Irrigated mapping in Africa and the Near East: physical based versus supervised classification

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INTRODUCTION

Since agriculture is a major consumer of water, monitoring of the irrigated agricultural area will be crucial for governments, to create policy for competing demands for continued agricultural, industrial development and human health. However, the current extent of the irrigated areas over country, continental to global scale is still uncertain[1].
Recently, a generic irrigation mapping method was developed in the framework of the FAO WaPOR data portal (https://wapor.apps.fao.org), to provide annual irrigation maps at a continental scale for Africa and the Near- East, starting from 2009. The method is based on a physical approach, comparing the water consumption (ETa) with the water availability (precipitation) through the Water Deficit Index (WDI).
However, next to this physically-based approach, supervised classification methods have also proven to be a suitable irrigation mapping method, although they suffer from the drawback that they require a large amount of reference information. In this study, a comparison of both approaches will be evaluated, to highlight the strengths and weaknesses of both.

Supervised approach

Supervised classification approaches rely on the availability of reference data, which depicts the water management at a parcel level. Given the wide range of irrigation practices, this is often not limited to the label irrigated/rainfed, but also intermediates such as supplementary irrigation are possible. Both optical and radar imagery have been reported to contain useful information with regard to crop water management.
Various optical and radar metrics were defined and their potential to identify irrigated fields was assessed based on the available reference data. Optical metrics from Sentinel-2 included vegetation indices related to greenness and moisture content, while VV, VH backscatter intensities and their ratio were computed based on Sentinel-1 data. All indices were summarized over various time periods by calculating their average, standard deviation, min, max, Q10 and Q90. In total, seven different time periods were defined in function of the timing and extent of the cropping season, i.e. full year, full season, before season, initial part of season, peak of season, last part of season and after season. As such, we not only aimed to identify relevant indices, but also crucial phenological stages for irrigation monitoring.
Reference data was available over different areas in Africa, including Office Du Niger, Mali; Koga and Awash, Ethiopia; Busia, Kenya; Rayak and Bekaa, Lebanon; and Zankalon, Egypt. However, not enough data was available to properly train supervised classification methods, and only the separability of the metrics was evaluated

Physical-based approach

Irrigation mapping is based on a labeling method, meaning that the delineation of the LC cropland areas and the land use irrigated/rainfed are two separate and independent steps. In order to be consistent at global scale, the CGLS-LC100 was used as a base layer to extract the cropland area[3]. Within this cropland class, irrigated areas are delineated by combining information on (i) the phenology, (ii) actual Evapotranspiration (ETa) and (iii) precipitation, all of which are made available on the WaPOR portal.
The general principle behind the irrigation labeling method is the calculation of the WDI, which is the ratio of the seasonal P and the seasonal Eta (and multiplied with 100 for scaling). A WDI of 100 or larger means that water made available through P sufficed to sustain the water that was consumed by the crops (ETa_s). A WDI<100 means a larger water consumption was observed in relation to the available water from precipitation over the growing season.

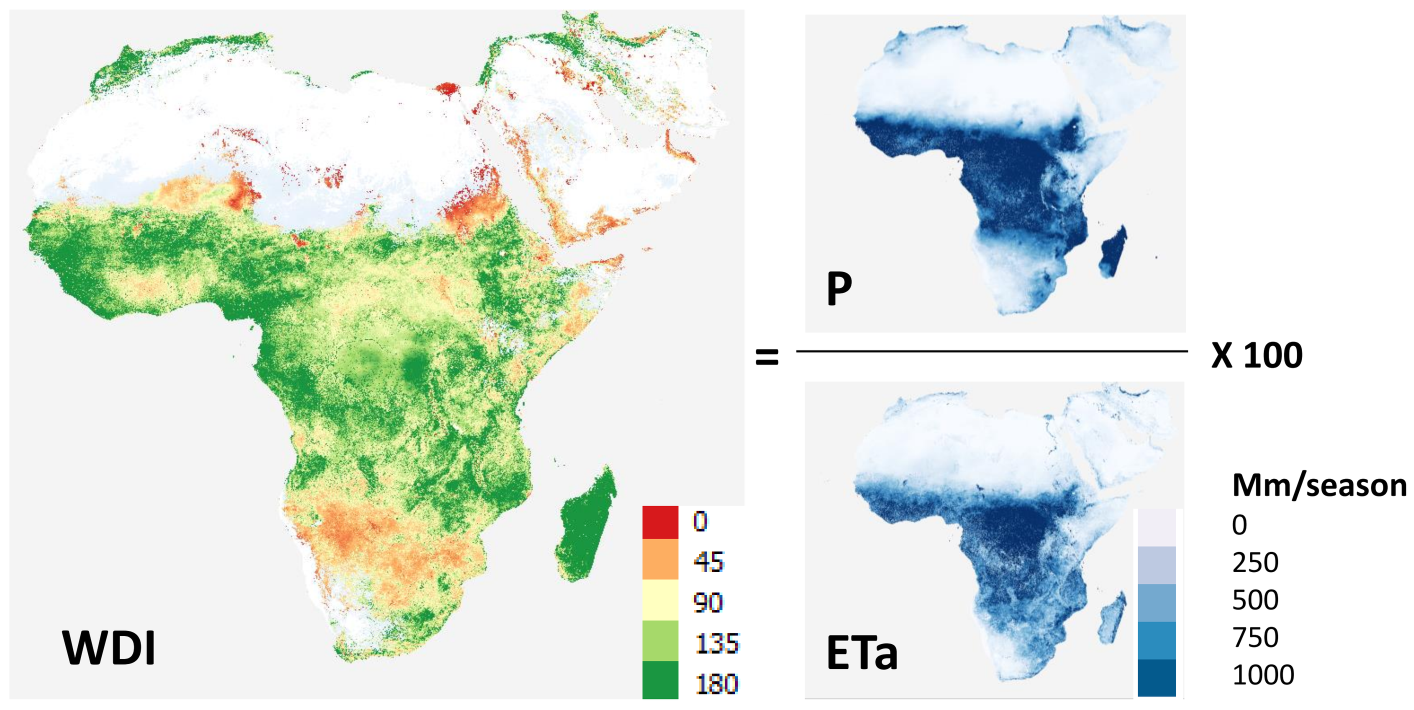


Figure 1: Graphical representation of how the WDI is calculated for 2015, clearly depicting the areas where the seasonal Eta is larger than the precipitation(red and orange areas).

RESULTS

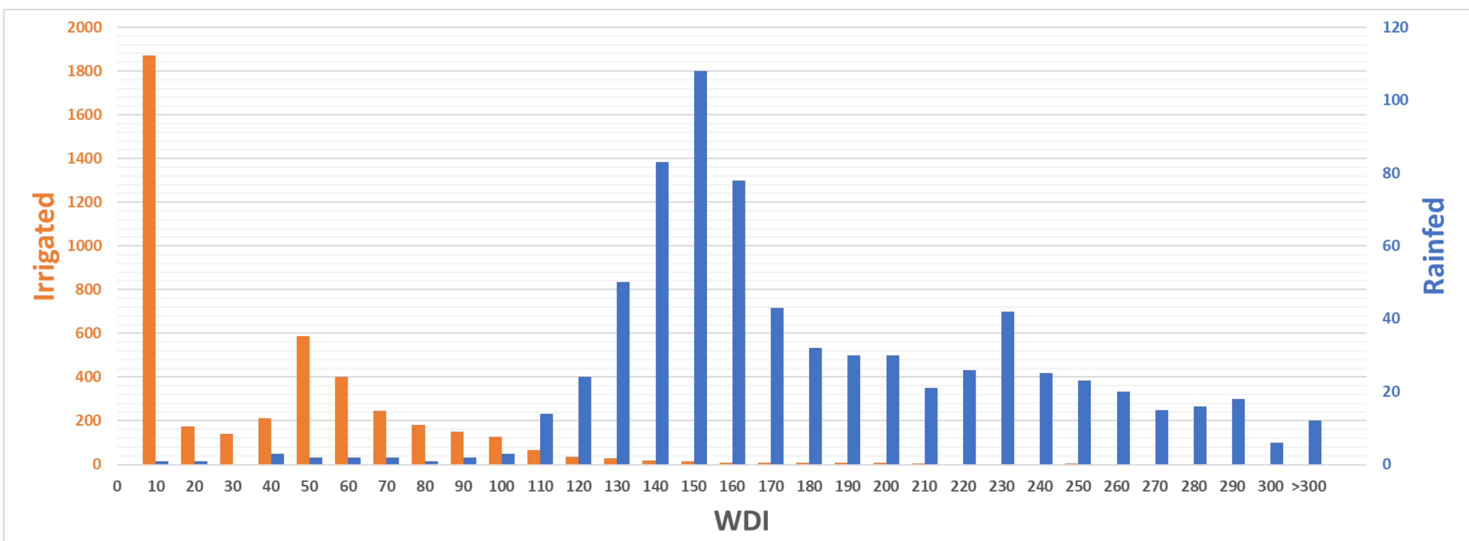
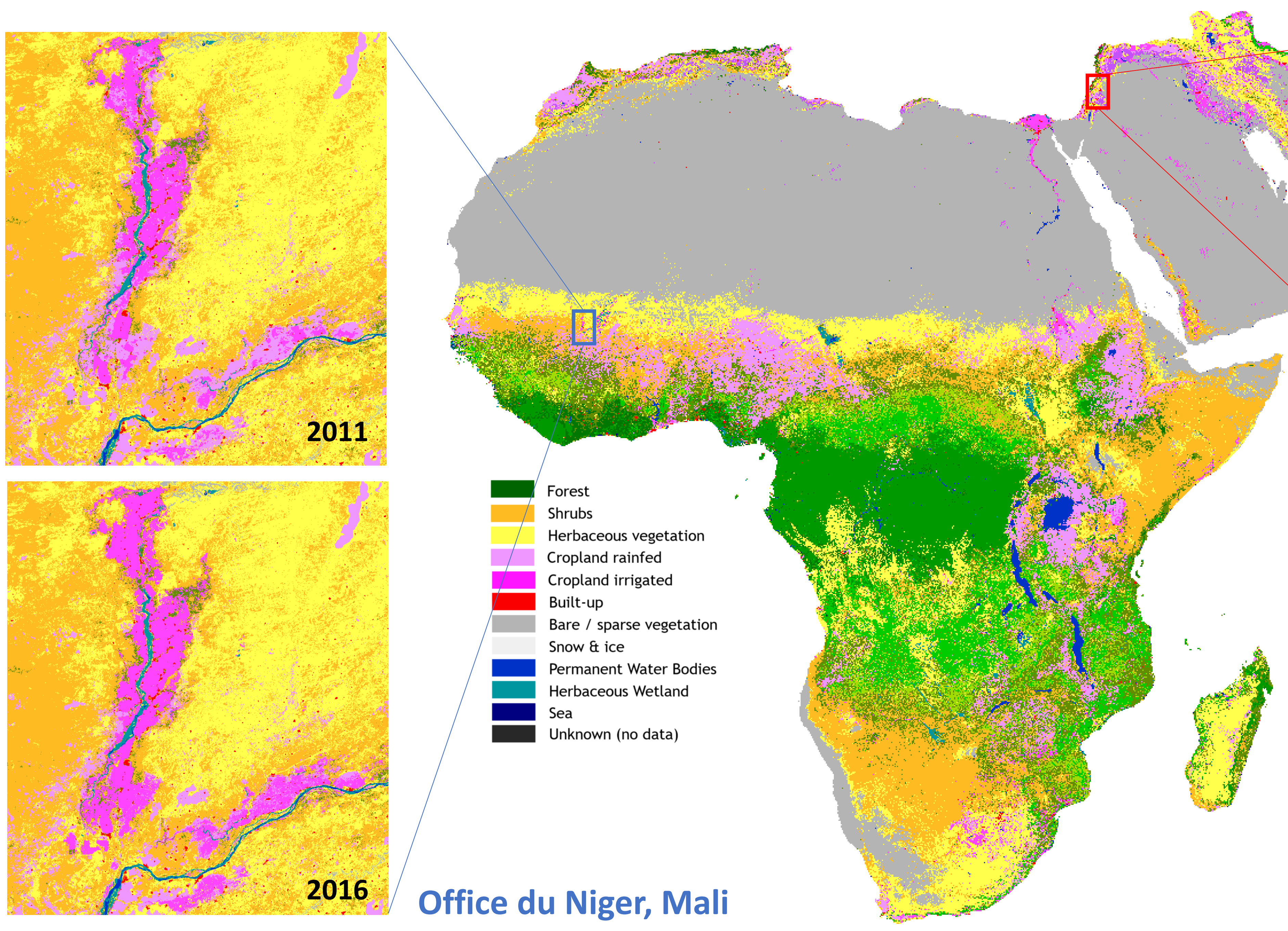


Figure 2: WDI values for all available reference parcels, with orange depicting the irrigated fields, and blue depicting the rainfed fields..

Overall, the WDI is a suitable metric for distinguishing between rainfed and irrigated croplands, when full irrigation is applied, or when there is a clear distinction between dry and rainy seasons. Figure 2 shows the WDI values for all available reference fields, showing a clear distinction. The resulting irrigation map for Africa and the Near East is subsequently shown in Figure 3 for the year 2015, with some more details for Office du Niger in 2011 and 2016 to highlight how WDI values can be used to track temporal changes in irrigated areas.
Some confusion remains, with WDI values around 70-140. These can be attributed to the application of supplementary irrigation on the one hand, and uncertainties in the reference data on the other hand. For those areas, the potential of Sentinel-1 and 2 metrics was evaluated (Figure 4). Examples are the standard deviation of the EVI throughout the growing season, which was significantly higher for supplementary irrigated fields, as well as the VV/VH backscatter ratio derived from the pre-growing season period.



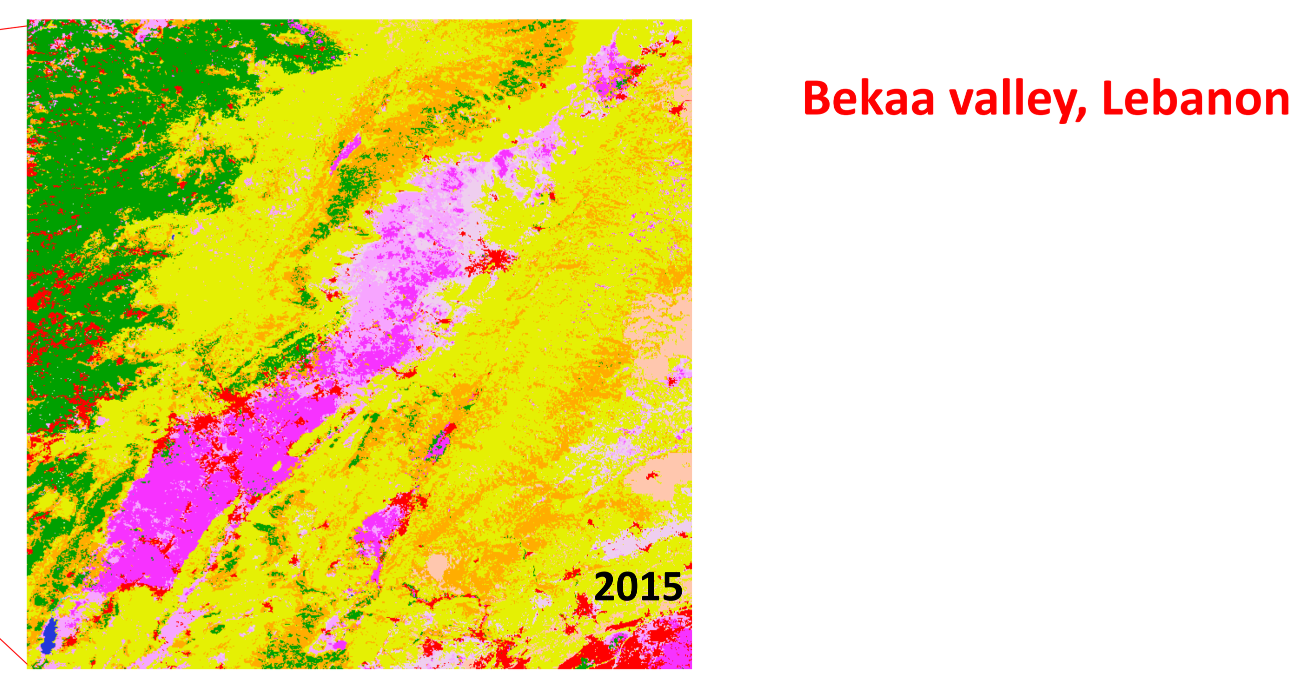


Figure 3: The 2015 irrigation map for Africa and the Near East, with a zoom for Office du Niger, Mali for the years 2011 and 2016, as well as for the Bekaa Valley.

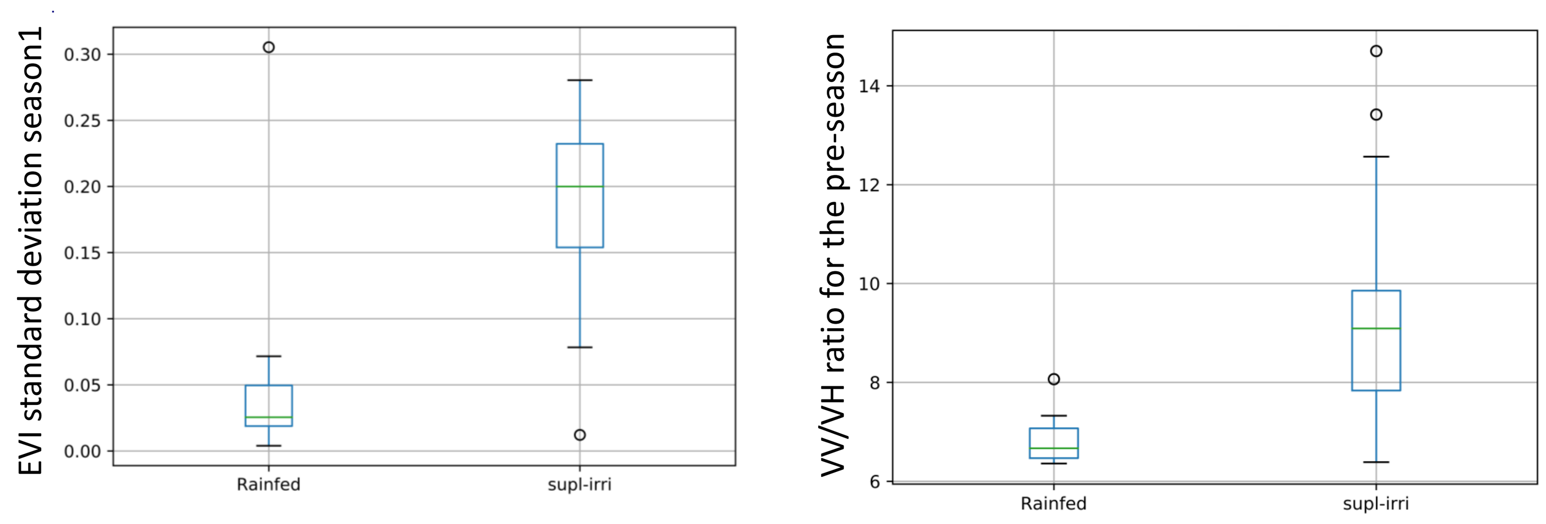


Figure 4: Metrics separability for the Bekaa valley, for the rainfed and supplementary irrigated fields. EVI standard deviation during the season (left) and VV/VH backscatter ratio for the pre-growing season period (right)

CONCL.

- WDI is a suitable metric for distinguishing between rainfed and irrigated croplands, when full irrigation is applied, or when there is a clear distinction between dry and rainy seasons.
- More complex systems may require more advanced methods, with Sentinel-1 and 2 providing useful information.
- For continental or global irrigation mapping, a combination of both methods is desirable. Irrigated areas in regions with low precipitation could best be mapped based on the WDI approach, while in more complex areas, supervised classification methods may be required. This would strongly reduce the need for detailed reference data over large areas, while maintaining a high mapping accuracy.

LITERATURE CITED

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