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ESTIMATION OF CROP EVAPOTRANSPIRATION USING REMOTE SENSING AND GIS

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Abstract— The aim of project is to Estimate Crop Evapotranspiration (ETc) using Remote Sensing & GIS for Laknavaram catchment area, Jayashankar Bhupalpally district, Telangana. Evapotranspiration is the important component in hydrological cycle and it is a basic factor to compute water balance in order to estimate its requirements and availability. In this project Crop coefficient method is used to estimate Actual ET for the laknavaram catchment area by using RS & GIS. Crop water requirements are represented by the actual crop evapotranspiration. Estimation of crop evapotranspiration (ETc) and crop coefficient using remote-sensing data is essential for planning the irrigation water use in arid and semiarid regions. This study focuses on estimating the crop coefficient (Kc) and crop Evapotranspiration (ETc) using satellite data integrated with the meteorological data and FAO-56 approach. This study compute ET obtained from the satellite with other various empirical standards. In this project, Crop coefficient method includes computing Net Radiation and soil heat flux to estimate ET. The result show that the values of ET in built up areas are low when compared with the vegetation & water surface. These processes to estimate ET are efficient and accurate.

Keywords— Evapotranspiration, Remote Sensing, Net radiation, soil heat flux, Crop coefficient

I. INTRODUCTION

Evapotranspiration (ET) is one of the important component of the Hydrological cycle. ET is a combined term of water lost from the soil surface represents evaporation and also the water lost from the plants represents transpiration which occurs simultaneously. On the land surface, an average of about 60% of the precipitation received is returned to the atmosphere through ET. Basically, there are many methods like weighing lysimeters, the Bowen ratio technique and eddy correlation techniques to estimate Evapotranspiration, but defect is that, these methods only provide Evapotranspiration for a specific location and fail to estimate Evapotranspiration at an affordable cost. From the recent years, Remote sensing techniques have been used to estimate Evapotranspiration using Crop coefficient method.

Remote sensing is an efficient tool utilized in estimating the ET, using satellite images for any required area. The techniques used in remote sensing are emerged to estimate ET by providing reliable algorithms. Remote sensing cannot provide a direct measurement of ET but it can estimate Evaporative Fraction, defined as the multiplication of ET with Crop coefficient.

Crop coefficient method is widely used to Estimate Evapotranspiration based on the analytical model. It calculates Evapotranspiration through sub-models that generate net surface radiation and soil heat flux by using the satellite images. This model main objective is that to use extreme remote sensing data. This model includes the inputs of surface albedo maps, Normalized Difference Vegetation Index (NDVI), soil heat flux. The applications of crop coefficient models relates to irrigation planning and other agricultural water use.

II. AIM

The main Aim of the project is to Estimate the Crop Evapotranspiration Using Remote Sensing and GIS (Geographical Information System) for Laknavaram Catchment.

III. OBJECTIVE

The objective of the project is to generate models for
1. Net Surface Radiation and
2. Soil Heat Flux in order to compute Reference Evapotranspiration (ETo)

IV. LITERATURE REVIEW

Narendra Kumar Gontia& Kamlesh N. Tiwari: - They used remote sensing and Geographical Information System (GIS) techniques to estimate actual crop Evapotranspiration of wheat crop grown in *Tarafeni South Main Canal* (TSMC) irrigation command of West Bengal State in India. The area under wheat crop was clipped from Land use / land cover map generated from Indian Remote Sensing Satellite P6 (IRS P6) image of January, 2004 for winter season 2003–04. The IRS P6 image and four wide field sensor (WiFS) images for different months of winter season were used to determine the Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI) for area under wheat crop. The relationship between vegetation indices and crop coefficients (Kc) of wheat for corresponding months were developed. Based on these developed regression equations crop coefficient maps were generated for each month of wheat crop season. Monthly reference crop Evapotranspiration (ETo) was estimated based on FAO-56, Penman–Monteith method. ETo was combined with spatially distributed Kc maps of different months of wheat crop season to generate crop Evapotranspiration (ETc) maps of each month. The crop water demand of wheat estimated using spatially distributed ETc maps for months of December 2003, January 2004, February 2004, March 2004 (1st Fortnight) and March 2004 (2nd Fortnight) were found to be 3.98, 8.14, 4.66, 2.49, and 1.21 million cubic meter (MCM) respectively. Based on crop Evapotranspiration the total crop water demand of wheat crop in irrigation command of TSMC was estimated as 20.48 MCM.

R. K. Singh and Airman: - Crop coefficient Kc based estimation of crop Evapotranspiration (ETc) is one of the most commonly used methods for irrigation water management. The standardized FAO56 Penman-Monteith approach for estimating ETc from reference Evapotranspiration and tabulated generalized Kc values has been widely adopted worldwide to estimate ETc. In this study, we presented a modified approach toward estimating Kc values from remotely sensed data. The surface energy balance algorithm for land model was used for estimating the spatial distribution of ETc for major agronomic crops during the 2005 growing season in south central Nebraska. The alfalfa-based reference Evapotranspiration ETr was calculated using data from multiple automatic weather stations with geo-statistical analysis. The Kc values were estimated based on ETc and ETr i.e., Kc=ETc /ETr. A land use map was used for sampling and profiling the Kc values from the satellite overpass for the major crops grown in south central Nebraska. Finally, a regression model was developed to establish the relationship between the normalized difference vegetation index NDVI and the ETr-based crop coefficients Kcr for corn, soybeans, sorghum, and alfalfa. We found that the coefficients of variation CV for NDVI, as well as for Kcr of crops were lower during the midseason as compared to the early and late growing seasons. High CV values during the early growing season can be attributed to differences in planting dates between the fields, whereas high CVs during the late season can be attributed to differences in maturity dates of the crops, variety, and management practices. There was a good relationship between Kcr and NDVI for all the crops except alfalfa. Validation of the developed model for irrigated corn showed very promising results. There was a good correlation between the NDVI estimated Kcr and the Bowen ratio energy balance system based Kcr with a R2 of 0.74 and a low root mean square difference of 0.21. This approach can be a very useful tool for a large watershed or regional scale estimation of ET using the crop coefficient and reference ET approach.

Er-Raki et al.: -The crop ET represents the crop water demand and governed by weather and crop conditions. The Food and Agriculture Organization (FAO) Penman–Monteith empirical calculation is an accepted method for calculating crop water requirements and has been tried and tested worldwide (Monteith, 1965; Allen et al., 1998; Gontia and Tiwari, 2010; Er-Raki et al., 2010;Papadavid et al., 2011). Remotely sensed spectral reflectance may provide an indirect estimate of crop coefficient or basal crop coefficients. The crop coefficient (Kc) can be estimated from spectral vegetation indices since both of them are related to leaf area index and fractional ground cover. Farg et al. (2012) estimated crop coefficient (Kc) and crop Evapotranspiration (ETc) using satellite data integrated with the meteorological data and vegetation indices (NDVI, soil adjusted vegetation index (SAVI). Kamble et al. (2013) estimated crop coefficient (Kc)-based crop ET for irrigation water management using satellite derived vegetation index

V. STUDY AREA

The area of study is Laknavaram Catchment located in Warangal district, Telangana, india.
The Laknavaram Lake is in the limits of Laknavaram village in Govindaraopet Mandal, Jayashankar Bupalpally district.
It is 80km from Warangal
Location: 18° 9′ 1.58″ N, 80° 4′ 10.56″ E.
Catchment area: 40.46 sq.km
Average annual rainfall: 95.5 mm

ERDAS IMAGINE

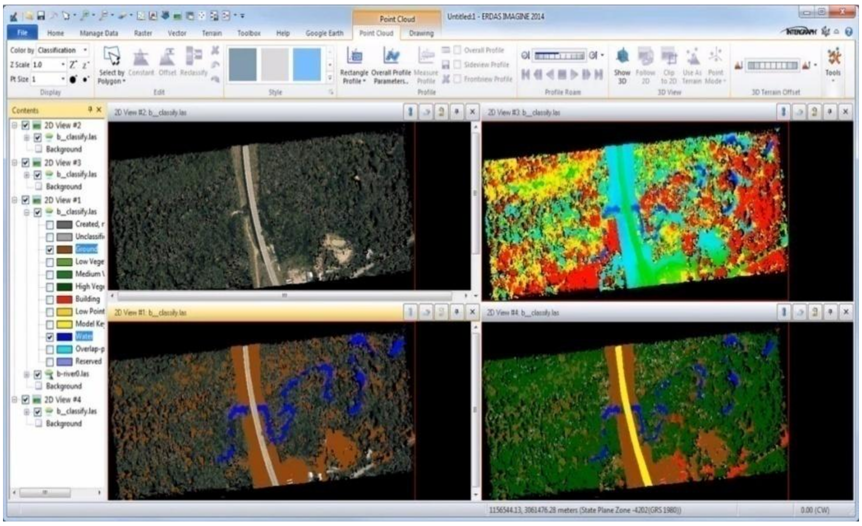


FIG NO.4 HOME PAGE OF ERDAS IMAGINE

VI. DATA REQUIRED FOR THE STUDY

Sl. No	Data	Source
1	Weather Data Temperature Wind speed Vapour pressure	Metrological Department (IMD)
2	Land sat Images (DEM)	USGS/Earth Explorer

Dec 24th,2018(from time and date website)	
T_{MAX}	**31^0C**
T_{MIN}	11^0C
T_{MEAN}	21^0C
RH_{MAX}	91%
RH_{MIN}	21%
RH_{MEAN}	56%
WIND SPEED(U_2)	7KMPH
ATMOSPHERIC PRESSURE	95.12KPa
PSYCHROMETRIC CONSTANT(υ)	$0.06323KPa^0C^{-1}$

VII. STUDY METHODOLOGY

CROP COEFFICIENT METHOD

Researchers propagate either one step direct estimation of ET or indirect step i.e. Crop coefficient approach. Determination of crop ET by direct methods are expensive and difficult, and almost all direct methods are impractical for permanent use on a large scale, so ET is commonly estimated by developed empirical methods. Food and agriculture organization proposed Penmen-Monteith method to determine reference Evapotranspiration (ETO) for irrigation scheduling. Compared with other common methods, Penmen-Monteith method has been widely used because it gives satisfactory results under many climatic conditions across the world. Crop coefficient method widely used because of its simplicity. This method divided into two types. They are:

- Single Crop coefficient method
- Double Crop coefficient method

Among two methods we are using Single Crop coefficient method. ET_C is determined by the crop coefficient approach whereby the effect of the various weather conditions are incorporated into ET_0 and the crop characteristics into the Kc coefficient:

$$ET_C = K_C * ET_O$$

$$ET_0 = \frac{0.408\Delta(Rn - G) + \gamma \frac{900}{T+273} X u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where as

K_C = Crop coefficient

ET_O = Reference Evapotranspiration (mm/day)

R_n = Net Surface Radiation at Crop Surface (MG/m^2 day)

G = Soil heat flux density (MG/m^2 day)

T = Air Temperature at 2m height (0 c)

u_2 = Wind speed at 2m height (m/s)

e_s= Saturation vapor pressure (KPa)

e_a = Actual vapour pressure (Kpa)

Δ =Slope vapor pressure curve (Kpa /0 c)

V= Psychometric constant (Kpa /0 c)

The operation of Crop coefficient model:

Net Surface Radiation

The First step is compute Net surface radiation (R_n) using

Rn = RS↓ - α RS↓ + RL↓ - RL↑ - (1-ε o) RL↓ …….(2)

Where, RS↓ is the incoming shortwave radiation (W/m2), α is the surface albedo (dimensionless), RL↓ is the incoming long wave radiation (W/m2), RL ↑ is the outgoing long wave radiation (W/m2), and ε o is the surface thermal Emissivity (dimensionless) This is accomplished in a series of steps using the ArcGis Model Maker tool to compute the terms in the above equation. A flow chart of the process is shown below.

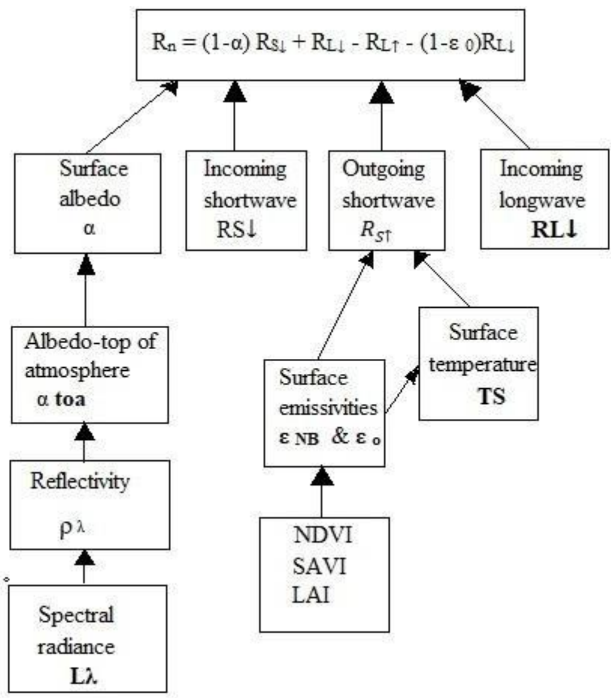


Figure 3.1 Flow chart of Computation of Net Surface Radiation

The computer model number used for each computation is given along with the variable name. The computation steps begin at the bottom of the figure with model 1 and continue upward to model 9 for the computation of Rn. The two terms RS↓ and RL↓ are computed with a spreadsheet or a calculator rather than the Model Maker tool.

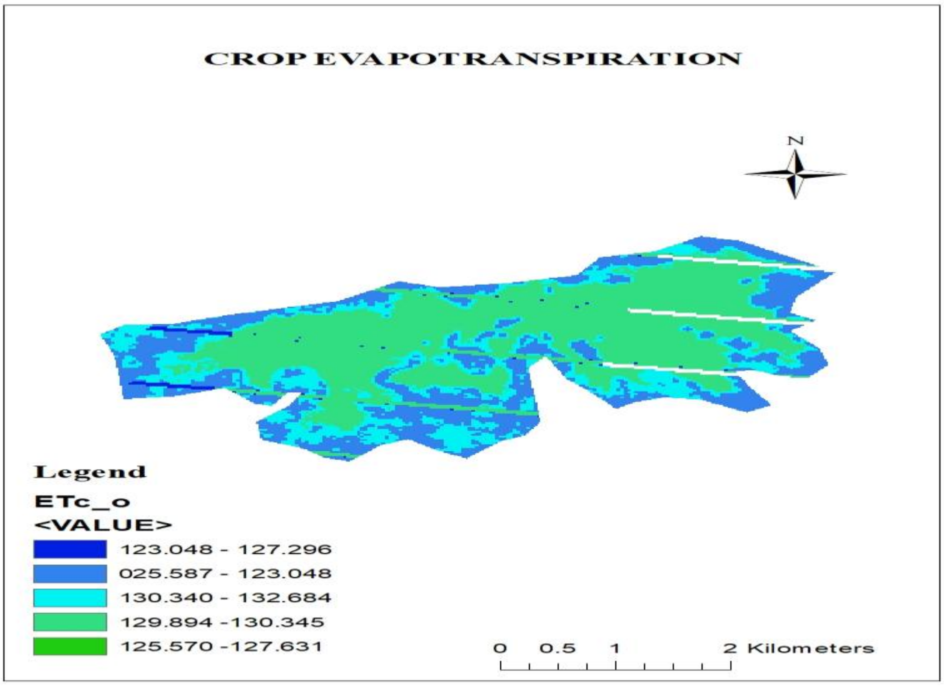
Soil Heat Flux

The second step in Crop coefficient is to calculate Soil heat flux by generating a model in ERDAS software same as generated for Net surface radiation. The soil heat flux (G) is the rate of heat storage to the ground from conduction. first computes the ratio G/R_n using the following empirical equation developed by Bastiaanssen (2000) representing values near midday:

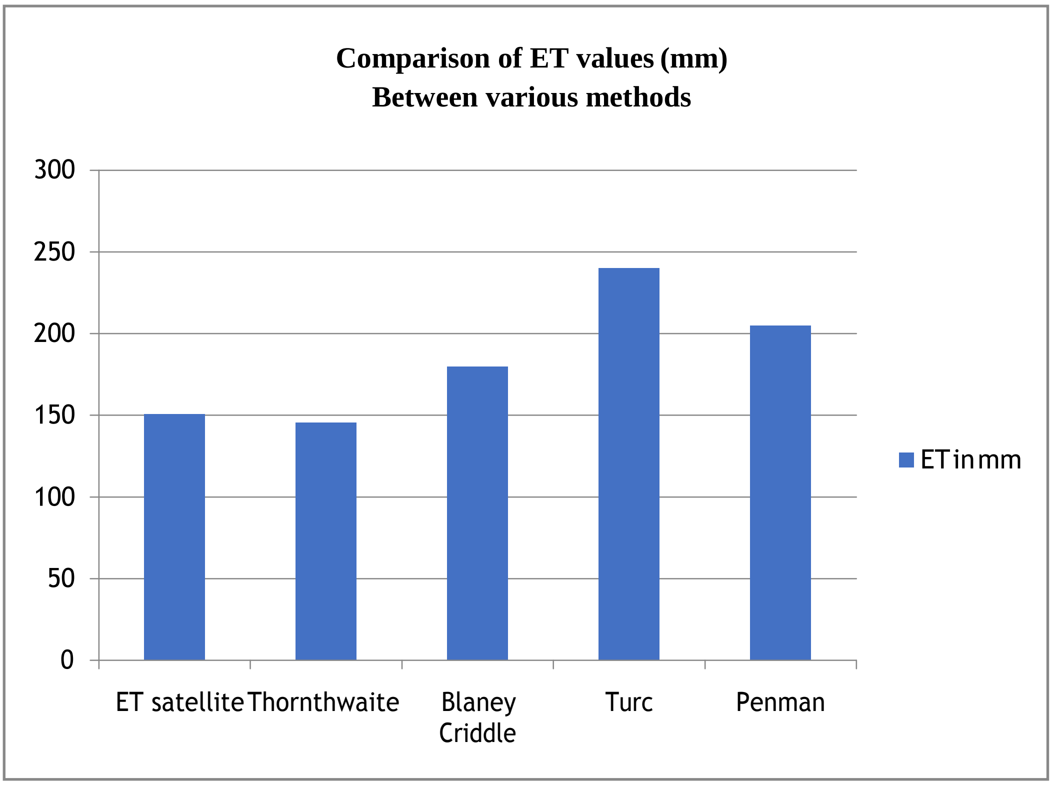
$G/Rn = T / \alpha\ (.0038\ \alpha + .0074\ \alpha^2)\ (1 - .98\ NDVI^4)\ (W/m^2)$ …..(3)

Where; Ts is the surface temperature (o C), α is the surface albedo, and NDVI is NORMALIZED DIFFERENCE VEGETATION INDEX

OUTPUT



Comparison between monthly ET with other empirical methods



VIII. CONCLUSIONS

Hence we conclude that the built-up areas have low ET values where as when compared with the areas of vegetation and the areas surrounded by the lake has high ET values. The ET values from the satellite image (LANDSAT 7 ETM) estimated more accurate when compared with values from empirical methods. SEBEL can compute ET for flat, agricultural areas with the most accuracy. Therefore we can conclude that the Monthly ET values can be extrapolated using reference ET to obtain seasonal ET values.

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