

## **Vegetation Condition Index based Agricultural Drought mapping over the past decade of Sri Lanka by utilizing the Satellite Remote Sensing**

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**Abstract:** Drought is one of the main disasters that act as a silent killer among Sri Lanka and it is the disaster that affects the highest number of people over the country. Further can identify different types of droughts such as Meteorological drought, Hydrological drought, Agricultural drought, physical Drought, and Socio- economic drought. Under the investigation explored the agricultural drought of Sri Lanka since Sri Lanka is an agricultural nation and it requires systematic and scientific investigation to study the magnitude of the Agricultural drought. Sri Lanka is one of the Asian countries which is often experienced in drought risks, when drought has happened it is constantly changed into disaster making various antagonistic effects on the network. The integration between Remote sensing techniques and Geographic Information Systems (GIS) was used for the investigation which is sophisticated in environmental studies rather than field data collection. Integration between 10 years (2009 to 2019) of Moderate Resolution Imaging Spectroradiometer (MODIS) remote sensing images were utilized for Agricultural drought detection by using the Normalized Difference Vegetation Index (NDVI) and Vegetation Condition Index (VCI) for the study in ArcMap 10.1 software environment. As a

result of the study presented an Agricultural drought risk assessment map for 2019 in Sri Lanka. Rendering to the results, it shows a considerable increase in drought conditions over the past decade of Sri Lanka while showing the dominant type is still no drought condition of 68% from the total area.

**Keywords:** Agricultural Drought, GIS, NDVI, Remote Sensing, VCI

### **Introduction**

The scientific and geographical identification of weather extremes is an important component in day to day life. This understanding helps to face these weather extremes in an appropriate way. Significant influences of those extraordinary situations on the civilization are more likely to influence through variations of utmost events than through slow fluctuations in mean conditions and which is why hydro-meteorological changes have attracted significant influence on human society within the recent era.

The earthquakes, hurricanes, floods, and droughts were the leading natural hazards that folks remember when the word heard the "hazard". These events act as natural agents who transform a vulnerable human condition into a disaster. Purely hazards themselves aren't considered as disasters.

But the influence of those disasters on the people and their environment causes a disaster situation. Drought is one among the many hazards among common risks to individuals' employments and financial improvement. Drought will, generally, happen less much of the time than different liabilities. Nevertheless, when it does occur, it generally affects a broad area for periods or years at a time. this will cause a much bigger extent of the inhabitants being influenced by drought than by different calamities. Drought may be a natural a part of the climate, in spite of the very fact that it'd be mistakenly considered as an uncommon and arbitrary occasion. It happens certain all intents and purposes every zone, yet its attributes fluctuate essentially starting with one area then onto subsequent. Drought may be a transitory distortion; it contrasts from aridity, which is restricted to low precipitation locales and may be a perpetual component of the climate (UNISDR, 2009). Agricultural drought is characterized all the more ordinarily by the absence of accessibility of soil water to assist harvest and forage development than by the take-off of typical precipitation over some predetermined timeframe. The connection between precipitation and penetration of precipitation into the soil is often not immediate. Penetration rates differ contingent upon precursor dampness conditions, slope, soil type, and therefore the power of the precipitation occasion. Soil qualities likewise contrast. as an example, a couple of soils have a better water-holding limit, which makes them less powerless against drought. Hydrological drought is generally defined by deficiencies in surface and subsurface water supplies relative to average conditions at various points in time through the seasons. Agricultural Drought this type of drought happens when there's

not sufficient dampness to assist normal harvest creation on ranches. Albeit farming drought frequently happens during dry, hot times of low precipitation, it can likewise happen during

times of normal precipitation when soil conditions or agrarian strategies require additional water (SAARCDMC, 2010).

### **Methodology**

The satellite or remote sensing methods might be apply to observer this state, previously, throughout or after disaster. they will be utilized to offer pattern information against which future changes are often considered while the GIS systems give an appropriate structure to coordinating and breaking down the various kinds of information sources required for disaster checking. Remote sensing provides land resource data within the sort of digital magnetic types and in several bands of the spectrum. Satellite remote sensing data, with their repetitive nature, have proved to be quite useful in mapping land use and land-cover patterns and changes with time. Quantification of such changes is feasible through GIS techniques albeit the resultant spatial datasets are at different scales/resolutions. This facilitates planners' and researchers' studies of the spatial difference and distinction between various land types from multi temporal satellite data (Muthumanickam et al., 2011). NDVI has become an important indicator for mapping changes in vegetation spread and investigating natural effects. NDVI is employed not only for the precise depiction of land spread, vegetation grouping and vegetation phenology (Exhaust et al. 1982, Tarpley et al. 1984, Equity et al. 1985), but on the opposite hand, is employed adequately for observing precipitation and drought,

assessing crop development conditions and harvest yields ((Bhuiyan et al., 2006)

$$NDVI = (NIR - RED) / (NIR + RED)$$

Where NIR and RED are the reflectances within the close infrared and red bands. NDVI may be a decent marker of green biomass, leaf region list, and samples of creation (Thenkabail & Rhee, 2017; Xiong et al., 2012). NDVI is that the most regularly utilized vegetation record. It fluctuates from +1 to - 1. Since the climate is one among the foremost significant variables influencing vegetation conditions, AVHRR-NDVI information has been utilized to guage climatic and environmental changes at regional and global scales (Navalgund et al., 2007; Pousette et al., 2014; Singh et al., 2003). Vegetation Condition Index (VCI) was first recommended by Kogan in 1997 (Thenkabail & Rhee, 2017) VCI may be a marker of the status of the vegetation spread as a component of the status of the vegetation spread as a component of the NDVI least and maxima experienced for a given environment over numerous years. There have likewise been examinations managing the estimation of grain creation that's extremely indispensable for worldwide nourishment security and exchange (Kogan, 1997). Satellite got drought pointers determined from satellite-inferred surface parameters are generally wont to consider droughts. Normalized Difference Vegetation Index (NDVI) and Vegetation Condition Index (VCI) may be a portion of the widely utilized vegetation indices.

$$VCI_j = (NDVI_j - NDVI_{min}) / (NDVI_{max} - NDVI_{min}) * 100$$

Where NDVI<sub>max</sub> and NDVI<sub>min</sub> is decided from an extended term record for a selected month, and j is that the list of this month. The state of the bottom vegetation introduced by VCI is estimated in percent. The VCI esteems

between half to 100% demonstrate ideal or better than average conditions while VCI values near zero percent mirror a unprecedented dry month. The examinations recommend that VCI catches precipitation elements better than the NDVI, especially in geologically non- homogeneous territories. Additionally, VCI values show what proportion the vegetation has progressed or weakened in light of climate. it had been finished up from the above examinations that VCI has given an appraisal of spatial attributes of the season, even as its span and seriousness, and were in acceptable concurrence with precipitation designs (Ghaleb et al., 2015).

Table 01: Agricultural drought risk classification using VCI

VCI Range (%)	Drought severity class
Above 40%	No drought
30% to 40%	Slight drought
20% to 30%	Moderate drought
Below 20%	Severe drought

Monthly data of Moderate Resolution Imaging Spectroradiometer (MODIS) remote sensing images from

Atmospheric Corrections

Source: (Bhuiyan & Kogan, 2010)

Normalized Difference Vegetation Index (NDVI)

Vegetation Condition Index (VCI)

The overoll workflow of the study can be describe as the following figure 01.

Figure 01: The Complete work flow of the experiments conducted under the study

### Results, and Discussion

Agricultural Drought Map of 2019

Agricultural drought relations numerous features of meteorological and hydrological drought to agrarian influences, concentrating on rainfall scarcities, alterations among definite and possible evapotranspiration, soil water shortages, abridged groundwater or tank levels, and so forth. Plant water request be contingent on dominant weather circumstances, organic appearances of the exact plant, its phase of development, and the physical and biological assets of the topsoil.

Agricultural drought has been calculated using MODIS Surface Reflectance data with 1 Km resolution. NDVI was a very sensitive widely used index for vegetation related analysis. Consequently NDVI value was determined for each image using the Red and Near Infrared (NIR) of the MODIS spectral bands. 10 years of monthly MODIS satellite images were implemented for the study which of the 120 satellite images. Annual average NDVI value obtained by averaging monthly NDVI of particular years as in Figure 02.

Figure 02: satellite Remote Sensing based Annual NDVI Mapping from 2009 to 2019.

Accurate assessing of condition of vegetation was vital for drought-related studies. Therefore VCI used for the analysis in order to obtain the condition of vegetation according to the NDVI anomalies. Spectral vegetation indices are among the most commonly used satellite data products for evaluation, monitoring, and measurement of vegetation cover, condition, biophysical processes, and changes. Kogan proposed a VCI based on the relative NDVI change with respect to minimum historical NDVI value. The VCI, therefore, compares the current Vegetation Index such as NDVI to the values observed in the same period in previous years within a specific pixel. Hence VCI was calculated for each image by using NDVI variances.

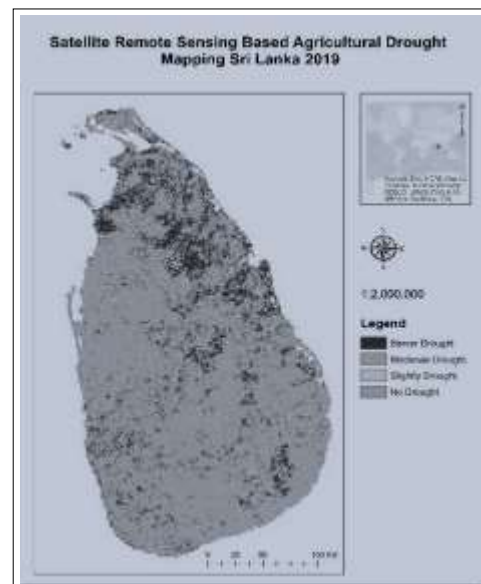
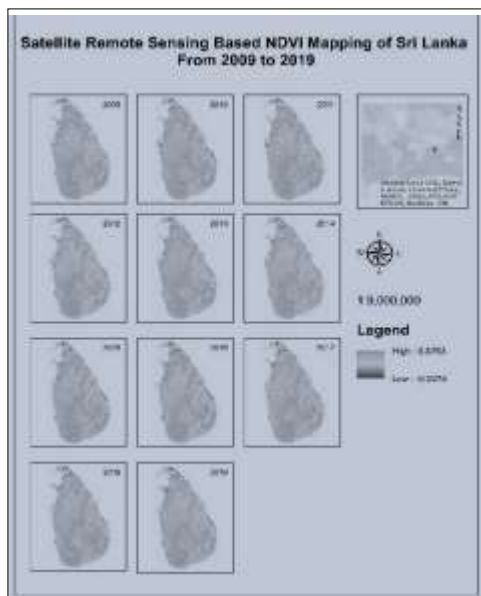


Figure 03: satellite Remote Sensing based Agricultural Drought Mapping 2019

Time series of NDVI anomaly used to detect agricultural drought. The threshold values used in this study to classify agricultural drought risk.

According to the VCI anomaly ranges drought severity was classified into four

severity classes according to the percentage of different harshness levels of the drought as shown in Figure 03.

Respective area coverage and percentage distribution of each type of drought in Sri Lanka in the year 2019 can be shown as following Table 02. According to the table, No drought condition could be identified as the dominant agricultural drought type of the country while server, moderate and slight drought has 16.07%, 7.10%, and 8.78% respectively.

*Table 02: respective Area coverage of each drought Condition*

Drought Condition	Area Coverage	Percentage of Area Coverage
Server Drought	10518 SqKm	16.07%
Moderate Drought	4646 SqKm	7.10%
Slightly Drought	5745 SqKm	8.78%
No Drought	44530 SqKm	68.05%

Because of that, Sri Lanka compromised of many of forests and agricultural lands and less urban and bare lands comparatively, it shows considerable No drought severity due to the agricultural conditions. No drought condition was the mainstream influence on the entire area as observed from the following figure 03. Therefore due to the spatial distribution of vegetation cover agricultural drought of Sri Lanka still in the non-significant severity level. But especially in the areas of the upper part of the country has considerable effect from the drought than the lower portion.

### Conclusion and Recommendations

Drought is a natural hazard that involves many factors, including meteorological and climatological parameters, having complex inter-relationships. Drought definitions vary from region to region and may depend upon the dominating perception, and the task for

which it is defined. Other than relying on conventional drought event counting method here present most effective method of drought mapping in spatial context by using the remote sensing aspects of agricultural drought.

Identifying patterns of drought and finding its associations with various indices derived from the conventional method and remote sensing techniques are becoming important for monitoring of this natural hazard. Dealing with a large volume of NDVI dataset for a time-series of 10 years make the study not only complicated but make it difficult to analyze. This thesis addresses the need for analyzing and studying the pattern of Agricultural drought by using spatial related time-series datasets. .

Satellite remote sensing was one of the highly developing techniques throughout the world. Currently it becomes a widely used data source for scientific studies and investigations. Most of the free data availability leads to the developing satellite remote sensing technique while having no boundary limitation for free access data worldwide. Hence, there is a lot of research to be carried out in these emerging areas, focusing on its applicability to Image processing and remotely sensed satellite imagery, which will reflect the independent signals from each source, thereby making it easy for analyzing time-series dataset. Further NDVI and VCI provide the best frame for the analysis and the VCI index scientifically suggest the significance of measuring drought by using NDVI anomalies.

GIS could be considered as fast-moving technology with the integration of web-based GIS, open source GIS, and the development of the analysis. Further nowadays it's actually difficult to find the applications where GIS not involved. Hence

GIS used as the interconnecting and analyzing platform for the study while connecting all the data in a scientific and meaningful way. Though the present work deals with satellite and meteorological parameters as well as hydrological parameters to arrive at a combined in a GIS context.

MODIS NDVI is found to be widely and extensively used for the detection and monitoring of the drought phenomenon for almost all regions of the world affected by drought effectively and efficiently. With the existence of such a dataset, it becomes easy and effective to monitor such natural phenomena. But, such datasets generally contain some of the errors introduced to the data by instrumental and data processing. So, in order to identify and remove such unwanted noise and signals from the data, the atmospheric and geometric procession was used. NDVI times-series was subjected to scale to VCI in order to estimate the vegetation health and monitored drought. To monitor drought effectively and for the identification of false alarm regions, drought identified with NDVI helped in monitoring the drought effectively thereby eliminating the false drought detected areas.

In this study it was only considered the agricultural drought and it's a one type of the drought that affect for srilaka. But there are other types of droughts could be identified such as meteorological drought and hydrological drought. Consequently combined analysis of the thse three droughts essential in in detailed drought analysis. Hence as a future development propose to do collective drought analysis while combining Agricultural drought, meteorological drought and hydrological drought.

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