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Field quantification of the water footprint of an apple orchard, and extrapolation to watershed scale within a winter rainfall Mediterranean climate zone

Dzikiti, Sebinasi
Council for Scientific and Industrial Research
Pretoria, 0001, South Africa
Email: SDzikiti@csir.co.za

Abstract

Field scale quantifications of the water footprints (WF) of crops, based on actual measurements, provide valuable and detailed information for on-farm water use management. However, watershed-based WF assessments are more appropriate for large-scale water resources management beyond the farm boundaries. In this study, blue, green and grey WF information, using the Water Footprint Network approach up to farm gate level, was determined for an apple (Malus pumila) orchard growing under Mediterranean climate conditions in South Africa. WF(subblue) and WF(subgreen) were determined through measurements of transpiration, total evaporation, rainfall, irrigation and other operational water uses, and WF(subgrey) was calculated from fertilizer applications. Combined field-scale blue/green/grey water footprint data were extrapolated to watershed scale by means of representative monthly FAO-56 type reference potential evaporation (ETo) values and crop coefficients derived from the field scale observations. Resultant water use values were converted to a volumetric equivalent by multiplying by the area under apple orchards in each watershed. The volumetric equivalents were then summed for all QCs in the Water Management Area to calculate the overall water footprint for apple production in the basin. Orchard-scale WF, taking into account all water uses and a fruit yield of 61.5t.ha(sup-1), was 212.1 m3.t(sup-1), comprising 62.7% WF(subblue), 14.9% WF(subgreen) and 22.5% WF(subgrey). Irrigation thus contributed the bulk of the WF in the apple production chain. Resultant water productivity (WP) figures for the orchard averaged 4.72kg.m^{-3}. Scaling up the WF estimates to QC level gave an average value of 228.4m3.t(sup-1) (WP=4.41kg.m^{-3}). Accurate crop coefficients, representative weather / ETo data and reliable crop areas within each QC are critical requirements in terms of upscaling WF estimates, where the information has potential application in water allocation decisions, Water-Energy-Food (WEF) Nexus cost-benefit analyses and other water resource management decisions