J Indian Soc Remote Sens (August 2017) 45(4):643–656
DOI 10.1007/s12524-016-0623-0

RESEARCH ARTICLE

Quantification of Agricultural Water Productivity at Field Scale and Its Implication in On-Farm Water Management

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Received: 13 April 2015 / Accepted: 8 September 2016 / Published online: 6 October 2016

Abstract The Kingdom of Saudi Arabia (KSA) is under extreme water shortage conditions. About 80 % of water in KSA is utilized by the agricultural sector; therefore, proper management of irrigation water is required to produce more food from less water. Water productivity concept was emerged and successfully quantified with the use of remote sensing as well as variable-rate application technologies. In this study, water productivity (WP) of three major crops (alfalfa, corn and Rhodes grass), cultivated in the Eastern Province of KSA under center pivot irrigation system, was estimated using Landsat-8 images in conjunction with in situ field observations. Evapotranspiration (ET)/water use maps (WUM) of irrigated fields was generated from Landsat-8 data using SEBAL model. Subsequently, the crop type and growth stage wise amount of water required for the irrigation was estimated and the irrigation schedules were prepared. Zone based Variable Rate Irrigation (VRI) system was used to optimize the application of irrigation water. Classified ET maps are used as a base for the formulation of prescription map for VRI. The accuracy of SEBAL derived ET maps were assessed against the actual ET recorded by the Eddy Covariance (EC) flux tower installed on an alfalfa field. Crop Productivity Map (CPM) of alfalfa and Rhodes grass were developed using hay yield monitor data, while forage corn productivity was represented by the relationship between the NDVI and sampled silage corn yield (kg m^{-2}). Water productivity map was generated by dividing the CPM with the WUM. The deviation between SEBAL predicted and EC flux tower recorded ET was ranged from 2.92 to 7.13 %. The mean predicted yield (kg ha^{-1}) of alfalfa, corn and Rhodes grass was 2934, 4650 and 3368, respectively. The fields with remote sensing (RS) and VRI application was shown higher WP compared to without RS and VRI inputs. The recorded WP of silage corn, Rhodes grass and Alfalfa with RS and VRI inputs was 1.09, 0.81 and 0.83 respectively, whereas, it was decreased to 1.03, 0.64 and 0.61 kg m^{-3} respectively for the fields without RS and VRI inputs.

Keywords Crop productivity · Evapotranspiration · Irrigation · Landsat-8 · Saudi Arabia · Water productivity

Introduction

The rapidly growing competition for limited water resources among domestic use, industry and agriculture has led to the restriction of the development efforts in most countries, and to the importance of supporting surface water by groundwater resources (FAO 1993). Hence, ground water plays a vital role in sustaining agricultural production in many irrigated areas of the world. The majority of the global groundwater withdrawals (750–800 km^3 $year^{-1}$) are used for irrigating crops (Shah et al. 2000). Therefore, quantification of the water use and its productivity become one of the key measures in understanding its implications on the sustainable agricultural production. One of the quick and most effective

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