Crop Stress Monitoring using Geospatial Technology[1]

Major Steps

1. Selection of study area
2. Download NDVI time series images from May 2016 to May 2022
3. Download available Rainfall Data from May 2016 to May 2022
4. Stress Year Identification to conduct the study
5. Prepare monthly maximum NDVI and stack every month's maximum NDVI images into a single image for the stress year ($NDVI_P$)
6. Prepare monthly maximum NDVI for every year and take the mean of obtained maximum NDVI images of the respective month into a single image. Repeating above for each month and stack 12 months' images into a single image ($NDVI_H$)
7. Difference between $NDVI_H$ and $NDVI_P$ to find the stress areas
8. These stress areas are masked out in the stress year NDVI stack image
9. Conduct unsupervised classification on the NDVI masked image
10. Generating ideal spectra bank and class spectra, and labelling classes using spectral matching techniques (SMT)
11. Grouping and categorizing classes as Mild, Moderate, and Severe stress

Methodology:

The below figure 1 shows the methodology for categorization of stress.

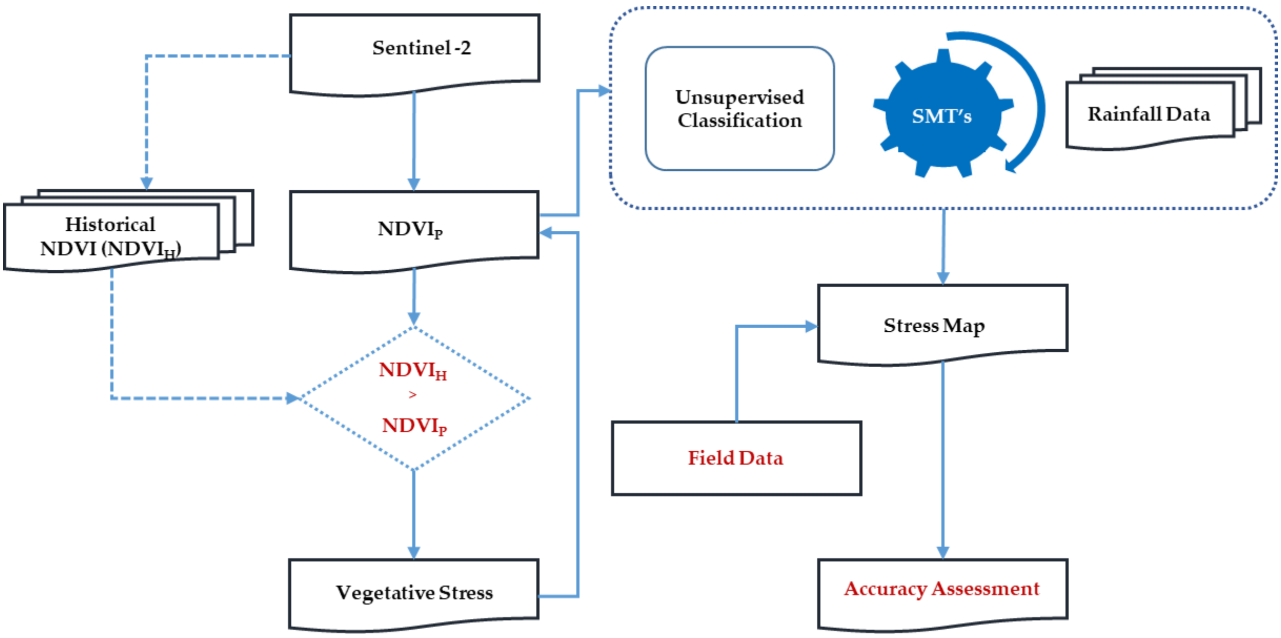

Figure 1: Flow chart showing methodology of identification of stress

[1] Gumma, Murali Krishna, Andrew Nelson, and Takashi Yamano. "Mapping drought-induced changes in rice area in India." *International journal of remote sensing* 40.21 (2019): 8146-8173.

The study starts with creating the monthly maximum value composite (MVC) NDVI images for the entire study period (i.e. from May 2016 to May 2020) (Eq. 1 and Eq. 2)

$$NDVI = \frac{(NIR - \text{Red})}{(NIR + \text{Red})} \quad (1)$$

$$NDVIMVC_i = Max\ (NDVI_{i1}, NDVI_{i2}) \quad (2)$$

"i1, i2" shows images in "i^{th}" month

Then prepare monthly maximum NDVI and stack every month's maximum NDVI images into a single image for the stress year ($NDVI_P$. Prepare monthly maximum NDVI for every year and take the mean of obtained maximum NDVI images of the respective month into a single image. Repeating above for each month and stack 12 months' images into a single image ($NDVI_H$).

The areas with stress were identified using a simple threshold on these seasonal MVCs using 'Equation (3)':

$$NDVI_H > NDVI_P \quad (3)$$

The areas identified above were used as masks for the study year NDVI stack and carried out unsupervised classification using the Iterative Self-Organized class (ISOCLASS) cluster algorithm. The classification was set at a maximum of 100 iterations and a convergence threshold of 0.99. Initially, 15 classes were extracted from the unsupervised classification. Class temporal profiles were generated using ISO CLAS k-means classification of the MFDC. The signature files of the 15 classes were plotted and similar classes were grouped. Classes were further grouped on the basis of decision tree algorithms and spectral matching techniques (SMTs) to match and label the classes with the ideal spectral signatures (Figure 2) for stress categorization[2,3] .

Stress areas were classified into four categories (severe, moderate, mild, and no stress), based on the intensity of stress. NDVI signatures from the four categories based on farmers' responses were used to identify ideal spectral signatures for severe, moderate, mild, and no stress areas.

Stress characterization normally involves the use of an index to describe stress severity or its absence. This study used stress categorization based on the difference between threshold values of maximum NDVI during the season for the selected years and the stress year.

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[2] Thenkabail, P. S., C. M. Biradar, P. Noojipady, V. Dheeravath, Y. Li, M. Velpuri, M. K. Gumma, et al. 2009. "Global Irrigated Area Map (GIAM), Derived from Remote Sensing, for the End of the Last Millennium." International Journal of Remote Sensing 30 (14): 3679–3733. doi:10.1080/ 01431160802698919.

[3] Gumma, M. K., N. Andrew, P. S. Thenkabail, and N. S. Amrendra. 2011a. "Mapping Rice Areas of South Asia Using MODIS Multitemporal Data." Journal of Applied Remote Sensing 5: 053547. doi:10.1117/1.3619838.

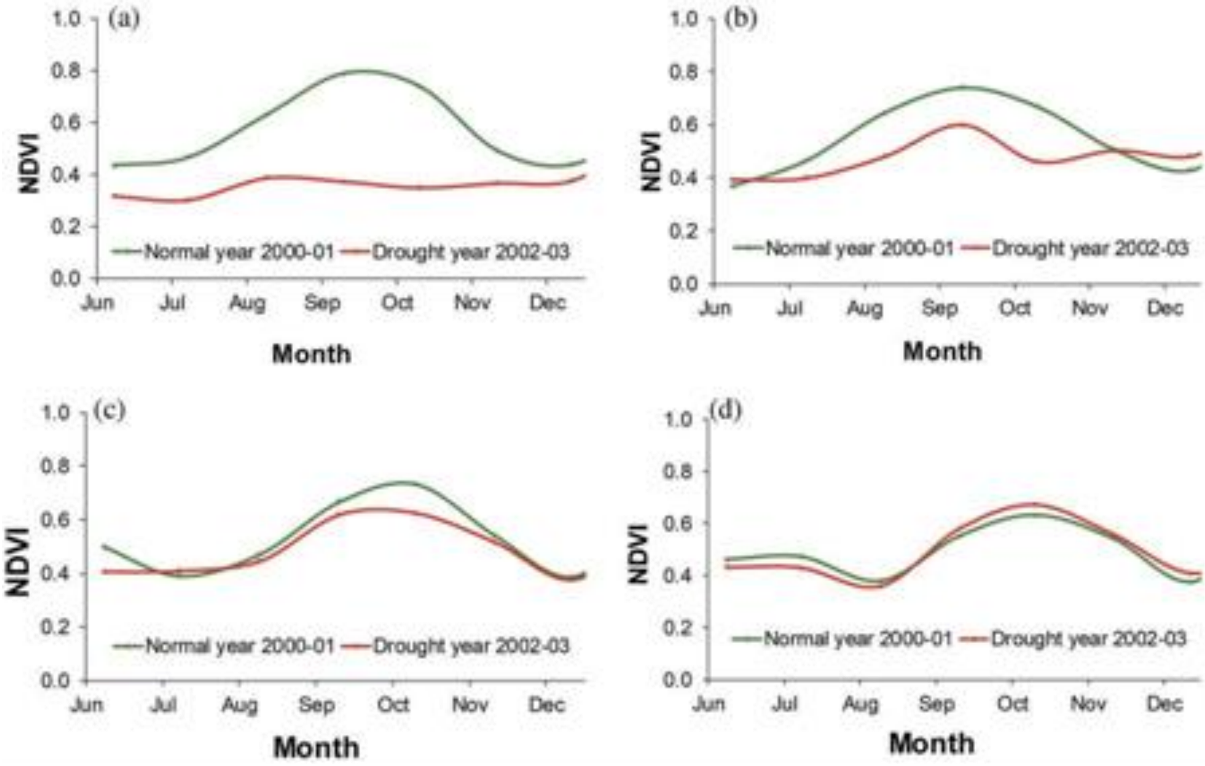

Figure 2: Samples illustrating the stress spectra signatures

a: Severe Stress b: Moderate Stress c: Mild Stress d: No Stress

An accuracy assessment of the stress classification was performed using an error matrix and kappa coefficient (κ)[4]. The assessment was based on independent field plots that were not used in the stress classification and labeling process.

[4] Congalton, R. G. 1991. "A Review of Assessing the Accuracy of Classifications of Remotely Sensed Data." Remote Sensing of Environment 37 (1): 35–46. doi:10.1016/0034-4257(91)90048-B.