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Estimation of Arecanut Crop Evapotranspiration Rate using Remote Sensing

Bhojaraja B.E, Anaswara Das S R, Amba Shetty

Abstract*: Arecanut is a plantation crop sustains for decades and its crop water demand varies with the age. For scheduling and management of irrigation water, crop water requirement information is important. To calculate the crop water requirement, estimation of evapotranspiration is crucial. The term Evapotranspiration (ET) refers to transport of water molecules into the atmosphere from soil (soil evaporation) and vegetation (transpiration) surfaces. It is a most important component of hydrological cycle and also the most difficult factor to quantify. Crop water need is the amount of water required for balancing loss due to evapotranspiration. There are different methods proposed by researchers for the estimation of evapotranspiration. The conventional methods of evapotranspiration estimation from ground data are tedious. The advancement in remote sensing data provides estimation of evapotranspiration in a global scale. The invention of thermal remote sensing has benefitted greatly since it reduces the field data requirement for estimation of ET. It also helps to understand spatial distribution of landmass and different estimates also in estimation of evapotranspiration over a larger extent timely and periodically. In this study to estimate Arecanut crop evapotranspiration Hargreaves Samani, Penman Monteith and Priestly Taylor methods were used and compared. Arecanut crop evapotranspiration rate estimated form Landsat 8 and MODIS data are showed similar range of values between 3 to 4.45 mm/day. The study area covers an area of 835.3 hectares of Arecanut crop and the gross crop water need is found to be 23059 m^3.

***Keywords* : Arecanut crop, Age based crop water requirement, Classification, Evapotranspiration..**

I. INTRODUCTION

Arecanut plays an important role in India's economy; India is the largest grower as well consumer of Arecanut. The crop stands for decades and requires irrigation throughout its life span. There is a lack of technical knowledge in irrigation water demand of the crop to the farmers. This issue needs to be addressed for sustainable agriculture. Estimation of precise quantity of irrigation water demand is crucial for water resources management and to produce improved crop yield. For the efficient planning of available water, timely and to map accurately total area, crop under different age groups and crop in stress condition are some of the inputs (Bhojaraja et al., 2015).

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Crop Water Requirement –CWR is the depth (or amount) of water required to fulfill the water loss through evapotranspiration (FAO). Usually crop water requirement (CWR) of a particular crop is expressed in water depth per unit area. The major parameters influence crop water need is climate, crop type, growth stage and also age of the crop.

The Evapotranspiration (ET) is a most important component of hydrological cycle and also the most difficult factor to quantify. There are different methods proposed by researchers for the estimation of evapotranspiration. The conventional methods evapotranspiration estimation from ground data is tedious. The advancement in space borne remote sensing data provides estimation of evapotranspiration in a global scale. The invention of thermal remote sensing has benefitted greatly since it reduces the field data requirement for estimation of ET. It also helps to understand spatial distribution of landmass and different estimates along with estimation of evapotranspiration over a larger extent timely and periodically. To estimate Arecanut crop evapotranspiration Hargreaves Samani, Penman Monteith and Priestly Taylor methods were used and compared in the study.

The study focuses to estimate the Arecanut Crop Water Requirement. To quantify Arecanut crop water requirement one of the important parameter is evapotranspiration. The ET can be calculated using numerous methods according to the availability of data. Though FAO Penman-Monteith method is known as the most accurate method, it has limitations of requirement huge number of meteorological parameters.

In such cases the other methods like Hargreaves-Samani method can be used which requires limited data and also the Priestly-Taylor method which uses the radiation data only for the estimation of ET.

II. STUDY AREA

A. Selection of study area

Small portion of Chennagiri taluk panchayat of Davanagere district of Karnataka, India is selected for the study. Fig.1 depicts the location map of the area under study. In the selected area majorly grown crop is Arecanut; hence locally it is popular as land of Arecanut. The Study area lies between $14^0$01'45'', $13^0$57'00''N latitude and $75^0$57'15'' and $75^0$59'15''E longitude. It covers an area of 3175.2 hectares. Chennagiri is located at a height of 662 m above MSL.

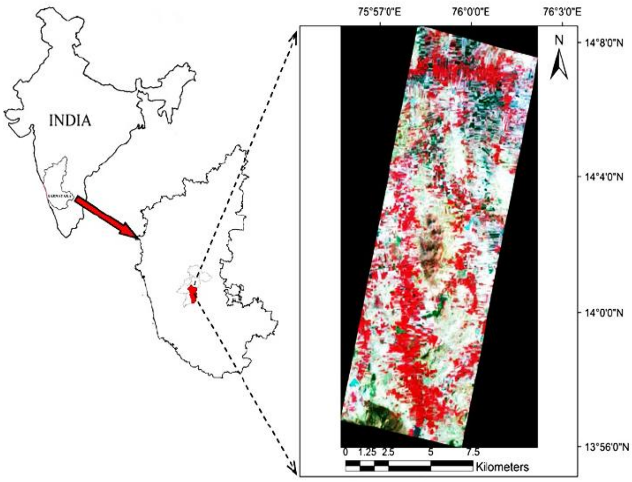

Fig. 1 Geographical Location of area under study

During summer temperature varies between 28°C to 40°C. It falls under semi-arid region and records 808 mm of average annual rainfall. Bore well water is the main source of water in the form of drip irrigation is followed in this region.

B. Data Used

MODIS, Landsat 8 and meteorological data of 21st and 17th January 2014 data were used in the study. For the altitudinal correction of land surface temperature data ASTER DEM acquired on 2011 October was used.

The Landsat 8 satellite consists of quantized and calibrated scale DN values with the resolution of 30m. It has 11 numbers of bands including panchromatic and thermal bands. The band 10 and 11 are thermal bands which gives the temperature variation in each object of image. The thermal bands were utilized for the derivation of land surface temperature, which is an essential parameter in calculation of the evapotranspiration.

MODIS data is used for obtaining land surface reflectance and land surface temperature respectively as proposed by the Hall et al. (2002)

ASTER global DEM by NASA of resolution 30m is used for altitudinal correction of land surface temperature.

Meteorological data of the study area were also collected to calculate evapotranspiration. It includes wind speed, minimum and maximum temperature, solar radiation, and humidity. Table 1 shows the meteorological data of 17th and 21st January 2014.

Ground truth data of the study area were collected using GPS.

Table 1: Climatological data

Date	17/1/2014	21/1/2014
Maximum temp. (°C)	30.02°C	30.40°C
Minimum temp. (°C)	14.72°C	16.31°C
Elevation (m)	886	886
Humidity (%)	70.06	43.85
Wind speed (ms-1)	0.92434	2.9995
Solar radiation (MJ/m2/day)	16.809	21.278

C. Methodology

The methodology adopted for the study is shown in the following flow chart (figure 2).

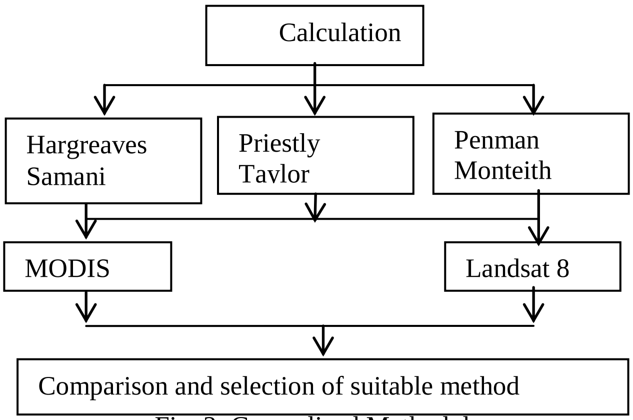

Fig. 2: Generalized Methodology

D. Pre-processing

The pre-processing of Landsat image includes, layer stacking, DN to reflectance conversion and resizing. The band 10 and band 11 of Landsat imagery provides thermal data. In order to convert it to land surface temperature, few mathematical calculations were carried out using band math operation.

For the pre-processing of MODIS data MODIS Re-Projection Tool (MRT) was used. It normalizes the data products and converts to standard format. The ASTER DEM data is mosaicked for covering the whole study area and then resized to the actual size of area. The DEM data are used for topographic correction of land surface temperature value.

E. Estimation of temperature

The land surface temperature is calculated using land sat data as per the procedure given by Sobrino (2004).

F. Estimation of evapotranspiration

In this study, three approaches have been used for the assessment of evapotranspiration namely, FAO Penman-Monteith, Priestly-Taylor and Hargreaves-Samani. These methods are commonly used and compared to other available methods, and it follows some arithmetic procedure for obtaining ET which uses climatological data. The main difference between these three algorithms are amount of data requirement.

FAO Penman Monteith method, though it is known as the most accurate method require huge amount of data including meteorological data. The equation uses standard climatological record of solar radiation (sunshine), air temperature, humidity and wind speed. FAO Penman Monteith method for estimation ET_o as proposed by Allen et al. (2006) is implemented for the study.

Computational data requirement for ET_o is as per the FAO-56 procedure. The climatological data is obtained from meteorological department. Since FAO-PM method uses climatological data which varies from day to day, ET was computed for both 17th and 21st January 2014 days of Landsat and MODIS data. ET_0 can be estimated using minimum climatological data proposed by Hargreaves Samani (1982) . The Priestly Taylor method can be defined as the completely satellite based method since it only depends on the radiation. The data requirement for PT method can be achieved through satellite data alone.

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The satellite data with thermal bands can be used for this method. Landsat 8 OLI-TIRS and MODIS based MOD11A1 provides thermal bands which can be used for derivation of land surface temperature which is an essential parameter for obtaining ET.
The assumptions made in the proposed equation by Jury (1975) have been validated by a review of studies and concludes that the vegetated areas with little water deficits, around 95% of evaporated demand are provided by radiation (Stagnitti et al *1984*).

III. RESULTS

The evapotranspiration value computed by FAO Penman Monteith method using parameters such as maximum and minimum temperatures, humidity, wind speed, sunshine hour, precipitation, solar radiation etc. The FAO-PM method was carried out for 17^{th} and 21^{st} January 2014 Landsat 8 and MODIS data respectively. ET value for 17^{th} January was 3.26 mm/day and for 21^{st} January it was 4.096 mm/day respectively.

Similarly using the minimum amount of data, Hargreaves Samani method of evapotranspiration calculation was carried out. The obtained value of was 4.16 mm/day for 21^{st} January and 4.45 mm/day for 17^{th} January. This method has given highest ET_0 values among three methods.
Priestly-Taylor method was completely satellite based method which uses thermal bands to obtain evapotranspiration. The Landsat 8 OLI-TIRS and MODIS bands were used. The MODIS, MOD11A1 directly provides land surface temperature over the area whereas for Landsat, land surface temperature can be derived from thermal bands with simple procedure. The obtained value of land surface temperature in kelvin from Landsat 8 is presented in the following figure no 3. The figure 4 shows the ET_0 values obtained from Landsat based PT method and the values ranges 0.8 to 3. Fig. 5: Shows ET value from MODIS based PT method and the value ranges 0.1 to 3.
Matlab coding was used for the calculation of various parameters for the estimation of evapotranspiration.
It was found that the obtained evapotranspiration maximum values are 3.0 mm/day from Landsat data and 3.067 mm/day from MODIS data.
Evapotranspiration values were computed for different data sets with three different methods namely FAO-PM, Priestly Taylor and Hargreaves Samani. The comparison of the results shows the range of ET_0 varies from 3.0mm/day to 4.45 mm/day for the study area. Table 1 shows the comparison of three methods with the different data sets.

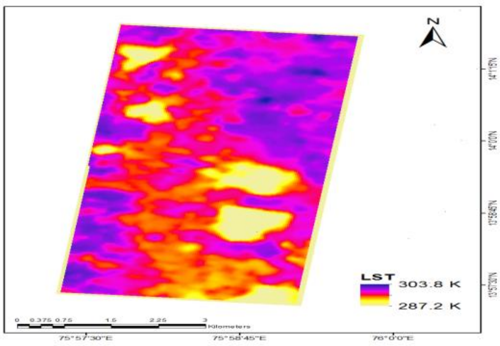

Figure 3: Land surface temperature

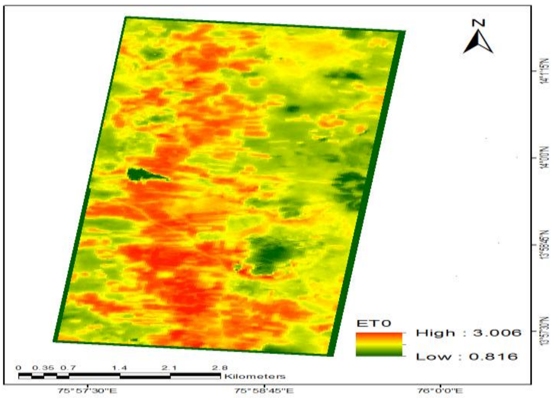

Fig.4: ET value from Landsat based PT method

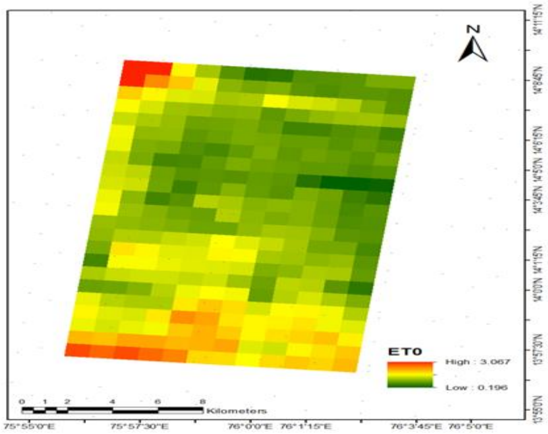

Fig. 5: ET value from MODIS based PT method

TABLE I. Obtained values of evapotranspiration

Method	Data	ET_0 (mm/day)
Hargreaves Samani method	Landsat 8	4.45
	MODIS	4.16
Penman Monteith	Landsat 8	3.26
	MODIS	4.09
Priestly Taylor	Landsat 8	3.0
	MODIS	3.06

Since FAO-PM was selected as a standard method because of its universal acceptance and the value obtained were validated by other methods, it may be selected for estimation of crop water need.

IV. CONCLUSION

Evapotranspiration is calculated using Penman Montieth, Hargreaves Samani and Priestly Taylor method. From the analysis ET_0 is in the range of 3 to 4.45 mm/day. ET_0 value of 4.09 mm/day from Penman Monteith method.
Arecanut crop evapotranspiration rate estimated form Landsat 8 and MODIS showed similar range of values between 3 to 4.45 mm/day. The study area covers an area of 835.3 hectares of Arecanut crop and the gross crop water need is found to be 23059 m^3.

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Dr. Bhojaraja B.E., Obtained his B.Tech degree from SIT-Tumkur, and M.Tech , Ph.D from NITK-Surathkal. He has 3 year of teaching experience currently working as an assistant professor in the Dept. of civil engineering of NMAMIT-Nitte Udupi Karnataka. He has several publications in reputed International journals and international, national conference proceedings.

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