Determination of Crop Health Monitoring in MPKV – Rahuri, Using Remote Sensing Approach

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Authors' contributions

*This work was carried out in collaboration among all authors. Author APK designed the study,
performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript.
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Original Research Article

ABSTRACT

Pests and diseases cause major harm during crop development. Also plant stress affects crop quality and quantity. Recent developments in high resolution remotely sensed data has seen a great potential in mapping cropland areas infected by pests and diseases, as well as potential vulnerable areas over expansive areas. Crop health monitoring in this study was carried out using remote sensing techniques. The present study was carried out in MPKV, Rahuri, Ahmednagar District, Maharashtra. Vegetation indices like Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI) were used to classify the crops into healthy and dead or unhealthy one. Sentinel-2 image data from October 2019 to January 2020 processed in Arc GIS 10.1 were used for this study. Vegetation is a key component of the ecosystem and plays an important role in stabilizing the global environment. The result showed that the average vegetation

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cover was decreased in the month of November and healthy vegetation was found more in month of October as compared to December and January. This shows that NDVI and SAVI indices for Sentinel-2 images can be used for crop health monitoring.

1. INTRODUCTION

Various remote sensing techniques are commonly used nowadays in providing information about land cover, as well as the condition of the land in terms of resources. With the application of the appropriate remote sensing techniques, one is able to capture information on changes in the growth of plants be it structural or chlorophyll changes. As such, some of the approaches one can adopt in this case include the use of airborne and satellite images for the purpose of classifying crops, examining their viability and health, as well as monitoring the farming practices. Remote sensing offers a new approach for rapid detection and assessment of crop diseases, such as stripe rust of wheat [1] and rice leaf blast [2].

The presence of diseases or insect feedings on plants or canopy surface causes changes in pigment, chemical concentrations, cell structure, nutrient, water uptake, and gas exchange. These changes result in differences in colour and temperature of the canopy, and affect canopy reflectance characteristics, which can be detectable by remote sensing. Therefore, remote sensing provides a harmless, rapid, and cost-effective means of identifying and quantifying crop stress from differences in the spectral characteristics of canopy surfaces affected by biotic and abiotic stress agents [3].

The Normalized Difference Vegetation Index (NDVI) is a commonly used remote sensing technique that identifies vegetation and measures a plant's overall health. NDVI has been the standard for understanding plant health in the agriculture industry for many years. Near Infrared imagery has typically been captured by satellites. NDVI relies on the comparison of near infrared light to measure healthy plant life across a wide range of conditions. Overall, it is the simplicity of the NDVI technique and its applicability to vegetation-base studies that have helped to make it perhaps the most extensively used in categories of remote sensing techniques used to monitor agriculture and plant growth.

A rising number of national, regional and local users and applications are employing geospatial tools that incorporate time series of spectral vegetation index data and other reference data such as roads, rivers and soil information for spatially and temporally explicit natural resource and agricultural monitoring.

Present study was done to determine vegetation indices like NDVI and SAVI for vegetation monitoring.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted for Mahatma Phule Krishi Vidyapeeth, Rahuri in Ahmednagar district in the Indian state of Maharashtra. The site of experiment is situated at 19°21'07.9"N latitude and 74° 38'40.9"E longitudes at 556 m above mean sea level (Fig. 1).

2.2 Climate

Climatically, the region falls under the semi-arid and sub-tropical zone with average annual rainfall of 566.5 mm. The distribution of rain is uneven, coupled with frequent droughts. The rainy days vary from 15 to 45 in different years. The annual mean maximum and minimum temperature range between 33 to 43°C and 10.10 to 22.9°C, respectively. The annual mean pan evaporation ranges from 3.7 to 12.4 mm day. The annual mean wind speed ranges from 3.2 to 13.09 km/hr. The annual mean maximum and minimum relative humidity range from 59 to 90 per cent and 21 to 61 per cent, respectively.

2.3 Used Data

To achieve the objective of this study, Sentinel 2 data is downloaded from the USGS (United State Geological Survey) Earth explorer website (earthexplorer.usgs.gov) for October 2019, November 2019, December 2019 and January 2020. The Sentinel-2 collects high-resolution multispectral imagery useful for a broad range of applications, including monitoring of vegetation,

soil and water cover, land cover change, as well as humanitarian and disaster risk. Resolution is about 10 m. Sentinel 2 was used to prepare NDVI and SAVI map for given study area.

2.4 Vegetation Indices

Firstly, Sentinel 2 data for October 2019, November 2019, December 2019 and January 2020 was downloaded from USGS (United State Geological Survey) and processed in ArcMap 10.1 software. The data is processed under NDVI and SAVI to extract the vegetation information.

Vegetation indices derived from optical satellite images, have been widely used for various ecological purposes for the last decades, because of their direct correlation with vegetation productivity reflection [4].

2.4.1 NDVI (Normalized Difference vegetation Index)

The NDVI is a simple numerical indicator that can be used to analyse the remote sensing measurements, from a remote platform and assess whether the target or object being observed contains live green vegetation or not.

The moderate 10 m spatial resolution of Sentinel-2 images is appropriate for NDVI producing in large scale area such as a province [5-7]. The NDVI was produced based on following formula

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

Where the RED and NIR are surface reflection over range of wavelength 0.6 μm and 0.8 μm for red and near infrared bands, respectively. The NDVI ranges are between -1 to +1 [8-10].

The NDVI is motivated by the observation vegetation, which is the difference between the NIR and red band. It should be larger for greater chlorophyll density. The value of NDVI ranges from -1 to +1. Very low value of NDVI (0.1 and below) correspond to barren areas of rock, building, sand, snow or non-cropped area were represented as dead vegetation. Moderate values (0.2 to 0.3) corresponds to shrub and grassland were represented as stressful vegetation while high value (0.6 to 0.8) indicates temperate and tropical rainforests, agricultural crop land represented as healthy vegetation. In other words, the degree of greenness is equal to the chlorophyll concentration.
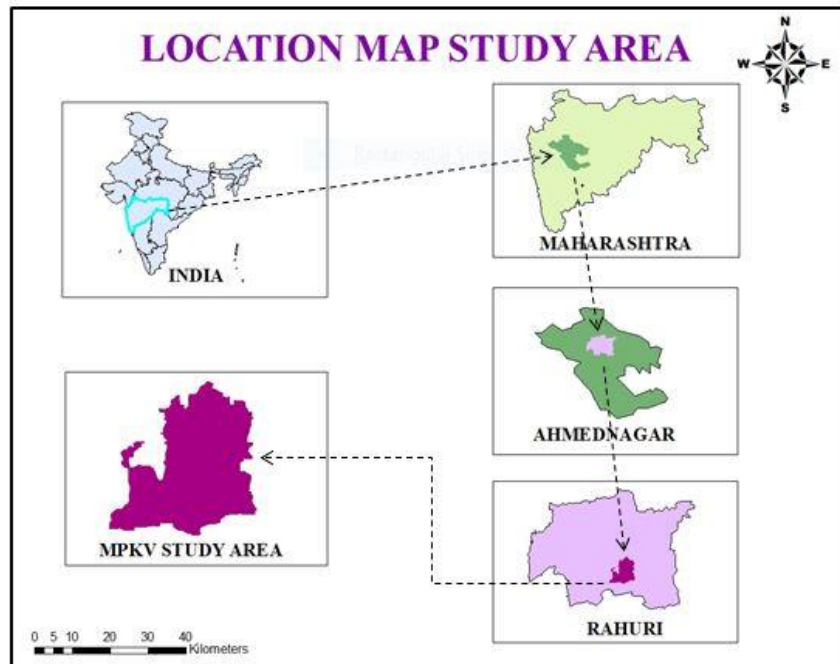

Fig. 1. Location of study area (MPKV, Rahuri)

NDVI values vary with the absorption of red light by plant chlorophyll and the reflection of infrared radiation by water-filled leaf cells. All visible ranges are captured by the Satellite camera in form of bands through which features can be extracted after applying the NDVI method for different characteristics.

2.4.2 SAVI (Soil Adjusted Vegetation Index)

Generally vegetation indices derived from NDVI have shown that they are unstable in areas with different values of soil colour, soil moisture and suffer from saturation effects by dense vegetation cover [11-12]. For the first time the SAVI has been introduced by Huete [11] to decrease the instability values by soil different colours which was based on simple radiative transfer. The SAVI results follow from this equation:

$$SAVI = ((1+L)*(NIR-Red))/(NIR+Red+L)$$

Where L is a canopy background adjustment factor which ranges from 0 for very high vegetation cover to 1 for very low vegetation cover. The most typically used value is 0.5 which is for intermediate vegetation cover and in present study we have used 0.5 for L.
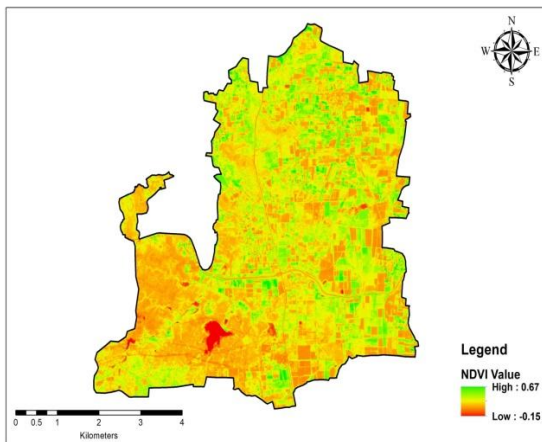
3. RESULTS AND DISCUSSION

Fig. 2 – Fig. 5 shows NDVI map for October, November, December 2019 and January 2020 respectively. Similarly SAVI map for October, November, December 2019 and January 2020 was shown in Fig. 7- Fig. 9 respectively. A brief of these outcomes is talked about in the accompanying sections.
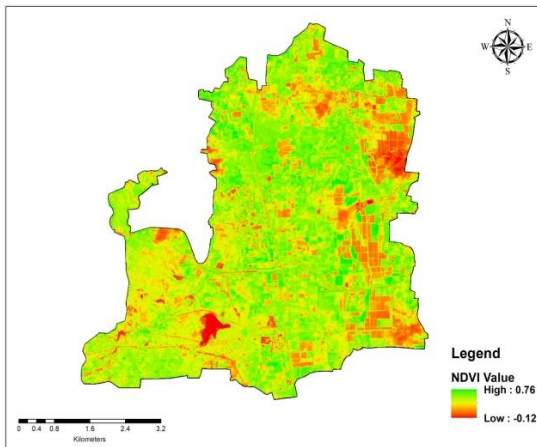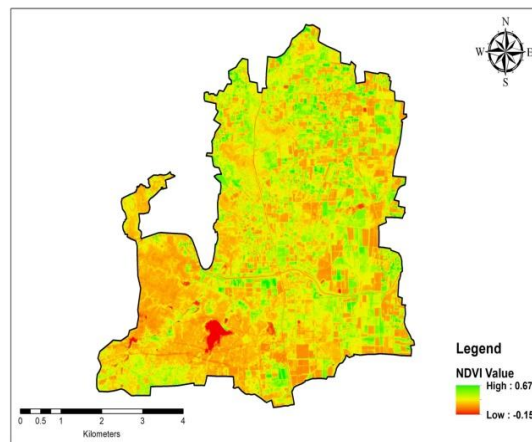

Fig. 2. NDVI map for October, 2019
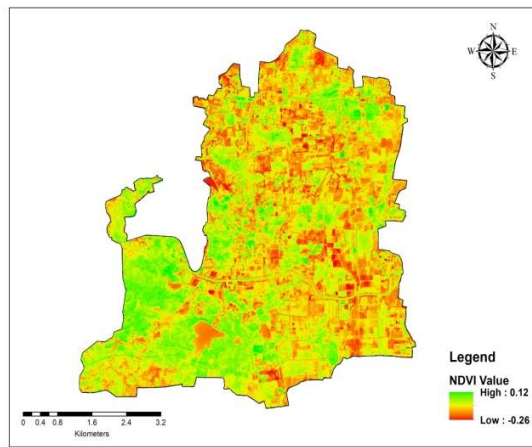
Fig. 3. NDVI map for November, 2019

Fig. 4. NDVI map for December, 2019

Fig. 5. NDVI map for January, 2020

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3.1 NDVI

The results of present study show that the highest NDVI value was observed in October as compared to other months. The average NDVI values of October for healthy and dead vegetation are 0.76 and -0.12 respectively (Fig. 2). This shows that, presence of crop vegetation in October. While in November, harvesting of *Kharif* crops were done this resulted in lowest NDVI value of 0.12 was observed in November month (Fig. 3). While in December and January, NDVI values were 0.65 and 0.67 respectively (Fig. 4, Fig. 5). This shows that sowing for Rabi crops had done in late November which shows increase in NDVI value in December.

3.2 SAVI

All VIs in present study have used Red or Infrared bands in their equations, which represent the greenness conditions of above ground biomass and vegetation cover. The results of present study show that the healthy vegetation range is highest (0.7389-1.1443) in October (Fig. 6) as compared to other months. This was mainly due to standing crops in October. The dead vegetation range is more (-0.2082-0.3654) in January (Fig. 9) due to sowing of *Rabi* crops and crops were still in seedling stage.
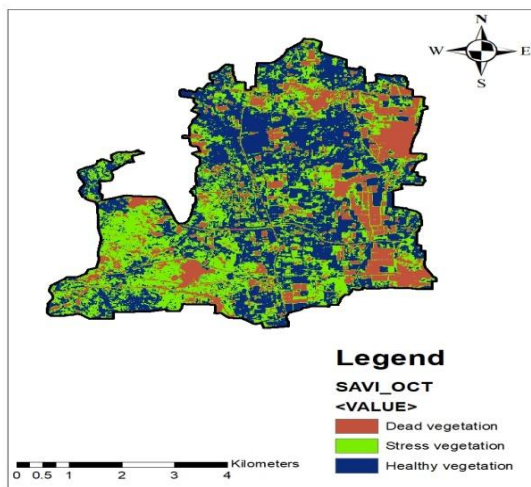

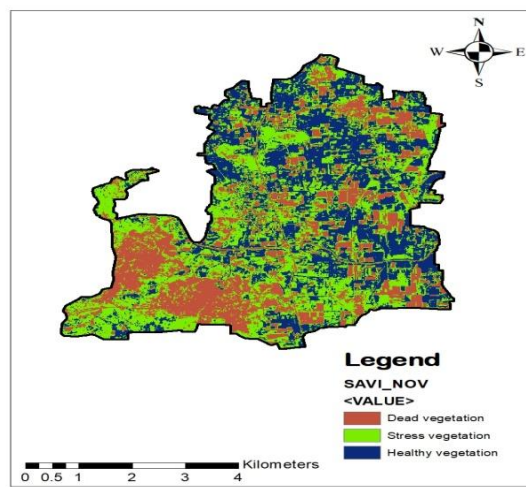**Fig. 6. SAVI map for October, 2019**
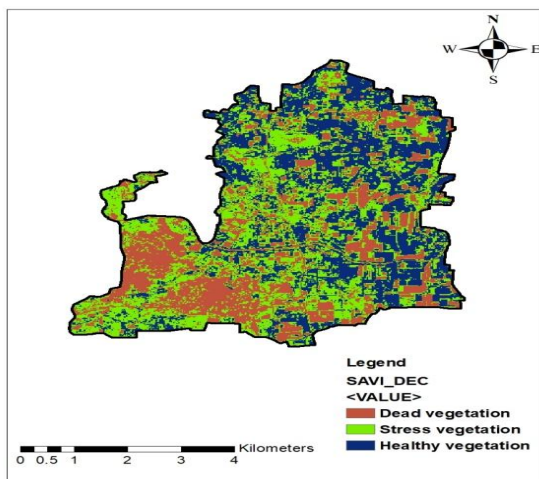

Fig. 7. SAVI map for November, 2019

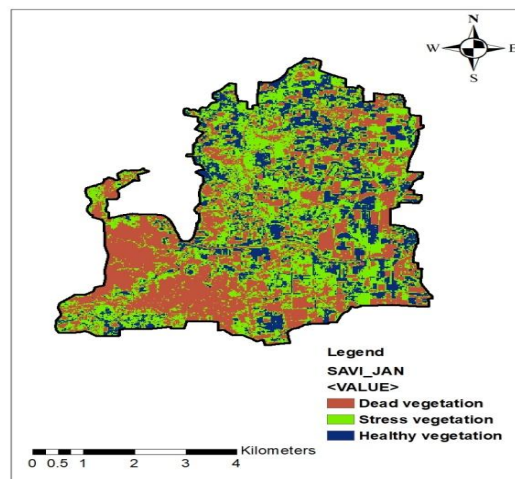**Fig. 8. SAVI map for December, 2019**

Fig. 9. SAVI map for January, 2020

4. CONCLUSION

The study was focused on detecting crop health condition with the help of satellite base vegetation indices. The study was conducted at Mahatma Phule Krushi Vidyapeeth, Rahuri in Ahmednagar district in the Indian state of Maharashtra. From this study the conclusions were made as in October NDVI value was 0.76 and SAVI in range of 0.7389-1.1443 which are highest as compared to other months. This was mainly due to presence of standing *Kharif* crops and Sugarcane fields in October. Also from November harvesting of *Kharif* crops were done and sowing for *Rabi* also started.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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