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Research Paper

An evaluation of the performance and subsequent calibration of two reference evapotranspiration estimation models for Gweru, Zimbabwe

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ABSTRACT

This study evaluated the performances and subsequently calibrated the Hargreaves and Blanney Criddle reference evapotranspiration (ET_o) estimation models for the semi arid Gweru climate in Zimbabwe. The FAO ï 56 Penman Monteith model was used as the standard method for the evaluation. The ET_o calculator (Version 2.3) was used for the computation of daily ET_o for all models using observed maximum temperatures, minimum temperatures, mean temperatures, mean relative humidity and wind speed at 2 m height as input data. The Hargreaves and Blanney Criddle models were evaluated using the Model Efficiency (EF), the Bias (B), the Root Mean Square Error (RMSE), the Mean Absolute Prediction Error (Err) and the coefficient of determination (R^2). The Blanney Criddle model was found to be highly accurate (Err of 6.807%), a B of -0.303 mm day^{-1}, a RMSE of 0.404 mm day^{-1}, an EF of 0.926 and an R^2 of 0.970. The Hargreaves model had a less accurate but rather good performance as evidenced by an Err of 12.06%, a RMSE of 0.855 mm day^{-1}, a B value of -0.211 mm day^{-1}, EF of 0.66 and an R^2 of 0.751. After calibration, the performance of the Blanney Criddle model was within acceptable limits of the evaluation methods used. The Err dropped to only 3.925%, the RMSE to 0.269 mm day^{-1} and the B value to -0.00012 mm day^{-1}. The EF also increased to 0.965. There was little change in the performance of the Hargreaves model even after calibration. The EF increased to 0.703 and the B value decreased to -0.081 mm day^{-1}. The Err, RMSE and the R^2 remained largely unchanged. From these observations, it can be concluded that the Blanney Criddle model is the best method to use for daily ET_o estimation for the semi arid region of Gweru because of its highly accurate prediction accuracy. For this site, it is highly recommended to use 0.303 as the value of the constant a in the equation instead of the default 0 value. The site specific k value of the Hargreaves model is 0.0025 instead of the default 0.0023.

Key words: Reference evapotranspiration, FAO-56 Penman Monteith, Hargreaves model, Blanney Criddle model.

*Zirebwa, F.S.[1] Sammie B.[1] Kapenzi A.[1] Mugandani R.[1] and Madanzi T.[2]

[1]Department of Land and Water Resources Management. Midlands State University, P. Bag 9055, Gweru, Zimbabwe
[2]Department of Agronomy. Midlands State University, P. Bag 9055, Gweru, Zimbabwe.

Tel: +263773446704 e-mail: zirebwasf@msu.ac.zw

INTRODUCTION

The quantification of evapotranspiration is a very important aspect of water management, determination of crop water requirements, irrigation designs and land use planning (Orang et al., 1995; Yoder et al., 2005; ElNesr et al., 2011; Umara et al., 2012). Evapotranspiration (evaporation and transpiration) may be quantified from soil surfaces, open water surfaces as well as vegetation surfaces for those applications to be achieved. This quantification can be done through direct measurement or through estimation using established equations. The direct measurement of evapotranspiration is complex, expensive and time consuming (Ejieji, 2011) thus the estimation of evapotranspiration is usually done indirectly using the reference evapotranspiration (ET_o). Integrating ET_o with the respective surface or crop factors will give the evapotranspiration. ET_o is the evapotranspiration rate from