EVALUATING WATER DISTRIBUTION EFFICIENCY OF PIVOT IRRIGATION SYSTEM IN EASTERN NILE DELTA USING REMOTE SENSING IMAGERY

By

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B.Sc. Agric. Sc. (Agricultural Engineering), Cairo University, 2007.

M.Sc. Agric. Sc. (Agricultural Engineering), Ain Shams University, 2012

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ABSTRACT

Eslam Farg Ahmed Farg: Evaluating Water Distribution Efficiency of Pivot Irrigation System in Eastern Nile Delta Using Remote Sensing Imagery. Unpublished Ph. D. Thesis, Department of Agricultural engineering, Faculty of Agriculture, Ain Shams University, 2015.

Traditional methods for center pivot evaluation are depending on the water depth distribution along the pivot arm. Estimation and mapping the water depth under pivot irrigation systems using remote sensing data is essential for calculating the coefficient uniformity (CU) of water distribution. This study focuses on estimating and mapping water depth using Landsat OLI 8 satellite data integrated with Heermann and Hein (1968) modified equation for center pivot evaluation.

Reference evapotranspiration (ET_O) estimated using FAO Penman-Monteith and meteorological data collected by agro-meteorological station including (minimum, average, maximum temperature, wind speed, sunshine hours, solar radiation andrelative humidity). Landsat OLI 8 image was geometrically and radiometrically corrected to calculate the vegetation and water indices (NDVI and NDWI) in addition to land surface temperature.

Results showed that the highest values of calculated VI’s that return to the high reflection from the plant canopy at the near infrared and high absorption at the red wavelength at middle season growth stage. On the other hand, collected spectral signatures of peanut and maize canopy were similar with slightly difference along the wavelength from 350 nm to 2500 nm of ASD hand held spectroradiometer at similar values of collected water depth. However the differences of peanut and maize canopy reflectance at minimum and maximum collected water depth location were significantly different especially at near infrared and short wave infrared.

The statistical analysis of the collected values of water depth values and NDVI, NDWI and LST showed that NDVI is highly negative correlated with NDWI, LST and collected water depth values.

Multi linear regression MLR analysis using stepwise selection was applied to develop water depth prediction equations for the different crops using NDVI, NDWI and LST. The results showed R^2 and adjusted R^2 0.93 and 0.88 respectively. Study area or field level verification was applied for estimation equation with correlation 0.93 between the collected water depth and estimated values.

Key words: Evapotranspiration, VI’s, NDVI, NDWI, CU, LST, spectral signatures, ASD, MLR.

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1. INTRODUCTION

One of the most populous countries in Africa is Egypt. More than 90 million inhabitants live near the banks of the Nile and the delta, in an area of about 5 % of Egypt area. In other words approximately only 5.5% of the total land area is used for different land use purposes. Nile River is the main water resources in Egypt in addition to Egypt had low precipitation rate only at the northern. South of Cairo, rainfall averages only around 2 to 5 mm per year. Parallel to the northern shore line the rainfall can be 410 mm, with most of falling in winter starts in October ends at march. Egypt is therefore totally depended on Nile water entering Egypt at the southern border with Sudan **(Droogers et al., 2009).**

According to food and agriculture organization FAO Water Report No. 29, 2005, the main land cover/land use of the Egypt area is desert land. Most of the cultivated land is located close to the banks of the Nile River, its main branches and canals, and in the Nile Delta. Rangeland is restricted to a narrow strip; in addition to along The Mediterranean coast few kilometers had bearing capacity is quite low. There is no forest land. The total cultivated is 3.4 million ha (2002). The River Nile is the main source of water for Egypt, with an annual allocated flow 55.5 km^3/yr under the Nile Waters Agreement in1959. Internal renewable surface water resources are estimated as 0.5 km^3/yr. the total water withdrawal in 2000 was estimated at 68.3 km3. The water use is as following 59 km^3 for agriculture 86%, 5.3 km^3 for domestic use 8% and 4.0 km^3 for industry 6 %. Apart from that, 4.0 km3 were used for navigation and hydropower. Surface water was the source for 83 % of the irrigated area in 2000, while 11 % (361 176 ha) of the area was irrigated with groundwater in the provinces of Matruh, Sinai and New Valley. The remaining 6 % (217 527 ha) irrigated with mixed sources.

Agricultural water resources are becoming more limited in arid and semi-arid parts of the world due to a combination of natural and anthropogenic factors, including but not limited to rapidly-growing demand from municipal, industrial, and environmental sectors and predicted increase in frequency and severity of droughts under climate change. As a result, the total irrigation and maximized production per unit area of land replaced with deficit irrigation and achieving maximum production per unit of applied water. Deficit irrigation (DI) is defined as deliberate application of water at rates lower than crop's required rate for producing optimum yield **(Fereres and Soriano, 2007).**

Remote sensing technologies is essentially used for monitoring crop water status, predicting yields **(Idso et al., 1978, 1980; Pinter et al., 1983)**, improving water use efficiency **(Evett et al., 2006)** and harvesting methods, and precisely managing irrigation **(Wanjura et al., 1995)**. crop canopy temperature and water content can be derived from infrared thermography and thermometry **(Shaughnessy et al., 2011).**

Evaluating the performance of irrigation system could play an important role in attaining sustainability. The most accurate way of evaluating and monitoring of any activity might require thorough ground survey. Which are most cases is costly and time consuming to be done frequently and even more difficult to cover large areas. In contrary to its requirement lack and unreliability of data is the most common problem on irrigation evaluation and monitoring, which makes use of remote sensing data important **(Aman, 2003).**

The pivot irrigation system, consider as best irrigation system or agricultural irrigation because of its low labour and maintenance requirements, performance and easy operation. When properly designed and operated, and equipped with high efficiency water applicators, a center pivot system conserves three precious resources water, energy and time.

Irrigation in arid areas plays an essential role in the agricultural productivity, especially. High water use efficiency can be achieved when precisely applied water equal to crop water demand spatially and temporally. In the past few decades, new technologies have played an important role in improving irrigation water allocation. For example, significantly advanced irrigation scheduling were applied in precision agriculture. Satellite sensors, such as MODIS, Landsat, GOES and other remote sensing imagery can be used to estimate crop water use and leaf water content for optimizing water management in irrigated areas as a continuous, automated, and easy-to-use source of information **(Fares et al., 2006; Cammalleri and Ciraolo, 2013; Hassan-Esfahaniet al., 2014 and 2015).**

SEBAL (Surface Energy Balance Algorithm for Land) is one of the first mathematical procedures that can operationally estimate spatially distributed ET_{act} of different land use types, including bare soils, water bodies, natural vegetation and rain fed / irrigated crops, etc. The SEBAL model solves the energy balance of each pixel. Cloud-free satellite images are needed to be processed for energy balance purposes **(Droogers et al., 2009).**

Crop water stress index (CWSI) varies to characterize plant water stress and schedule irrigations. Usually, this thermal-based stress index has been calculated from near solar noon or after and in cloud free conditions daily or over a short period of time measurements **(Shaughnessy et al., 2012).**

Biophysical aspects of vegetation canopies as means are quantified using multispectral Vis such as leaf area index and crop cover.