Article

Mapping of Evapotranspiration and Determination of the Water Footprint of a Potato Crop Grown in Hyper-Arid Regions in Saudi Arabia

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Abstract: Seasonal quantification of a crop's evapotranspiration (ET) and water footprint (WF) is essential for sustainable agriculture. Therefore, this study was conducted to estimate the ET and WF of an irrigated potato crop using satellite imagery of Landsat and Sentinel-2 sensors. The Simplified Surface Energy Balance (SSEB) algorithm was used to evaluate the crop water use (ET_a) for potato fields belonging to the Saudi Agricultural Development Company, located in the Wadi-Ad-Dawasir region, Saudi Arabia. Normalized difference vegetation index (NDVI), soil-adjusted vegetation index (SAVI), and land surface temperature (LSD) were computed for Landsat and Sentinel-2 datasets, which were used as inputs for mapping the potato tuber yield and, subsequently, the WF. The results indicated that the NDVI showed the best accuracy for the prediction of the potato tuber yield ($R^2 = 0.72$, P > F = 0.021) followed by the SAVI ($R^2 = 0.64$, P > F = 0.018), compared to the field harvested actual yield (Y_A). A comparison between the satellite-based ET_a and the actual amount of water applied (W_A) for irrigation showed a good correlation ($R^2 = 0.89$, RMSE = 4.4%, MBE = 12.9%). The WF of the potatoes in the study area was estimated at values between 475 and 357 m^3 t^{-1} for the early (September–December) and late (December–April) growing periods, respectively. A major portion (99.2%) of the WF was accounted for from irrigation with variations of 18.5% and 3.5% for early- and late-planted potatoes, respectively, compared to the baseline (crop planted in season). In conclusion, the results showed the possibility of satisfactorily estimating the WF using the SSEB algorithm by integrating the Landsat-8 and Sentinel-2 datasets. In general, the high rates of ET in the early planting season led to higher WF values compared to the in-season and late planting dates; this will help in selecting suitable planting dates for potato crops in the study area and areas with similar environments, which enhances the opportunities for sustainable management of irrigation water.

Keywords: satellite data; vegetation indices; SSEB; CROPWAT; water footprint

1. Introduction

Population growth and rapid changes in people's lifestyles have led to a significant increase in the demand for water all over the world, and this requires paying special attention to the quantities of water used in irrigating agricultural crops and those used in associated industries [1]. The water footprint (WF), which was introduced to assess