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Cotton vegetation condition monitoring using LSWI and NDVI

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Abstract

This study aims to assess late-season agricultural drought in cotton growing Surendranagar district of Gujarat, India during *Kharif* cropping season 2015. Persistent abiotic (i.e. Moisture deficits and nutrient deficiency) during flowering and yield formation stage are stress referred to as late-season agricultural drought. Satellite-based indices like the Normalized Difference Vegetation Index and Land Surface Water Index from landsat-8 satellite data were analyzed. The analysis was carried out by comparing the satellite-derived indices with the previous normal years, and the assessments were made. The satellite-based indices clearly brought out the stress that crop endured during September, while LSWI indicated soil and crop water stress in early September. The result showed that NDVI and LSWI satellite based Vegetation indices which help to derived drought or stress affect cotton crop at critical growth stage very well.

Keywords: Cotton vegetation, LSWI and NDVI, *Kharif*

Introduction

Enhancing the efficiency of farm inputs without negatively impacting profitability or the environment has been a primary focus of precision agriculture research for quite some time. Plant production has to meet considerably mounting demands in the future. Expanding global markets and the competition of food and non-food uses require further significant progress in productivity levels. In India as well as globally, increased production will have to be achieved on the same or decreasing area of arable land. Need to maintain or improve an increased efficiency per unit area is required. At the same time, climatic changes may aggravate the conditions of growth in less favorable locations. Thus, the scenario which agriculture facing is further intensified the crop rotations with a limited number of high-yielding crops for the food or raw materials market, under aggravated climatic conditions. Altogether, these developments will result in a significant increase in problems caused by different stresses, which will inevitably limit yield levels. To overcome on this problem, there is a need to spatial and timely monitoring of crop season (F. Feldmann, D. V. Alford, c. Furk (eds.) 2009) [7].

Cotton (*Gossypium hirsutum* L.) belongs to the family Malvaceae. Cotton is a potentially important commercial crop and plays a vital role in the textile industry in India. The history of cotton production in India has spanned a period of more than seven decades. Gujarat is the leading cotton producing state, near about 35% production and area of cotton in Gujarat. Area of cotton in Gujarat 26.18 lakh ha and production is 104 lakh bales of 170 kg and cotton Productivity 675 kg ha^{-1}. In India, cotton is grown in about 122.35l lakh ha and production 377 lakh bales of 170 kg (ICAR-All India Coordinated Research Project on Cotton – Annual Report (2017-18). It is obvious that growth and development of cotton has to face one or other stress entities under rainfed. Cotton physiology portrays unique indeterminate growth habits with longer crop duration which make cotton vulnerable to abiotic and biotic stress influences from emergence to senescence. The adverse effects on the ongoing physiological processes may affect yield projection trends leading to production lapses, inadequacies and may become the focal point of attention. Cotton crop is one of the important cash crops and raw material for textile industry. It is very sensitive for water stress condition. If drought or any stress occurs during its critical growth stage i.e. maximum flowering to boll formation stage, it adversely effects on yield of crop. Environmental stress conditions such as drought, heat, salinity, cold, or pathogen infection can have a devastating impact on plant growth and yield under field conditions. Water stress is important cause for adverse yield in agriculture. Drought is one of the important factors which effect on yield directly or indirectly such condition demand timely and site specific crop monitoring. Satellite gives us chance for near-real time drought monitoring approach on crop condition using different vegetation indices.

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The objective of the study is to correlation of vegetation indices derived by satellite data with different plant parameter at critical growth of Cotton crop.

Study Area

Area is selected for study is Surendranagar, one of the important cotton producing district in Gujarat state of India. The chief agricultural product of Surendranagar district is cotton. In fact Surendranagar district is one of the highest quality producers of cotton in world. First private cotton future trading exchange was established in Surendranagar. Surendranagar is situated between 22° 43'N Latitude and 71° 43'E Longitude. Surendranagar is surrounded by North side: Patan and Kutch, South: Bhavnagar, East and South East, West and South West: Rajkot District, Gujarat. Surendranagar district has found wide range of soil type such as alluvial soil, sandy land of thin layer, medium type black and loamy soil and less fertile land with thin layer. Medium type black soil is found here and there. As the land is able to absorb moisture and sticky. Climate of Surendranagar is too hot in summer. Summer highest day temperature lies between 33 °C to 43 °C. Average temperatures of January 22 °C, February 24 °C, March 29 °C, April 32 °C, May 35 °C. Average annual rainfall of area is 500-600 mm per annum. Major crops grown in area *viz*., Cotton, Green gram, Sesamum and Wheat.

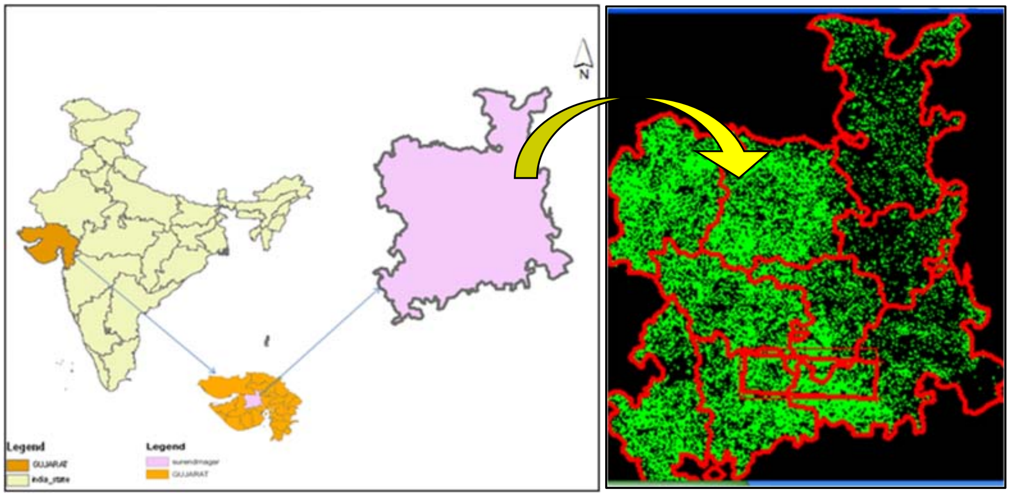

Fig 1: Map of study area and cotton area masked

Methodology

Here we are using the Landsat image acquired from USGS Earth Explorer. The data is in Geo-Tiff format with 16 bit radiometric resolution (ranges from 0-65535). Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. The resolution for Band 8 (panchromatic) is 15 meters. In addition, it also has two Thermal IR bands with a spatial resolution of 100 m (later re-sampled into 30 m). Before calculating the NDVI and LSWI the DN data must be converted to reflectance using the equations given in their website*http://landsatlook.usgs.gov*. Here the IR and NIR bands are 4 and 5, respectively (Francesco Pirotti *et al*., 2014) [8].

Table 1: Bands and wavelength of Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)

Bands	λ(μm)
Band 1- Coastal aeroso	1 0.433 - 0.453
Band 2-Blue	0.450 - 0.515
Band 3- Green	0.525 - 0.600
Band 4- Red	0.630 - 0.680
Band 5- Near Infrared	0.845 - 0.885
Band 6- SWIR	1 1.560 -1.660
Band 7- SWIR	2 2.100 -2.300
Band 8- Pan	0.500 - 0.680
Band 9- Cirrus	1.360 - 1.390
Band 10- TIRS 1	10.60 - 11.19
Band 11-TIRS 2	11.50 - 12.51

The following equation is used to convert DN values to TOA reflectance for OLI image:

$$\rho\lambda' = M\,\rho Q\,cal + A\,\rho$$

Where:

ρλ=TOA planetary reflectance, without correction for solar angle. Note that ρλ' does not contain a correction for the sun angle.

Mρ=Band-specific multiplicative rescaling factor from the metadata (Reflectance_Mult_Band_x where x is the band number)

Aρ=Band-specific additive rescaling factor from the metadata (Reflectance_Add_Band_x where x is the band number)

Q cal =Quantized and calibrated standard product pixel values (DN)

Reflectance with a correction for the sun angle is then:

$$\rho\lambda = \frac{\rho\lambda'}{\cos\theta SZ} = \frac{\rho\lambda'}{\sin\theta SE}$$

Where:

ρλ = TOA planetary reflectance

θSE = Local sun elevation angle. The scene center sun elevation angle in degrees is provided in the metadata (Sun Elevation).

θSZ = Local solar zenith angle; θSZ = 90° – θSE

NDVI and LSWI

Normalized Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index (NDVI) is a measure of the amount and vigor of the vegetation at the surface. The magnitude of NDVI is related to the level of photosynthetic activity in the observed vegetation. In general, higher values of NDVI indicate greater vigor and amounts of vegetation. NDVI is a good indicator of green biomass, leaf area index, and patterns of production. NDVI is computed using Red and NIR bands, which varies from -1 to +1. (Xiaojun Shea *et al*. 2014) [14].

$$\mathrm{NDVI} = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RER}}$$

Where,
ρNIR = reflectance in near infrared band
ρ RED = reflectance in red band

Land Surface Water Index (LSWI)

Studies have been conducted on VIs closely related to canopy water status. The Land Surface Water Index (LSWI) was calculated as the normalized difference between the near-infrared (NIR; 780−890 nm) and the shortwave-infrared (SWIR; 1580 nm−1750 nm) wavelengths.

Land Surface Water Index (LSWI) is sensitive to change in vegetation canopy water content

$$\mathrm{LSWI} = \frac{\rho_{NIR} - \rho_{SWIR}}{\rho_{NIR} + \rho_{SWIR}}$$

Where,
ρNIR = reflectance in near infrared band
ρSWIR = reflectance in short wave infrared band

Ground data collected

From different sites of study area, we collected plant and soil information in the month of September, 2015 at critical stage of plant.

Result and Discussion

No single index can fully describe the multi-scale, multi-impact nature of drought in all its complexity. Hence, all research efforts on drought monitoring and assessment are directed towards developing a composite index through appropriate blending techniques. In order to make it acceptable by a wider section of drought management, the information of drought also needs to be put in simpler terms (Chandrasekhar, K and Sesha Sai, 2015) [6]. Unlike point observations of ground data, satellite sensors provide direct spatial information on vegetation stress caused by drought conditions. Satellite remote sensing technology is widely used for monitoring crops and agricultural drought assessment. Over the last 30 years, coarse resolution satellite sensors are being used routinely to monitor vegetation and detect the impact of moisture stress on vegetation. The NOAA AVHRR NDVI has been extensively used for drought/vegetation monitoring, detection of drought and crop yield estimation (Batista *et al*., 1997; Moulin *et al*., 1998 [3] and Tucker *et al*., 1985) [4].

Monitoring the intensity and the density of the green vegetation, growth be measured using the reflection from the red band and the infrared band. Green vegetation reflects more energy in the near- infrared band than in the visible range. It observe red band more for the photosynthesis process. From Fig.1 reflection of NDVI from cotton field initially shows minimum or less NDVI i.e. in -0.01 to 1 in month of June as just starting of land preparation or sowing of cotton crop. As crop growth increased highest NDVI observed during month of December after that again NDVI started decline as crop harvesting started. The overall trend of NDVI readings for each sensor generally increased with increasing cotton crop growth stage and decline from crop maturity to crop harvesting.

Leaves reflect less in the near-infrared region when they are stressed, diseased or dead. Features like Clouds, water and snow show better reflection in the visible range than the near-infrared range, while the difference is almost zero for rock and bare soil. We analyze the correlation between the plant height, plant nitrogen% observed on dated 13th Sep, 2015, NDVI and LSWI information obtained from vegetation indices extracted from Landsat 8 datasets on same date. Most of studies shown that the thermal infrared is more sensitive to acute water stress than is reflectance in visible, NIR, or SWIR wavelengths. However, the reflective portion of the spectrum and VIs also respond to plant water status when it produces a change in canopy architecture, e.g., wilting or leaf rolling (Jackson and Ezra, 1985; Moran *et al.*, 1989a) [10, 12]

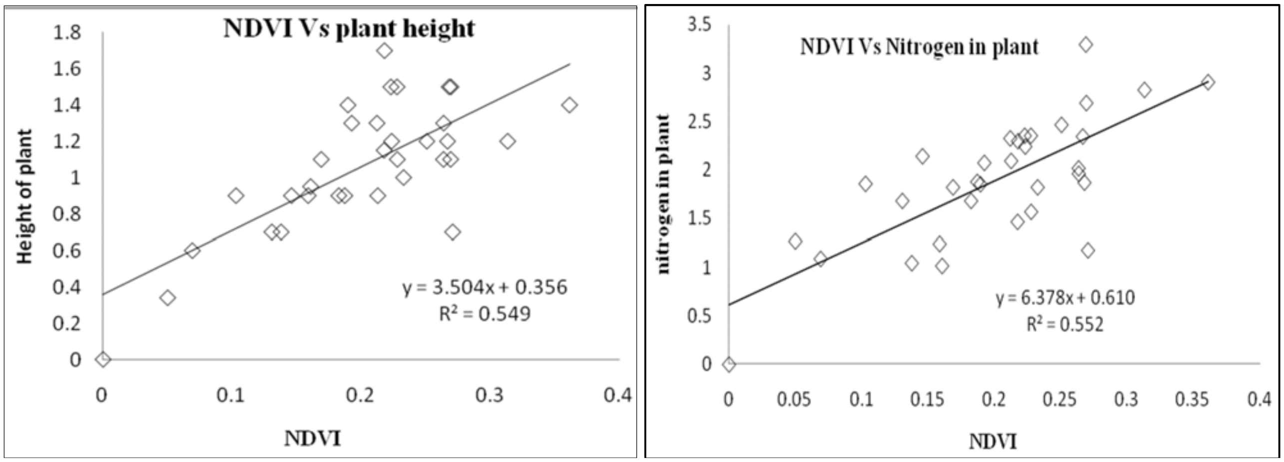

Fig 2: Correlation OF NDVI with plant height and nitrogen uptake by plant

Plant height and Leaf nitrogen content correlates well to the NDVI data that also becomes more accurate as growth stage increases., When we plot graph NDVI obtained from satellite data with ground data recorded on 13th Sept 2015, plant height and nitrogen uptake of cotton crop calculated by Kinjadal method, graph (Fig.2) shows linear correlation between these parameter 0.54 and 0.55 R^2 respectively.

However, maximum NDVI of healthy cotton was 0.743, whereas the maximum NDVI was 0.697 for infected cotton Most of the infected cotton died on average a month before harvest (Mingquan Wu *et al*., 2016) [11], observed highest NDVI of healthy cotton crop field on 13th Sep 2015, was 0.356 is very less. Cotton crop occurs continuously from June to September when the temperature was high and no rainfall at flowering and boll formation critical growth stage in the study area, because of this condition leaves dry and reduction in leaf area and chlorophyll content, this will lead to a reduction of NDVI.

Land Surface Water Index

Due to the large fraction of surface water during the cropping season, reflectance in the short-wavelength infrared (SWIR) range, which is sensitive to water, can be used to record the soil moisture status at the critical growth stage of cotton crop.

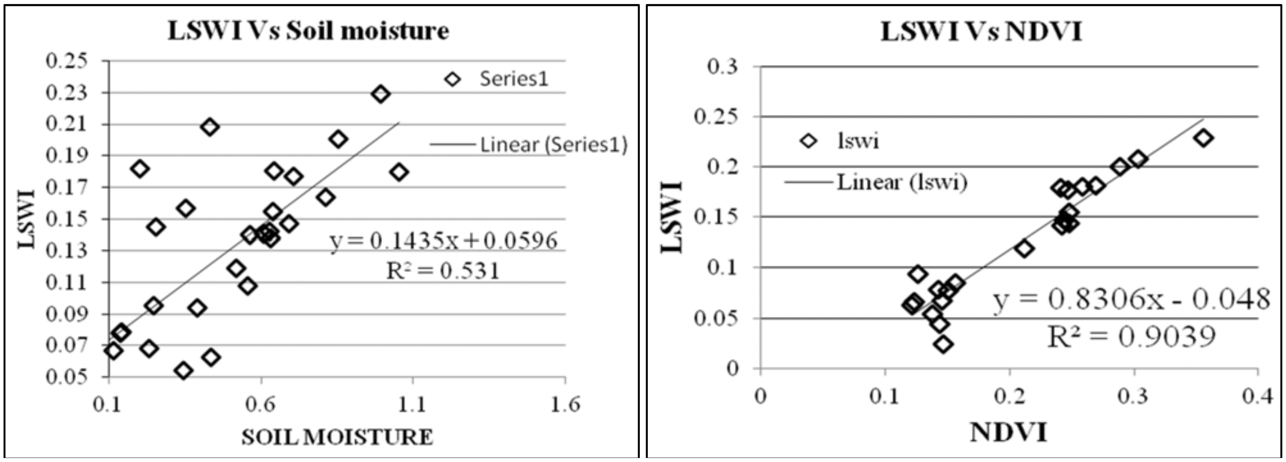

Fig 3: Correlation of LSWI with Soil Moisture and NDVI

The strong linear relationship between the indices is due to the dominant impact of vegetation water content and the non-flooded nature on the observed LSWI in the cotton fields. LSWI of the cotton showed increasing trend with NDVI. Even though LSWI is scattered widely around the linear fit, LSWI increase linearly with NDVI until the NDVI of cotton reached approximately 0.4.The decreasing trend of LSWI with NDVI was observed when crop at maturity stage and soil moisture decreases. From graph (Fig.3) R^2=0.53 when plot LSWI Vs soil moisture and R^2= 0.90 plot LSWI Vs NDVI. LSWI shows linear relation with soil moisture and NDVI of crop.

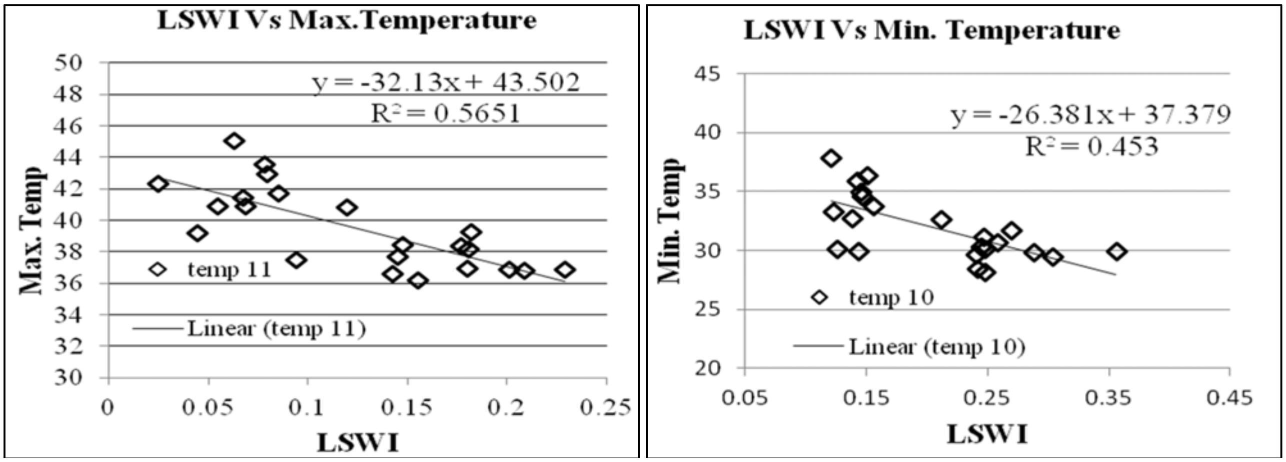

Fig 4: Correlation of LSWI with Max. and Mini. Temperature

From graph (Fig.4) R^2=0.56 when plot LSWI Vs Maximum temperature and 0.45 plot LSWI Vs Minimum temperature. LSWI decreases with increase in temperature as soil moisture decrease.

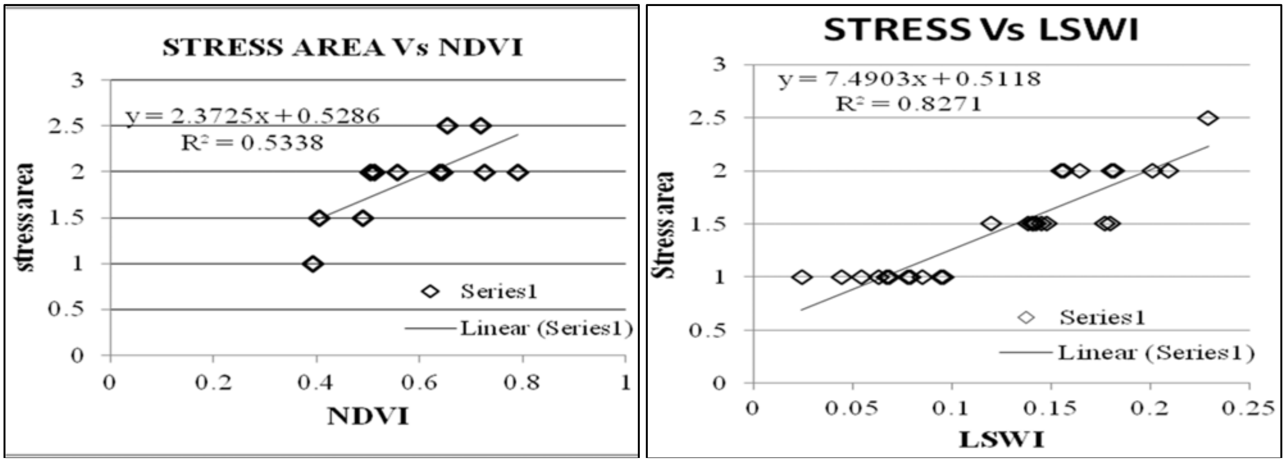

Fig 5: Correlation OF NDVI and LSWI with plant stress area

Normalized difference vegetation index perform exceptionally well when management goals require a quantitative means for tracking green biomass or leaf area index through the season or for detecting uneven patterns of growth within a field (Jackson and Huete, 1991; Wiegand *et al*., 1991) [9, 13]. LSWI was found to correspond well with the drought severities that were defined by the United States Drought Monitor in previous studies. An LSWI-based drought severity scheme is divided into four groups as extreme and exceptional drought (LSWI ≤ -0.1), severe and moderate drought ($-0.1 < \text{LSWI} \leq 0$), abnormally dry ($0 < \text{LSWI} \leq 0.1$), and no drought (LSWI > 0.1) (Bajgain, R., 2015) [2]. During field survey we marked cotton crops which shows stress condition due to lack of may be by nutrient, water, insect pest etc because of these chlorophyll contain of leaves decreases or leaf damaged. Such area marked depending on condition of crop as : less than 1 is very poor,1- poor,2-good and 2.5-very good., However, when we plot graph of NDVI and LSWI obtained from satellite data from such field with observed stress area marked during field survey, its (Fig.6) shows correlation $R^2$0.53 and 0.82 respectively. Graph shows that as moisture stress increases LSWI decreases same trend observed in case of NDVI. Result shows that LSWI and NDVI were played good remote sensing indices to monitor vegetation condition in cotton crop.

Conclusion

Remote sensing is one of best answer for the present problem of drought in growing season of crop. NDVI and LSWI remote sensing indices which help to monitor crop and soil condition and agriculture mid-season drought in many aspects of cotton crop.

References

1. AICRPDA. District wise promising technologies for rainfed cotton based production system in india a compendium of AICRPDA, CRIDA, AICCIP, SAUS, AN AICRPDA contribution. Compiled by K.P.R Vittal, T.P. Rajendran, G Ravindra, Chary, G.R Maruthi Sankart, Sri Jayays, Ramakrishna, J.S. Samra, Gurbachan Singh. All India Coordinated Research Project, Central Research Institute For Dryland Agriculture, Hyderabad 500 059, Andhra Pradesh, India, 2004, 01.
2. Bajgain R, Xiao X, Wagle P, Basara J, Zhou Y. Sensitivity analysis of vegetation indices to drought over two tall grass prairie sites. ISPRS J Photogramm. Remote Sens. 2015, 108:151-160.
3. Moulin SA, Bondeau A, Delecolle R. "Combining agricultural crop models and satellite observations: from field to regional scales, International Journal of Remote Sensing. 1998; 19:1021-1036.
4. Tucker CJ, Townshend JRG, Goff TE. "African land covers classification using satellite data", Science, 227, 369-375. Wang, Lingli., Qu, J. John., Hao, Xianjun and Zhu, Qingping, 2008, "Sensitivity studies of the moisture effects on MODIS SWIR reflectance and vegetation water studies", International Journal of Remote Sensing, 29, 7065-7075. Tucker, C. J. and Chowdhary, B. J., 1987, "Satellite remote sensing of drought conditions", Remote Sensing of Environment, 1985; 23:243-251.
5. Bausch WC, Diker K. Innovative remote sensing techniques to increase nitrogen use efficiency of corn, Communications in soil science and plant analysis, 2001; 32(7-8):1371-1390.
6. Chandrasekar K, Sesha Sai. Monitoring of late-season agricultural drought in cotton-growing districts of Andhra Pradesh state, India, using vegetation, water and soil moisture indices, M.V.R Nat Hazards. 2015; 75:1023.
7. Feldmann F, Alford DV, Furk C. (eds.) Crop plant resistance to biotic and abiotic factors: current potential and future demands. 3rd International Symposium on Plant Protection and Plant Health In Europe held at the Julus Kühn - Institute, Berlin-Dahlem, Germany, 14-16 may, 2009.
8. Francesco Pirottia, Maria Parragab A, Enrico Stuarob, Marco Dubbinib, Andrea Masieroa, Maurizio Ramanzinb. NDVI from landsat 8 vegetation indices to study movement dynamics of capra ibex in mountain areas. the international archives of the photogrammetric, remote sensing and spatial information sciences, volume xl-7, 2014, ISPRS technical Commission Vii Symposium, 29 September – 2 October 2014, Istanbul, Turkey, 2014.
9. Jackson RD, Huete AR. Interpreting vegetation indexes, Preventive Veterinary Medicine. 1991; 11(3-4):185-200.
10. Jackson RD, Ezra SE. Spectral response of cotton to suddenly induced water-stress, International Journal of Remote Sensing. 1985; 6(1):177-185.
11. Mingquan Wu, Chenghai Yang, Xiaoyu Song, Wesley Clint Hoffmann, Wenjiang Huang, Zheng Niu *et al*, Monitoring cotton root rot by synthetic Sentinel-2 NDVI time series using improved spatial and temporal data fusion. Scientific Reports Article number, 2016, 2018, 8.

12. Moran MS, Jackson RD, Raymond H, Gay W, Slater PN. Mapping surface-energy balance components by combining landsat thematic mapper and ground-based meteorological data. Remote sensing of environment, 1989; 30(1):77-87.
13. Wiegand CL, Richardson AJ, Escobar DE, Gerbermann AH. Vegetation indexes in crop assessments. Remote sensing of environment. 1991; 35:105-119.
14. Xiaojun Sheab, Lifu Zhanga, Muhammad Hasan Ali Baigab, Yao Lia. Calculating vegetation index based on the universal pattern decomposition method (VIUPD) using landsat 8, IGARSS 2014, 4734-4737.
15. Annual Report. ICAR-All India Coordinated Research Project on Cotton, 2017-18, 3-4.