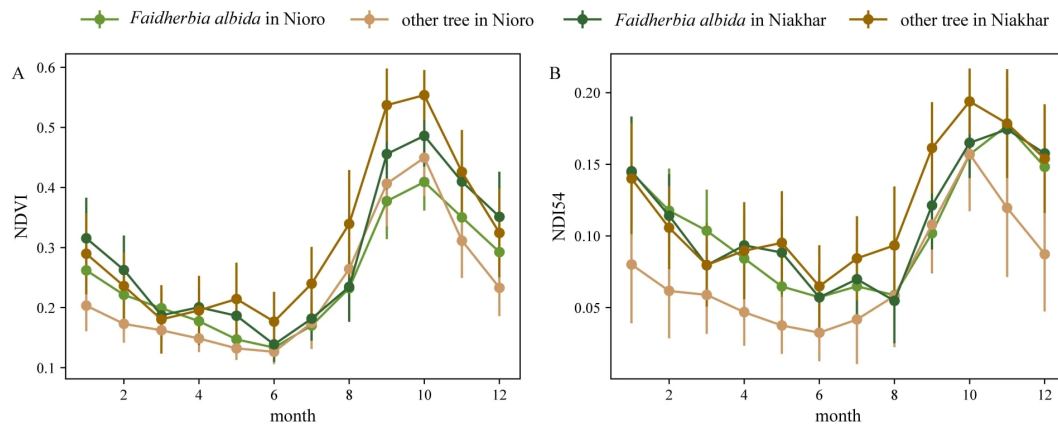
STUDY AREA AND DATA

• Major parts of Senegal in West Africa are located in the Sahelian and Sudanian zone between the Saharan desert and the humid Guinean zone.
• All available Sentinel-2 images from January 2017 to December 2019 with cloud cover less than 50% on GEE
• The *Faidherbia albida* occurrence map which was generated from the traditional Species Distribution Model was provided by Kindt[1]

A

Sample points Niakhar
Sample points Nioro
Senegal landcover type
- Shrub
- Herbaceous vegetation
- Cropland
- Urban
- Bare vegetation
- Water
- Wetland
- Closed forest
- Open forest

0   75   150 km

100 - 300 mm
arid

300 - 600 mm
semi-arid

600 - 1000 mm
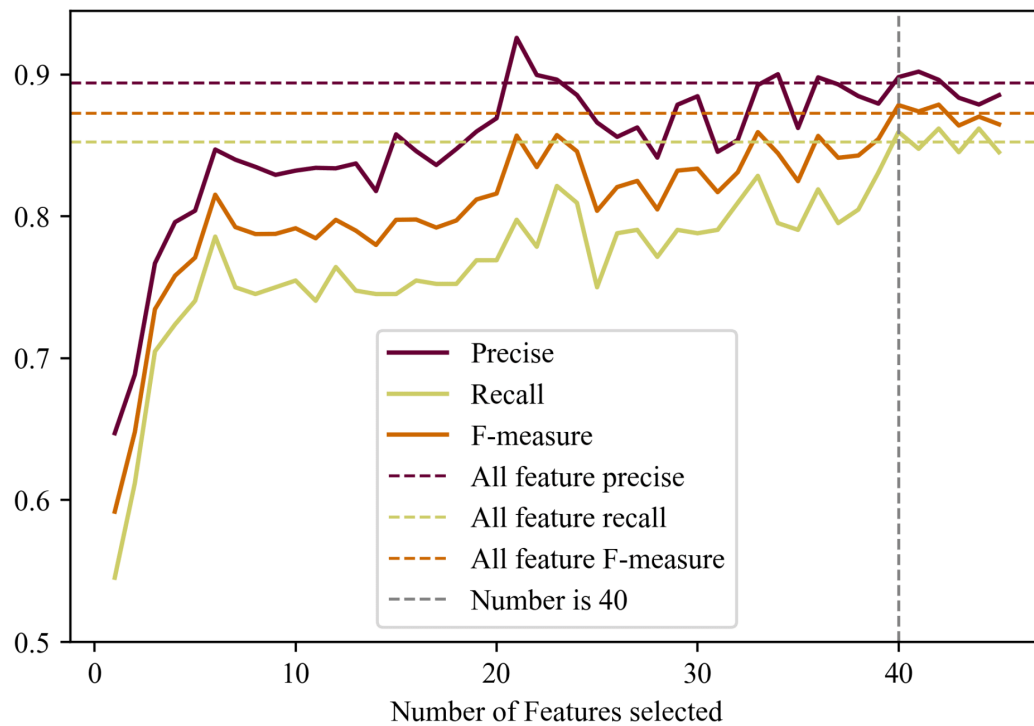sub-humid

B

I   II   III   IV

SEASONAL VARIATION AND FEATURE SELECTION

The monthly NDVI and NDI54 indicate that the values of pixels with *Faidherbia albida* show the same seasonality in both regions and this trend is different to other tree species.
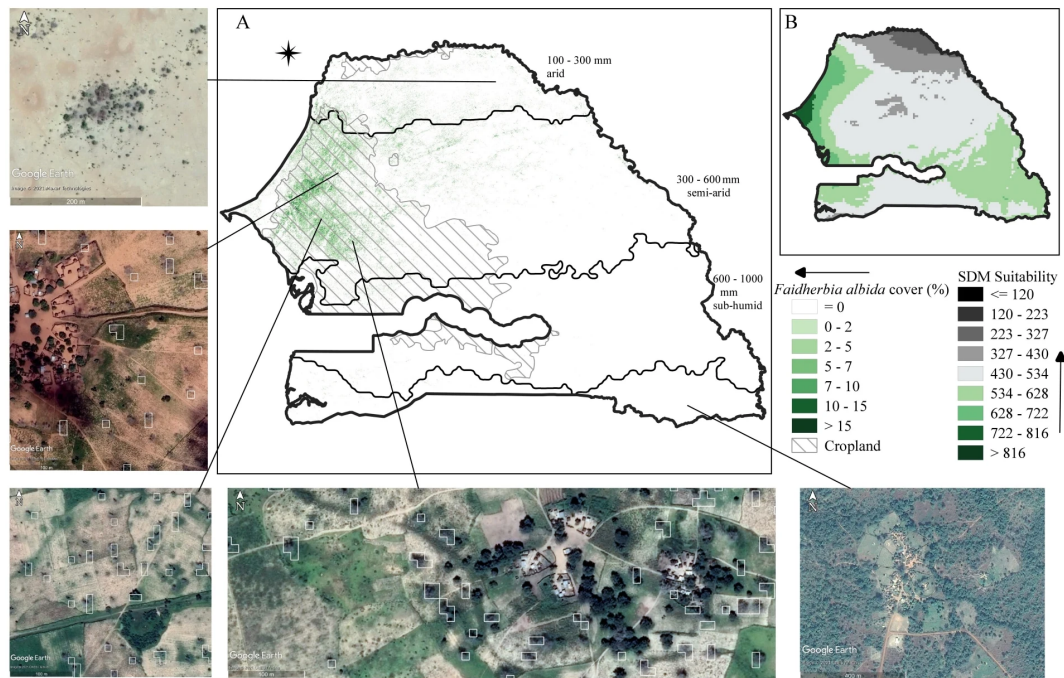

This study attempts to take seasonal dynamics (difference of monthly image) and monthly band/ vegetation indices value into consideration to map *Faidhebria albida.* This led to **936** features in total.
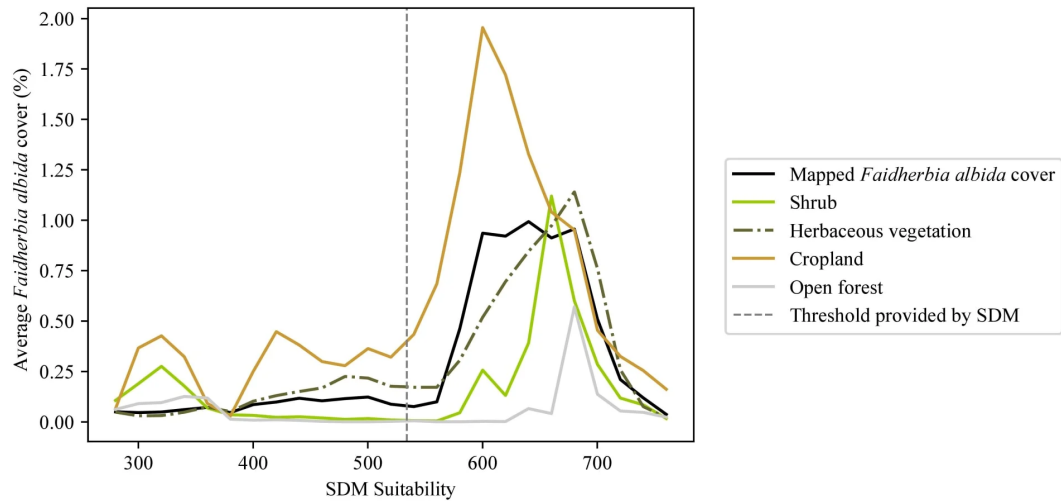

By conducting a Recursive Feature Elimination analysis on the 936 features, those subsets of feature combinations were generated and cross-validation results show when increasing the features number to 40, the total variability in the feature layers reaches the same level of accuracy as when using all features, indicate only 40 features is enough for classification.

DISTRIBUTION OF FAIDHERBIA ALBIDA

The remote sensing based *Faidherbia albida* distribution map indicates that the *Faidherbia albida* is mainly distributed at cropland and they are the dominant tree species at cropland. For most of the cropland areas, the percentage of *Faidherbia albid*a cover is in the order between 2-15%.

THE RELATION BETWEEN FAIDHERBIA ALBIDA COVER AND ITS SUITABILITY MAP

The figure of the relation between average *Faidherbia albida* cover (percentage per ha) and suitability(every 20 steps) show:

• The mapped *Faidherbia albida* trees mainly occur in areas with suitability value above 560, otherwise suggesting the absence of Faidherbia albida trees below this threshold as assessed from remote sensing, except cropland.

• The *Faidherbia albida* cover in cropland is always higher than other land use/cover types within the same suitability value.

• When suitability values exceed 680, the *Faidherbia albida* cover decreases as mapped from remote sensing data, relating to the near coastal areas around the Dakar peninsula mentioned above.

ABSTRACT

Multi-purpose Faidherbia albida trees represent a vital component of agroforestry systems in West Africa (so-called parklands). Faidherbia albida is characterized by reverse phenology, thereby providing growth and fodder especially during the dry season, and shedding leaves during the wet season, thereby minimizing competition with pastures and crops for resource capture. The deep-rooted trees have access to hidden water and mineral resources, offering nitrogen fixation, wood products for construction, fodder for livestock, fruits for food, medicine, etc. Accurate mapping of Faidherbia canopies is important for a better understanding of the interaction with crops within agricultural system for optimal management (species, density, planting design etc.). This has become even more important in recent times of population increase driving agricultural intensification and climate change in West Africa both threatening these traditional agroforestry systems. With the launch of multi-spectral and multi-temporal satellite systems and novel development of computational methods, a door is now open towards better classification results of single trees and individual species. Here, this study used a Multi-Layer Perception to classify the pixels cover Faidherbia albida canopy from time series Sentinel-2 data. To better discriminate the Faidherbia signal from the background, the features from monthly vegetation indices and seasonal dynamic were extracted. A Recursive Feature Elimination analysis was applied to reduce the data dimensionality. The evaluation on a test set of ground samples results in average precision and recall rate around 0.93 and 0.83. Finally, A 10-m resolution Faidherbia canopy map in Senegal was generated based on the model trained by a selection of 34 features. A comparison with an existing 10-m resolution woody canopy map showed noticeable differences, reflecting an underestimation of woody canopies in agricultural areas of the existing map.