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Evapotranspiration and LST Mapping for Drought Monitoring using Remote Sensing Indices and Water Balance

CHINMAY TR, HARSHAVARDHAN SB, MANU HS, SHASHANK J

Department of Civil Engineering, Dayanand Sagar Academy of Technology and Management (DSATM), Kanakapura Road, Bangalore, India

ABSTRACT: Monitoring and assessing the remote sensing indices along with Evapotranspiration mapping (ET) and land surface temperature (LST) gives more precise and accurate results to mitigate and predict the future. In hydrology and Irrigation systems, ET mapping is one of the important components of monitoring environmental conditions. Identifying the damage, as the identification of damage factors, quotients are true to be quantified to assess the situation. Drought monitoring, crop monitoring, and crop yield are the resultant factors of the entire monitoring system. Global warming and food security are the present concerns to predict the future and secure the future for the next generations. This paper concentrates on how ET is affecting soil moisture and how ET is affected by LULC cover. The process also involves estimating the relationship between energy-water balance and ET along with LST maps, considering the carbon dioxide assimilation in plants. Landsat data is used to map ET and LST along with a few indices along with LULC by SVM (support vector machines) method. This monitoring method using water balance and remote sensing-based ET and LST maps will help identify the radiance between the surface and subsurface. Radiant energies can be estimated between the surface heat and water flux to identify the primary causes behind the occurrence of drought. Monitoring the drought in rain shadow regions by analyzing hydrological components is essential to achieving a sustainable environment and food security.

KEYWORDS: Algorithms, Evapotranspiration, Radiometric, Radiation, Remote sensing

I. INTRODUCTION

- Evapotranspiration (ET) is an essential component of the water cycle that connects hydrologic and biological processes. It is directly affected by water and land management, land-use change, and climate variability. Therefore, estimation of ET in vast areas using efficient tools is important for optimum water resources management over different land-use systems.
- The knowledge of ETA and its spatial distribution can have great potential to develop new cost-effective indicators of irrigation performance and increase water use efficiency.
- The ET can be estimated using many methods and techniques such as lysimeters, sap flow, eddy covariance, Bowen ratio, scintillometer, etc. Remote sensing and biophysical modeling are adequate techniques for evaluating ET patterns over large-scale regions.

II. REVIEW

Satellite-based regional-scale evapotranspiration estimation mapping of the rice bowl of Tamil Nadu: A little water to spare (2020): Estimation and mapping ET using a vegetation index coupled with a crop coefficient method over the famous rice bowl region of Tamil Nadu, India. Utilization of a very high-resolution satellite- Sentinel (10 m). The study is based on crop coefficient-NDVI- based ET estimation

Evapotranspiration mapping for agricultural water management: An overview(2013): Estimation of crop water use at both field and regional scales using remote sensing based agro-meteorological models. Studies on developing numerous ET algorithms to use remote sensing data acquired by sensors on airborne and satellite platforms.

Drought monitoring over India using multi-scalar standardized precipitation evapotranspiration index(Received 8 February 2018, Accepted 14 June 2019): The main objective of this study was to accommodate evapotranspiration along with a spatial variation of precipitation which gives an integral conclusion of the atmospheric need of soil moisture for the occurrence of precipitation

Drought Assessment Over India using RCMs with Standardized Precipitation and Evapotranspiration Index(10-14dec 2018): To evaluate the performance of RCMs in simulating the historical and future drought characteristics over India with Standardized Precipitation Evapotranspiration Index (SPEI) as the drought index

Drought Assessment By Evapotranspiration Mapping In Twente, The Netherlands (Feb 2012): Standardized precipitation index (SPI) and The Palmer Drought Severity Index (PDSI) are commonly used indices for monitoring drought in Netherland Ugyen Eden

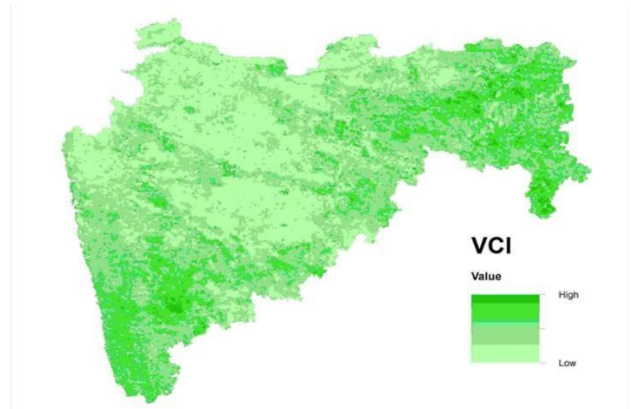
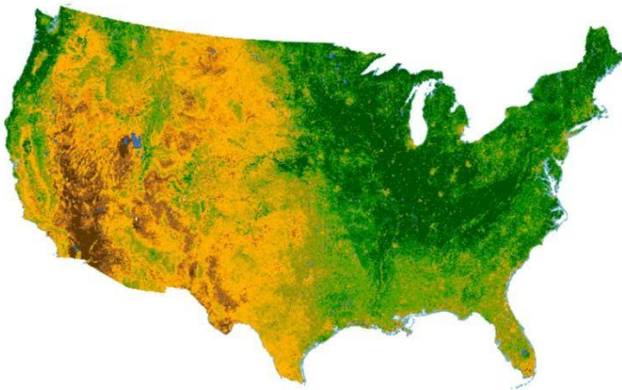
Mapping crop evapotranspiration by integrating vegetation indices into a soil water balance model (27 June 2014): the basal crop coefficient (Kcb) derived from vegetation indices (VIs) with the daily soil water balance, as proposed in the

FAO56 paper, to estimate daily crop evapotranspiration (ETc) rates of orange trees it predicts ETc and Kc as a function of weather data, stage of crop development and water availability could be a useful and low-cost tool for estimating crop water requirements and enhancing water management in those areas afflicted by limited water availability. Consoli * D. Vanella

NDVI:“Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).”

NDVI always ranges from -1 to +1. But there isn’t a distinct boundary for each type of land cover.

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$



Vegetation Condition Index (VCI):

The Vegetation Condition Index (VCI) compares the current NDVI to the range of values observed in the same period in previous years. The VCI is expressed in % and gives an idea of where the observed value is situated between the extreme values (minimum and maximum) in previous years. Lower and higher values indicate bad and good vegetation state

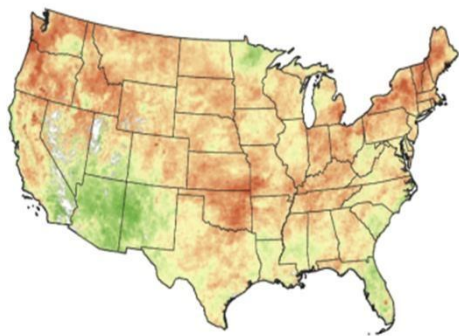
conditions, respectively. VCI varies from 0 for extremely unfavorable conditions, to 100 for optimal. Formula: $VCI = 100 * (NDVI - NDVI \text{ min}) / (NDVI \text{ max} - NDVI \text{ min})$ (Kogan, 1990) NDVI max and NDVI min are multiple year maximum NDVI and minimum NDVI for a pixel concerning a specific climatology

infrared (NIR – MODIS band 2) and the short-wave infrared (SWIR – MODIS band 6) reflectance

Calculation of NDWI: The NDWI is a remote sensing-based indicator sensitive to the change in the water content of leaves (Gao, 1996). NDWI is

$$NDWI_t = \frac{NIR_t - SWIR_t}{NIR_t + SWIR_t}$$

computed using the near-



$$Z_{Ratio} = \frac{Ratio - \overline{Ratio}}{\sigma_{Ratio}} \tag{2}$$

We derive the standardized NDVI (Z_{NDVI}) for each composite period during the classified growing season at each grid cell as

$$Z_{NDVI} = \frac{NDVI - \overline{NDVI}}{\sigma_{NDVI}} \tag{3}$$

The Z_{Ratio} and Z_{NDVI} terms are then summed as

$$Z = Z_{Ratio} + Z_{NDVI} \tag{4}$$

The remotely sensed DSI is finally calculated as the standardized Z value as

$$DSI = \frac{z - \bar{z}}{\sigma_z} \tag{5}$$

Chitradurga has a geographical area of 8388sqkm, It has 6 taluks. It has mixed red and black soil It receives low to moderate rainfall and it’s a drought-prone area Annual rainfall varies between 668mm in hillwalker in the western part to 487mm in challakere in the Northern part. The major part of the district lies in the Krishna basin and is drained by the vedavathi river. The district has failed to receive ample rainfall for 6 consecutive years. This year the region is facing 75 percent rain scarcity. Due to the large consumption of groundwater in the area, the groundwater table is depletion The Chitradurga district faced deficit rainfall from 2002 to 2004. it was reported that a total of 101 farmers committed suicide in the district between 2003 to 2007 (45 suicide cases due to crop failure)

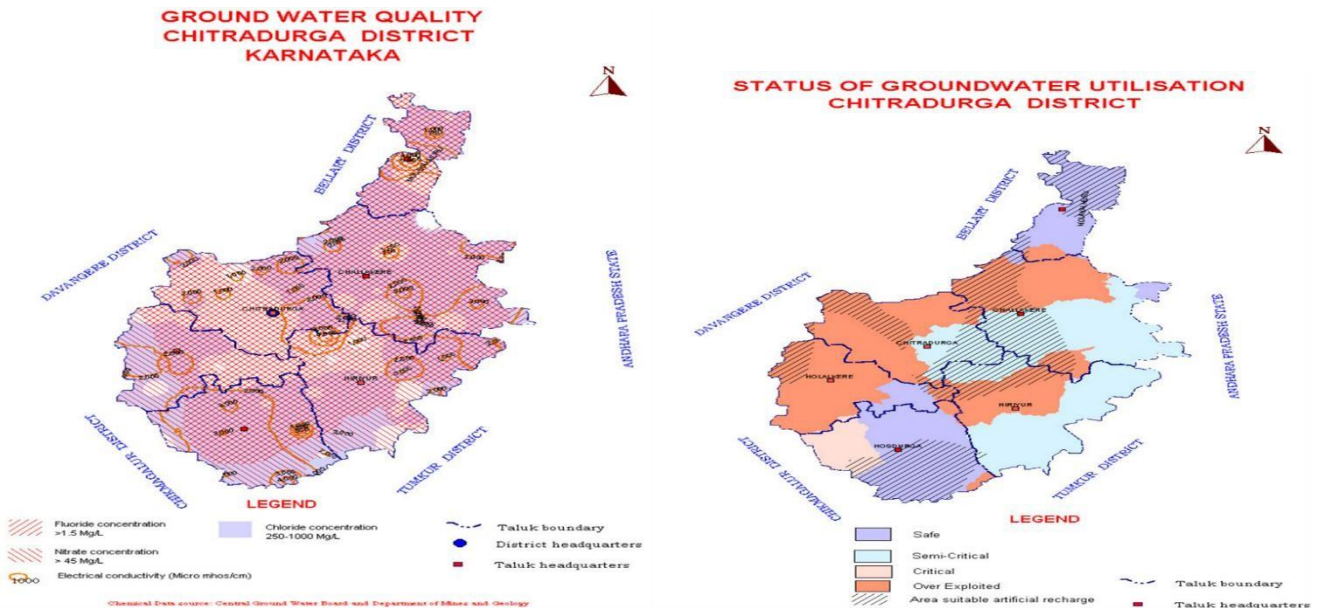
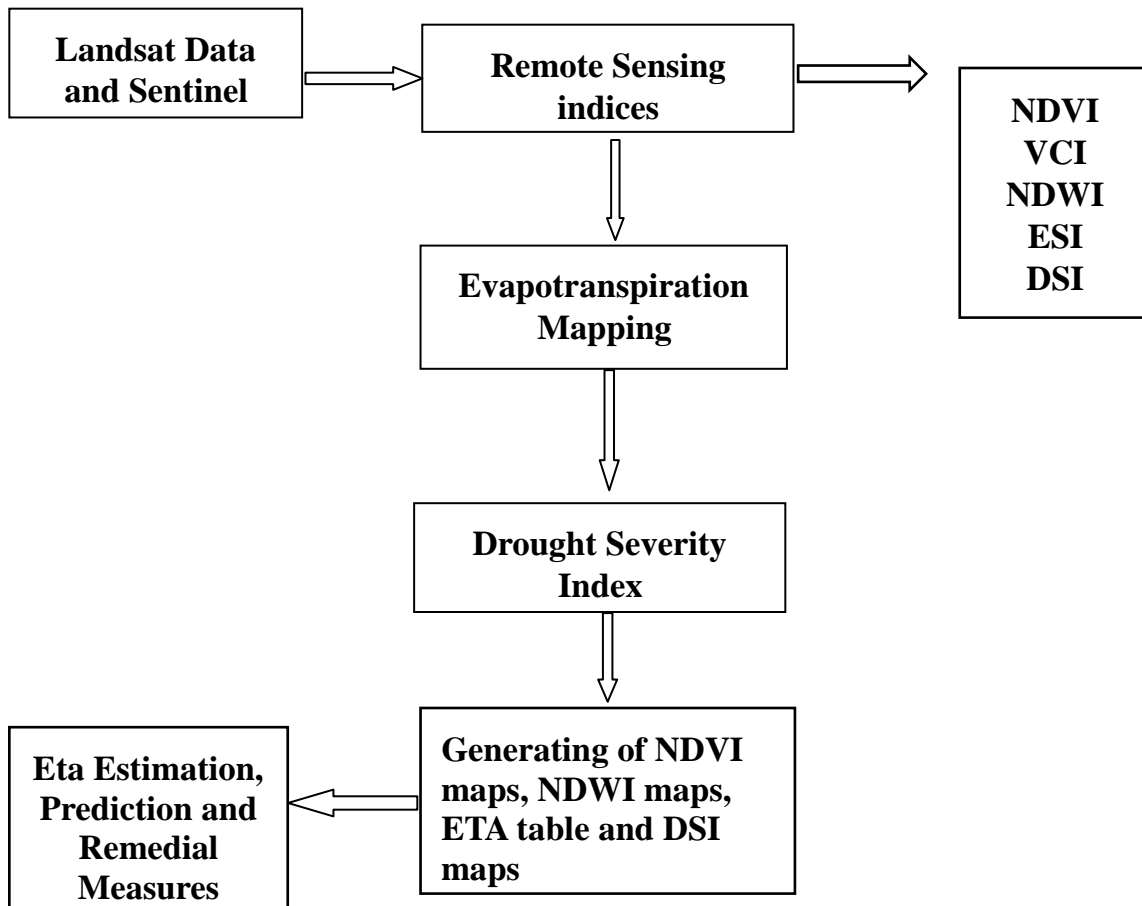


Table 1: Data on suicide of farmers.

Sl. no	Taluks	2003-04			2004-05			2005-06			2006-07			Total		
		Total cases reported	Due to Crop loss	Due to other reasons	Total cases reported	Due to Crop loss	Due to other reasons	Total cases reported	Due to Crop loss	Due to other reasons	Total cases reported	Due to Crop loss	Due to other reasons	Total cases reported	Due to Crop loss	Due to other reason
1	Challakere	08	-	08	04	01	03	-	-	-	02	02	-	14	03	11
2	Chitradurga	15	05	10	07	02	05	04	03	01	02	02	-	28	12	16
3	Hiriyur	14	04	10	01	-	01	-	-	-	08	08	-	33	12	11
4	Holalkere	13	06	07	03	-	03	-	-	-	05	05	-	21	11	10
5	Hosadurga	05	01	04	04	01	03	04	03	01	02	02	-	15	07	08
6	Molakalmuru	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	55	16	39	19	04	15	08	06	02	19	19	-	101	45	56

III.METHODOLOGY



V.CONCLUSION

Using observation and reanalysis data, we created a drought index based on the distinction between AET and PET, and we used a percentile technique to establish the classifications.

We evaluated SEDI's performance in comparison to soil moisture, three widely used drought indicators (scPDSI, SPI, and SPEI), and other variables. We verified that SEDI's capacity to explain drought evolution as a whole and its sensitivity to vegetation change as a result of drought evolution. These key findings from this study can be summed up as follows: Particularly across arid and semi-arid regions, SEDI can fairly record dry and wet climate fluctuations. SPI, SPEI, scPDSI, and soil moisture all exhibit similar interannual changes and long-term trends with SEDI. Additionally, SEDI can identify extreme drought events at scales ranging from monthly to annual. SEDI has a strong ability to correlate signals of dry and wet climatic fluctuations with changes in vegetation. Additionally, although SEDI is linked to soil moisture, it also involves energy and water balance processes that can be used to describe how vegetation responds to water stress conditions.

This study reveals that SEDI is more useful in identifying indications of biological consequences in climatic droughts than precipitation and temperature indicators. In order to forecast probable future changes in regional ecological settings, we will quantify the link between dry and wet change and ecological processes.

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