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Crop water footprints and irrigation water volumes: a comparison of empirical measurements with CROPWAT model estimates for the seasonally dry tropics

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Within the global context of growing water scarcity and water demand for food production, the "water footprint" has been proposed as the indicator to evaluate and compare the consumptive water use associated with any product. In the case of crops, CROPWAT 8.0 model (FAO, 2010) was proposed in the Water Footprint Assessment Manual as the reference tool to estimate green and blue crop water footprints (Hoekstra et al., 2011). Additionally, the CROPWAT model was released by FAO as a tool for the calculation of crop water requirements and irrigation planning. Consequently, and because of its simplicity, openly available software, and low "in situ data" demand, the CROPWAT model has been used extensively for crop water footprint estimation and irrigation planning, especially in developing countries. CROPWAT uses the crop coefficient method to estimate actual crop evapotranspiration (ETc) (Allen, 1998). This method estimates ETc as the product of a crop coefficient (Kc), that incorporates crop water requirements and cropland characteristics, and a reference evapotranspiration (ETo) that represents atmospheric water demand based on meteorological conditions. Crop coefficients have been extensively estimated for the majority of commercial crops, and tables are available with global values of Kc for the different growing stages of the crops (Allen, 1998). Despite the recognition that global Kc values are valid only for "non-stressed crops cultivated under excellent agronomic and water management conditions and achieving maximum crop yield", most often these are the values used when running CROPWAT model. This is because site specific Kc values for crops growing in non-ideal conditions are difficult to find in the literature or to estimate due the scarcity of site specific ETc or soil water measurements. We used empirical measurements of ETc based on water vapour fluxes determined by eddy covariance for three crops (upland rice, melon, and sugar cane) grown under water scarce conditions in the seasonally dry region of Guanacaste Costa Rica to assess the accuracy of crop water footprints and irrigation volumes derived from CROPWAT model. We evaluated CROPWAT under three Kc data availability scenarios possible for most model users: (Basic) using global Kc values; (Intermediate) using adapted Kc values based on site specific meteorological conditions according to Allen (1998) guidelines; and (Advanced) using site specific Kc values derived from site ETc measurements. The three scenarios were tested under theoretical irrigation (CROPWAT model estimates irrigation volumes and frequency) and actual irrigation (actual irrigation volumes and frequency are used as model inputs). Based on the results of this assessment, we will discuss the potential and limitations of CROPWAT model to estimate crop water footprints for potential water planning in areas facing water scarcity.