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RESEARCH ARTICLE

Utilization of Landsat-8 data for the estimation of carrot and maize crop water footprint under the arid climate of Saudi Arabia

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Abstract

The crop Water Footprint (WF) can provide a comprehensive knowledge of the use of water through the demarcation of the amount of the water consumed by different crops. The WF has three components: green (WF_g), blue (WF_b) and grey (WF_{gr}) water footprints. The WF_g refers to the rainwater stored in the root zone soil layer and is mainly utilized for agricultural, horticultural and forestry production. The WF_b, however, is the consumptive use of water from surface or groundwater resources and mainly deals with irrigated agriculture, industry, domestic water use, etc. While the WF_{gr} is the amount of fresh water required to assimilate pollutants resulting from the use of fertilizers/agrochemicals. This study was conducted on six agricultural fields in the Eastern region of Saudi Arabia, during the period from December 2015 to December 2016, to investigate the spatiotemporal variation of the WF of silage maize and carrot crops. The WF of each crop was estimated in two ways, namely agro-meteorological (WF_{Agro}) and remote sensing (WF_{RS}) methods. The blue, green and grey components of WF_{Agro} were computed with the use of weather station/Eddy covariance measurements and field recorded crop yield datasets. The WF_{RS} estimated by applying surface energy balance principles on Landsat-8 imageries. However, due to non-availability of Landsat-8 data on the event of rainy days, this study was limited to blue component ($WF_{RS\text{-}b}$). The WF_{Agro} of silage maize was found to range from 3545 $m^3\ t^{-1}$ to 4960 $m^3\ t^{-1}$; on an average, the $WF_{Agro\text{-}g}$, $WF_{Agro\text{-}b}$, and $WF_{Agro\text{-}gr}$ are composed of < 1%, 77%, and 22%, respectively. In the case of carrot, the WF_{Agro} ranged between 297 $m^3\ t^{-1}$ and 502 $m^3\ t^{-1}$. The $WF_{Agro\text{-}g}$ of carrot crop was estimated at <1%, while $WF_{Agro\text{-}b}$ and $WF_{Agro\text{-}gr}$ was 67% and 32%, respectively. The $WF_{Agro\text{-}b}$ is occupied as a major portion in WF of silage maize (77%) and carrot (68%) crops. This is due to the high crop water demand combined with a very erratic rainfall, the irrigation is totally provided using groundwater delivered by center pivot irrigation systems. On the other hand, the $WF_{RS\text{-}b}$ estimated using Landsat-8 data was varied from 276 (±73) $m^3\ t^{-1}$ (carrot) and 2885 (±441) $m^3\ t^{-1}$ (silage maize). The variation