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A novel use of agricultural survey data for food security studies: correlating satellite-derived rainfall indices with declared sowing dates for millet in Niger

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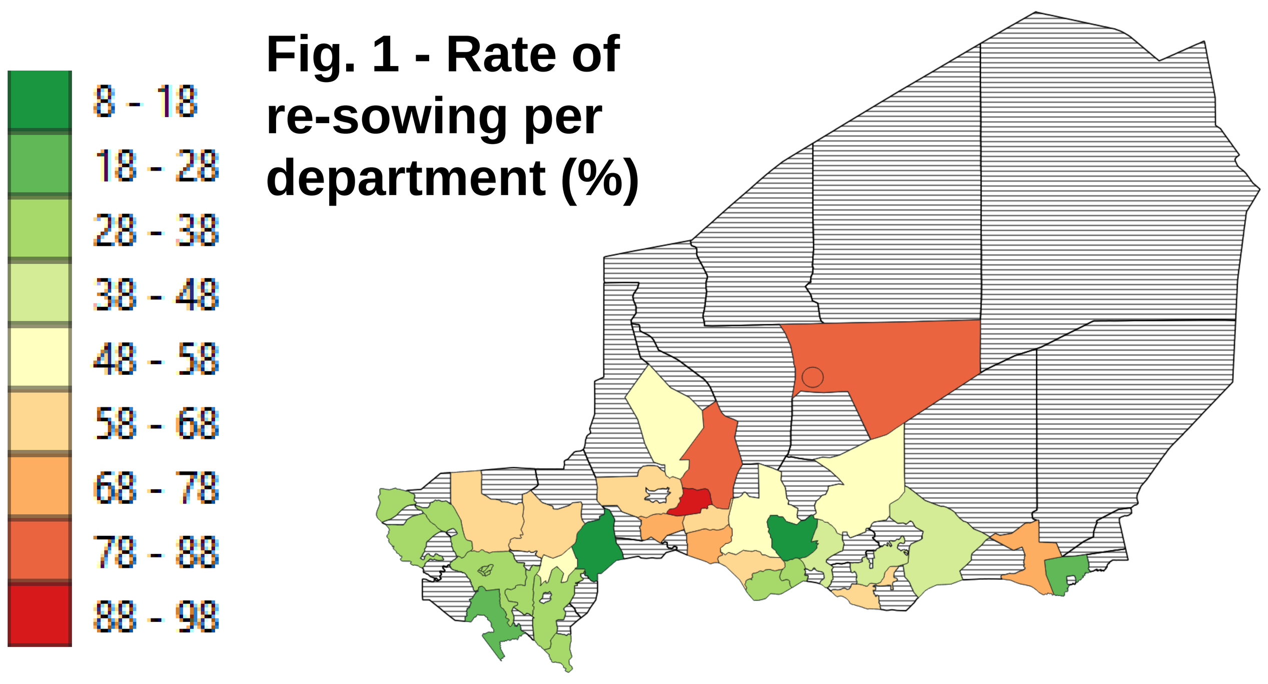
Motivation, Problem Statement and Aim

Agriculture in Niger, as in many regions globally, is profoundly affected by rainfall variability, including droughts and floods. Permanent agricultural survey data such as the Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA) offers a wealth of relevant data (Carletto & Gourlay, 2019), however their potential use for exploring the correlation between satellite-derived rainfall indices and declared sowing dates remains untapped. This study leverages this information source, aiming to identify the thresholds of satellite-based rainfall indices that could be used to estimate successful sowing dates.

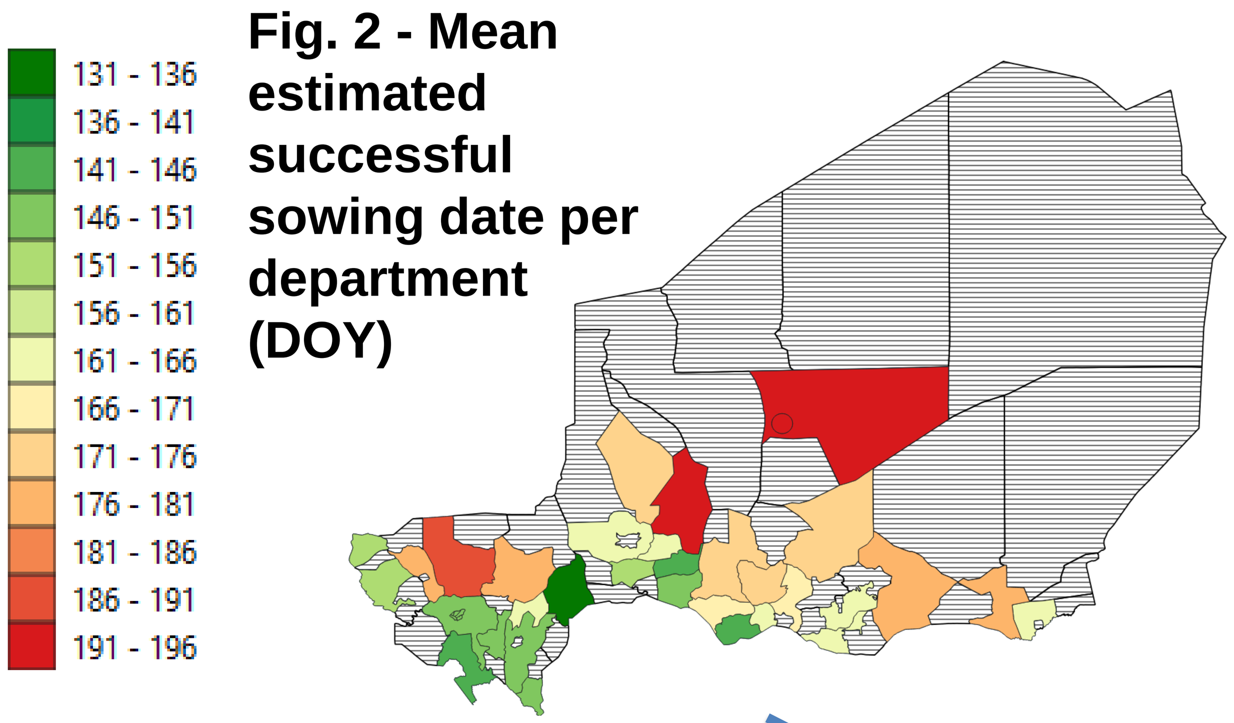
Fig. 1 - Rate of re-sowing per department (%)



Methodology

The study utilised LSMS-ISA 2014 survey data for Niger, providing information on the sowing and re-sowing dates, along with department-level location data. Satellite-based rain estimation products, such as TAMSAT (*Maidment et al., 2017*), CHIRPS (*Funk et al., 2015*), and PrISM (*Pellarin et al., 2022*), were employed to derive rainfall onset indices such as the first wet day after April 15th of a 3-day wet spell receiving at least *x* mm of rain (referred to as FWO) (*Marteau et al, 2011*). Along with climate data derived from Copernicus ERA5 models, spatial onset date simulations were performed with the SARRA-Py crop simulation model (*doi:10.5281/zenodo.10125716*) to compute water balance in the topsoil layer. A statistical analysis was conducted to investigate the correlation between the rainfall onset date map aggregated at departmental levels, and the mean successful sowing date per department from the survey.

Fig. 2 - Mean estimated successful sowing date per department (DOY)

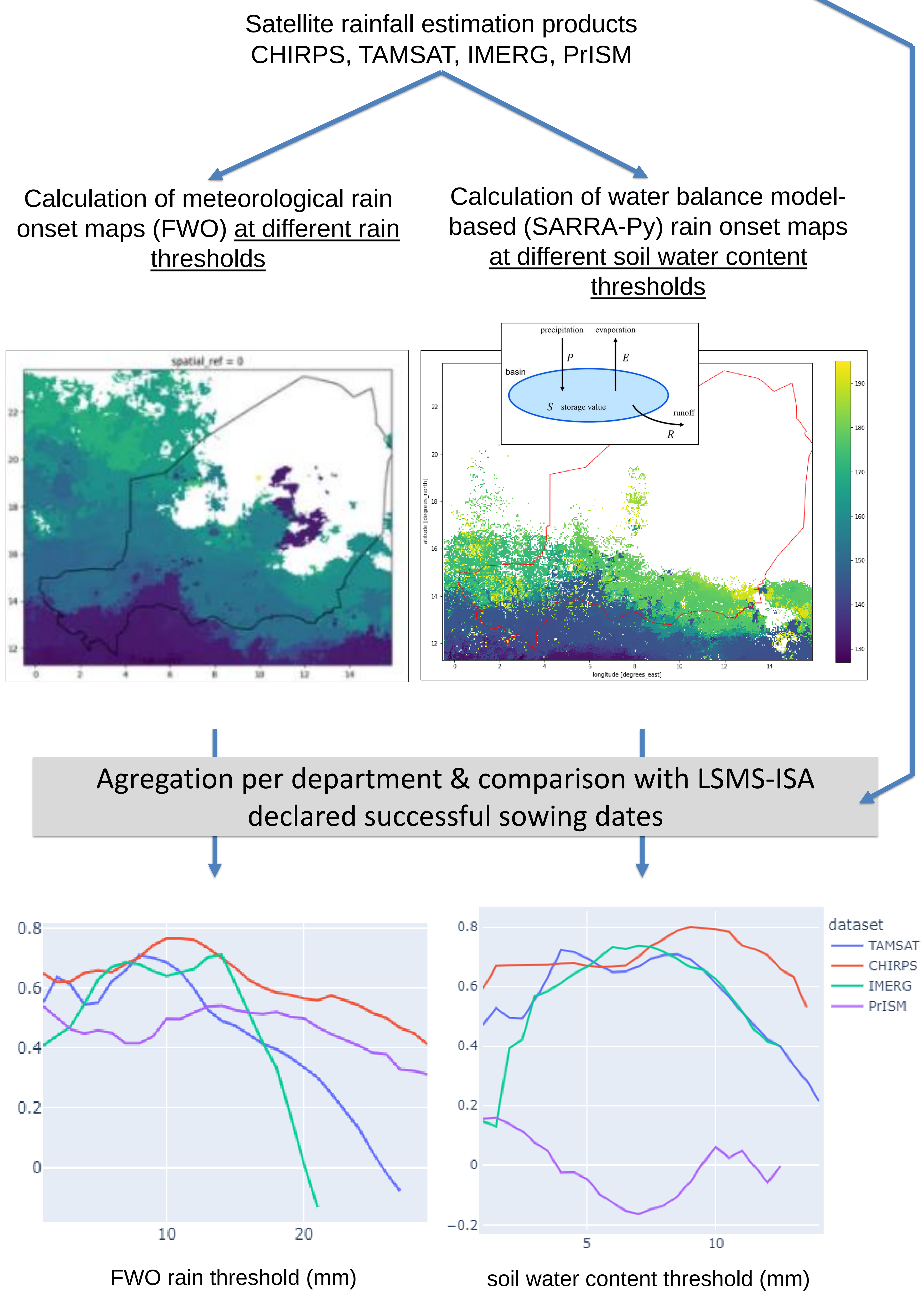


Results

The considered dataset surveyed 1713 cultivated millet across 3371 plots in Niger during the 2014-2015 season (*doi:10.48529/3xnb-sd96*), as it included information about sowing dates. At the national scale, 49% of the plots could be considered as successfully set after first sowing. This successful first sowing rate was variable in between departments, going from only 10.5% in Keita (n=95) up to 93.9% in Dogondoutchi (n=164) (**Fig. 1**). Also, successful sowing dates were scattered 60 days (**Fig. 2**). As these results were obtained from a significant number of individuals (26.7 plots per department), these observations **underscore the necessity of decision-making tools for optimizing sowing dates**.

In that aim, we explored and found significant correlations satellite-derived rainfall indices and reported sowing dates at the departmental level. Notably, the approach based on **FWO led to a Pearson correlation coefficient of 0.76** (using CHIRPS and a 3-day cumulative rainfall threshold of 10 mm), while the **water balance approach reached a Pearson correlation coefficient of 0.81** (using CHIRPS and a soil water content threshold of 9 mm) – a value that is coherent with reported thresholds historically used by the AGRHYMET system in the region to derive seasonal bulletins. It seems that **using a water balance model-based approach returns better results than the meteorological rain onset approach**. Furthermore, **it appears that the CHIRPS product outperforms other satellite rainfall estimations products for the task**, while TAMSAT seems to be a good second choice.

Fig. 3 – Analysis workflow



Conclusion

The correlation between satellite-derived indices and agricultural survey results, in our case LSMS-ISA data, **holds significant potential to explore links between heterogeneous data sources for agricultural risk management**. By determining the thresholds of rainfall indices linked with sowing dates, proactive identification of regions vulnerable to sowing-date related yield losses becomes feasible at country-scale, allowing for the early implementation of preventive measures and targeted aid programs.

The better results obtained by the crop model-based approach may be explained by evapotranspiration, which is not taken into account by meterological onset methods such as FWO. In our exemple however, we would have benefitted from replicates of LSMS-ISA-like datasets including sowing dates to perform multi-year calibration and evaluation of this method. This is why **we advocate for including extensive surveying of agricultural practice information in upcoming agricultural surveys.**

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