Open Data and AquaCrop : sorghum yield estimates in support to food security in Niger

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❶ Introduction

Because of its substantial and extensive character, the agricultural sector in Niger contributes to over 40% to its Gross Domestic Products (Habou et al., 2016) and occupies 80% of its active population. The variability of its production constitutes hence a threat to the food availability, one of the principal factors of food security.

Like several West African countries, Niger has set up a Harvest Forecast and Estimation Survey. This national system provides yield estimates based on samples of previously selected households. However, the results of such a survey are not published until January of the following year, well after the harvest, which hinders the process of combating food insecurity. In this study, a tool is proposed to estimate the total biomass and yield of sorghum at parcel level for the benefit of institutions working in food security and related areas.

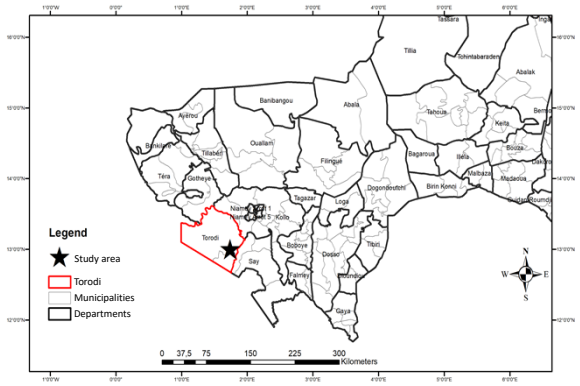
In order to overcome the lack of data that is a recurrent problem in developing countries, the proposed tool also uses freely available "Open Data".

❷ Methods

The study area is located in western Niger in the Makolondi municipality, Torodi department. This area has an average annual rainfall of 590 mm (1981-2009 period) with a maximum of 918 mm and a minimum of 262 mm in 1984 (drought year). 17 plots were selected on the basis of their size, shape and available field managed data, and were regularly monitored.

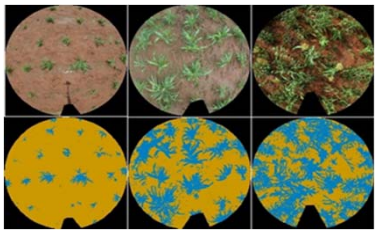
AquaCrop is the main model used in this study. Developed by FAO, AquaCrop is a water productivity model that simulates crop yields (Raes et al., 2009). Version 6, implemented in a processing chain programmed in R (Wellens et al., 2017), was used to considerably enhance model calibration and validation processes.

Calibration/Validation: The model was calibrated with the *in situ* data described below. Green fractional canopy cover (fCover) was assimilated in the model. ¾ of the plots were used for calibration and ¼ for validation. In order to evaluate the interoperability of open access data, a second validation was performed using Open Data.



In situ data

fCover:
- Per plot 15 hemispherical pictures were acquired weekly at ± 2 m above the canopy
- fCover calculation with Can-Eye (Weiss and Baret, 2010).

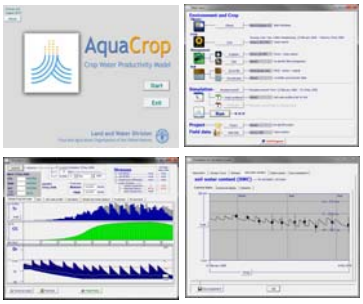


Meteorological data:
- Rainfall: study site rain gauge
- Temperature: Torodi station (National Meteorological Directorate)
- Penman-Monteith ETo, with ETo Calculator (FAO, 2012)

Soil characteristics:
- ISRIC Africa Soil Profiles Database (Hengl et al., 2015)

Model

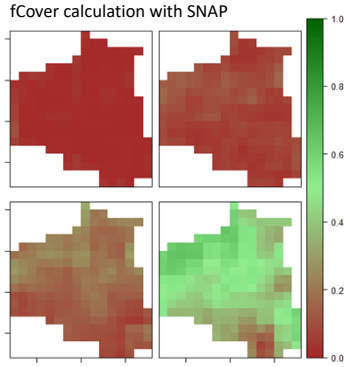
Crop data:
- Sowing density
- Sowing & harvest date
- Weeds (Raes, 2016)



Biomass & Yield

Open Data

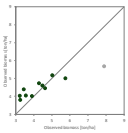
fCover Sentinel-2:
- Atmospheric corrections with Sen2Cor
- fCover calculation with SNAP



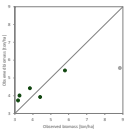
NASA POWER DATA:
- Rainfall
- Temperature
- ETo

Soil characteristics:
- ISRIC Africa Soil Profiles Database (Hengl et al., 2015)

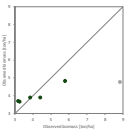
❸ Results & discussion



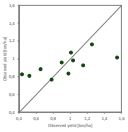
Biomass calibration using *in situ* data
(> 90% of plots: R^2 = 0.8; nRMSE = 13.2%)



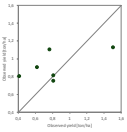
Biomass validation using *in situ* data
(> 90% of plots: R^2 = 0.8; nRMSE = 13.6%)



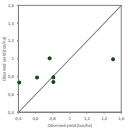
Biomass validation using Open Data
(> 90% of plots: R^2 = 0.9; nRMSE = 13.8%)



Yield calibration using *in situ* data
(R^2 = 0.5; nRMSE = 26.4%)



Yield validation using *in situ* data
(R^2 = 0.4; nRMSE = 36.3%)



Yield validation using Open Data
(R^2 = 0.5; nRMSE = 33.7%)

Biomass: For over 90% of the fields, the calibration R^2 obtained was 0.8 with a normalized mean square error (nRMSE) of 13.2% of the mean biomass. Validation with *in situ* data resulted also in an R^2 of 0.8 and an nRMSE of 13.6% of the average biomass. As for the validation with Open Data, the R^2 was 0.9 and the nRMSE slightly higher at 13.8%.

Yield: In AquaCrop, yield is the product of the biomass (*B*) and crop specific harvest index (*HI*). The latter was calculated on the basis of the calibration data. During the calibration phase, obtained R^2 was 0.5 and the nRMSE 26.4% of the average yield. For validation the R^2 was 0.4 and 0.5 respectively or *in situ* and Open Data. The nRMSE was equal to 33.6% and 33.7% for both types of data. These results are justified by the variability of harvest indices, particularly the number of grains per ear from one variety to another (see also grain pictures above). Especially since each farmer uses its own mixture of varieties.

Considering these results, Open Data seem promising in the use of such tools. However, additional field data are needed to improve the model.

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