Regional-based estimates of water use for commercial sugar-cane in South Africa

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Abstract

The water use of rain-fed sugar-cane has come under the spotlight in South Africa, largely as a result of changes in legislation and a focus on streamflow reduction activities. In this study a robust relationship between sugar-cane yield and evapotranspiration derived by Thompson in 1976 is applied in conjunction with regional cane production records in South Africa. These were used to provide regional estimates of water use of commercial rain-fed and irrigated sugar-cane as affected by environmental limitations. The mean water use of sugar-cane at an industry scale was 598 $mm \cdot a^{-1}$. This included irrigated cane and is approximately 40% of the mean industry potential evapotranspiration for a full canopy crop. An estimate of water use of rain-fed cane is approximately 36% of potential evapotranspiration. The results shown in this paper provide strong evidence that simple comparisons of the potential evapotranspiration of different crops or land covers are of little value in determining potential hydrological impacts of land-use changes. This illustrates that the use of potential sugar-cane evapotranspiration to compare this crop's impacts on streamflow reduction to those of original vegetation is a problematic approach and is fundamentally flawed

Keywords: water use, sugar-cane, regional production, evapotranspiration, Thompson model

Introduction

The water use of rain-fed sugar-cane has come into focus in South Africa, largely as a result of changes in legislation. In the new South African Water Act (Act 36 of 1998), definitions of water use have been extended to include: "engaging in a streamflow reduction activity" (SFRA). An SFRA is defined in Section 36 of the Water Act as any activity, including the cultivation of any particular crop or vegetation which, in relation to a particular area, has a significant impact on water availability to other users, including the Reserve. To date, forestry is the only declared SFRA; however, in light of the new Water Act, other crops or land covers have come under the spotlight as potential SFRAs.

In an influential study, Kruger et al. (2000) adopted a methodology whereby candidate SFRAs were determined based largely on a comparison of their potential evapotranspiration (PET) rates with the PET rates of corresponding Acocks veld types (Acocks, 1975). In this study Kruger et al. (2000) reported that the PET of sugar-cane was approximately 1 400 $mm \cdot a^{-1}$, compared to corresponding country-wide average PET rates of Acocks veld types of approximately 1 100 $mm \cdot a^{-1}$. As a result, it was concluded that sugar-cane should be targeted for further investigation as a potential SFRA.

Estimates of the PET of a crop assume ideal growing conditions and no soil-water limitations. However, in reality, growing conditions are seldom ideal and as a result the actual water use /evapotranspiration of a crop (AET), which represents the real water use, is very different to the PET. In addition, the AET of different crops can be very similar when grown under water limited conditions, such as in shallow soils, despite large differences in PET rates. An analogy is to consider several reservoirs, each containing the same amount of water. If the water in each of these reservoirs is pumped out with different sized pumps, the same total amount of water will be pumped, independent of the pump sizes, provided the reservoirs are not replenished. Therefore, if sugar-cane could potentially consume 1 400 $mm \cdot a^{-1}$ (a relatively larger pump in the analogy) and the Acocks veld type it replaces could potentially consume 1 100 $mm \cdot a^{-1}$ (a relatively smaller pump in the analogy), but only 700 $mm \cdot a^{-1}$ is available (the amount of reservoir water available for pumping in the analogy), then both vegetation covers are likely to consume close to 700 $mm \cdot a^{-1}$. AET is therefore similar for both crops, and significantly less than PET, since AET will be limited by the amount of water available. This is simplistic, but it does highlight the fact that actual water use and potential hydrological impacts of different crops is complex and probably more dependent on limitations imposed by specific growing environments and rooting conditions, rather than a comparison of PET rates.

The key question, therefore, should be to establish the AET of sugar-cane (rather than the PET) in the different regions where this crop is grown. Currently research studies are underway whereby actual water use or AET of sugar-cane is measured using remote sensing techniques (e.g. Hemakumara et al., 2003). Results from these and similar studies are, however, site- and season-specific and cannot be simply extrapolated to other conditions without limitations.

In this study a robust relationship between sugar-cane yield and AET derived by Thompson (1976) is applied in conjunction with historical cane yield records from mill areas in South Africa in order to give regional estimates of the actual water use of sugar-cane as affected by environmental limitations.

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