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Remote Sensing-Based Biomass Estimation to Support Rangeland Management and Food Security in the Sahel

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Abstract

The livestock sector plays an important economic role in the Sahel and contributes to the food security of the people. However, it is highly vulnerable as a result of the large inter-annual variability of precipitation and, hence, rangeland production. This study aims to support effective rangeland management in Niger by developing an approach for mapping rangeland biomass production with remote sensing data. Our linear regression model utilises the phenology-based seasonal cumulative Normalised Difference Vegetation Index (cNDVI), computed from 10-day image composites of the Moderate Resolution Imaging Spectroradiometer (MODIS) NDVI data, as a proxy for biomass production and is calibrated with ground measurements of herbaceous biomass at the end of the growing season from 2001 to 2015. Different spatial aggregation levels for the model calibration were tested in cross-validation (cv) to find the most suitable one for biomass prediction. In general, the model performance increased with increasing model parameterisation, indicating the importance of additional unobserved and spatially heterogeneous agro-ecological effects (which might relate to grazing, species composition, optical soil properties, etc.). The aggregation scheme, whose calibration units were derived from an unsupervised ISODATA classification utilising 10-day NDVI images from January 2001 to December 2015, showed the best performance in respect to the predictive power ($R^2_{cv} = 0.47$) and the cross-validated root-mean-square error (398 kg ha^{-1}) values, although it was not the model with the highest number of calibration units. Once established, the presented approach can be applied for the timely production of estimated biomass production maps at the end of the growing season and before the field measurements are made available. This would mean a time gain of two to four weeks, which is the length of time the field trips normally last. Therefore, such maps could be used for the planning of more in-depth field missions, for the better management of rangeland resources, and for timely decisions on aid allocation and fire prevention. Additionally, the approach can serve as a backup solution in the event that field surveys are not carried out in a specific year or a specific region.

Keywords: Livestock, MODIS, NDVI, Niger, phenology

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