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Estimation of crop fractional cover (FCover) in smallholder farming systems using UAV and Sentinel-2 images : Case study of a Senegalese agroforestry parkland

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Scattered trees in farmer fields, also known as agroforestry parkland, are integrated part of West African smallholder agricultural landscapes. While they are used for centuries by farmers, they are now recognised by the scientific and politic communities as a mean to face climate changes (Skole et al., 2021). Fractional cover (FCover) is an important biophysical parameter allowing to monitor the crop growth. Satellite images has been proven very efficient for crop FCover estimation in various ecosystems (Gräzing et al 2021). However, in agroforestry parklands, the presence of trees inside the fields induced a huge variability that can be hardly captured by traditional approach relying on satellite images and ground information.

We propose an original empirical framework relying on the combining use of UAV-based FCover and Sentinel-2 data to estimate the pearl millet FCover at landscape scale in an agroforestry parkland of Senegal. 6 UAV images were acquired during the 2021 cropping season and the millet FCover has been derived from a threshold of UAV images for 95 subplots on a 3-m grid and used as targeted variable. 4 vegetation indices and 8 texture featured calculated from S2 data were used as models' predictors. 3 machine learning regression algorithms (RF, GBM and SVM) and a multiple linear regression (MLR) model were calibrated over the 3-m grid using a cross-validation approach and different scenarii of modelling were tested: (1) fit the four models date by date dataset, (2) fit the four models on all dates dataset with and without date information as predictor,

(3) single models *vs* a meta-model resulting from the stacking of the different models.

Our results evidenced that for each model tested the accuracy is dependent to the millet growth stage, the vegetative period being overall the one allowing to reach the higher accuracy. MLR is not adapted to estimate millet FCover (R^2 between 0.07 and 0.13) while the machine learning models gave overall good results, RF being the better one (R^2 between 0.45 and 0.69).

We have shown that the use of date information as predictor allowed to improve the FCover estimation (R^2 increases up to 24%) however, the use of a meta-model didn't significantly improve the accuracy suggesting that RF, GBM and SVM are robust enough for millet FCover estimation in such kind of landscape.

While the original workflow we proposed in this study need to be confirmed by adding data from the 2022 cropping season, the results obtained show promising opportunities for improving the crop monitoring in heterogeneous landscapes. The next step will be to better understand the influence of trees on the millet FCover, at the field scale and at the landscape scale.