Chapter 4
Remote Sensing–Based Evapotranspiration Modelling for Agricultural Water Management in the Limpopo Basin

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ABSTRACT

The study was motivated by the need to determine the spatial variation of ET and to test the applicability of RS based methods in arid to semi-arid climates with limited ground-based measurements. In this paper we present results of an effort of determining spatial actual evapotranspiration in the Limpopo basin, the Notwane subcatchment in the south-eastern part of Botswana, using remote sensing data from MODIS and Landsat Data sets. The Simplified Surface Energy Balance Index (S-SEBI) was applied to determine actual evapotranspiration using the seven bands of Landsat and MODIS surface reflectance and temperature channels. Three different dates were used to estimate ET from both Landsat and MODIS scenes. The estimated ET values from the two sensors show approximately equally comparable results. An assessment was also conducted to determine the factors influencing evapotranspiration. No strong correlation was identified for ET against the five factors investigated: Net radiation, NDVI, Surface Temperature, emissivity and surface albedo.

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INTRODUCTION

One of the most important difficulties to overcome is the spatial data presentation. The use of remote sensing in determining parameters of the water balance has become increasingly popular, since it offers a solution to the determination of the spatial variability of hydrological variables on a pixel by pixel basis.

In agricultural water management, the challenge always is associated with accurately determining the green water component or actual evapotranspiration of a catchment. This can be achieved through using direct measurement methods (e.g. lysimeters); from indirect climate methods or micrometeorological (energy balance or climate or combination) methods; through hydrological methods (water balance) or soil-water balance modelling, in which field measurement of soil moisture data can be used for calibration. If accurately measured ET is available, the water balance remains accurately determined and actual surface and groundwater components which can be harvested or retained for use in water deficit periods is a key in agricultural water management at field or basin level.

This study therefore sought to determine evapotranspiration from remote sensing data using the S-SEBI method (Roerink et al. 2000) and making a comparison with the traditional point estimate methods with the following specific objectives.

1. To develop a model to estimate ET over the study catchment based on the Simplified Surface Energy balance Index (S-SEBI) from MODIS terra/aqua data and Landsat Data and develop a script in ILWIS
2. To determine the spatial variation of actual evapotranspiration
3. To evaluate the degree of applicability and compare with meteorological methods
4. To make recommendations with regard to the use of RS in determining ET in the Limpopo catchment as a whole

A comparison was made between the ET values obtained from remote sensing data and FAO Penman-Monteith method using climatic data for Sir Seretse Khama Airport (SSKA). The results of the two methods demonstrate relatively good agreement for the station under consideration proving satisfactory accuracy of the spatially calculated ET for different land use and land cover. The work concludes that the RS based S-SEBI model provides a relatively less data intensive method of determining the spatial variation of ET in this semi-arid region over the considered sub-catchment. The study recommends that more time series satellite data be acquired and considered for further model calibration and verification and in order to determine the temporal variability of ET using the S-SEBI algorithm in the sub-basin.

The complete GIS and remote sensing scripts based on ILWIS for S-SEBI algorithm and various energy balance parameterizations for the Landsat and MODIS remote sensing data are developed and used for this research.

In this study, the applicability of the SEBI algorithm using the remote sensing data from MODIS and Landsat data sets was tested through comparison of the results of the two data sets by evaluating those with climate-based evapotranspiration model estimates, using the Penman-Monteith method, determined at selected stations in the study area.