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Remote Sensing and its Applications in Agriculture through Satellite Imagery

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2. Abstract

The art and science of gathering information about real-world objects or areas at a distance without having to come into direct physical contact with them is known as remote sensing. Remote sensing is a technique for monitoring the earth's resources that combines space technology with ground observations to provide greater precision and accuracy. In the whole process of remote sensing around seven elements are involved. There are different kinds of satellites used for different purposes having their uniqueness. Remote sensing in Agriculture is also an emerging field. This technology is very expensive for a farmer to adopt. But several portals provide free of cost data to farmers as well as researchers indulged in this field. These portals provide unique information of ones area with a very little period.in developing countries like India, there are some roadblocks in the fields of remote sensing in Agriculture. Farmers are least aware about such technologies. There is need of interventions of Institutes like Village knowledge centres, e-centres etc. which bridging farmers and advanced technologies. This study starts with little basic information and then leads to several portals working with application in agriculture and concluded by several prospective in future.

Key words: Remote Sensing, Eo-Portals, Satellite imagery, Index

3. Introduction

According to Dr. Nicholas Short *Remote Sensing is a technology for sampling electromagnetic radiation to acquire and interpret non-immediate geospatial data from which to extract information about features, objects, and classes on the Earth's land surface, oceans, and atmosphere.*

Remote sensing is the art and science of gathering information about real-world things or areas at a distance without having to come into direct physical contact with them. Remote sensing is a technique for monitoring the earth's resources that combines space technology with ground observations to provide greater precision and accuracy. The utilization of electromagnetic spectrums (visible, infrared, and microwaves) for measuring the earth's properties is the principle behind remote sensing. Because the targets' normal reactions to various wavelength ranges differ, they can be utilized to differentiate objects like flora, water, bare earth, concerts, and other comparable phenomena.

Many research experiments make use of aerial images and digital image processing techniques. However, the field of remote sensing aids in reducing the amount of data collected in the field and enhancing the precision of estimates. (Kingra et al., 2016). When compared to broadband multispectral remote sensing, hyper spectral data can drastically improve crop and vegetation characterisation, discriminating, modelling, and mapping (Thenkabail et al., 2011). The Normalized Difference Vegetation Index is the most often used index for assessing vegetation status (Rouse et al.,1974). The NDVI has been widely utilised as a vegetation indicator, and numerous efforts have been made to produce additional indices that can lessen the impact of soil background and atmosphere on spectral measurement findings.

Remote sensing technology can help agriculturists by allowing them to quickly examine biophysical indicators of plant health using spectral data. Remote sensing techniques aid in the detection of physiological changes in plants caused by stress, which can be determined by changes in spectral reflectance/ emission characteristics. (Menon, 2012)

Crop yield forecasting relies heavily on remote sensing, which is generally based on statistical– empirical connections between yield and vegetation indices. (Casa and Jones 2005). Remote sensing technology can be used to identify pest-infested and unhealthy plants efficiently and cost-effectively. canopy features can be detected via remote sensing, and that spectral reflectance variations between insect infestation damage and disease infection damage in oat crops (William et al.,1979).

5. Results and Discussion:

Different Portals used for Satellite-Based Data Extraction:

- Bhuvan – INDIA
- Sentinel HUB – Europe
- JAXA – Japan
- GaoFen-1 – China
- SMAP - USA

5.1 Bhuvan:

- Bhuvan began modestly in 2009, with a simplistic display of satellite data and basic GIS functionality, as well as several thematic maps.
- ISRO's Geo-portal, Bhuvan is providing visualization services and Earth observation data to users in the public domain.
- Besides, the portal also services several users for their remote sensing application needs.

5.1.1 Land Use Land Cover:

Earth observations from space platforms play a crucial role in generation and dissemination of information on LULC pattern in a timely and reliable manner providing vital inputs required for optimal land use planning. The evolution of Indian remote sensing program over the past two decades, providing a variety of remote sensing- based solutions for national development, is an apt and timely national initiative. Some of the important projects of ISRO/DOS under the theme of LULC

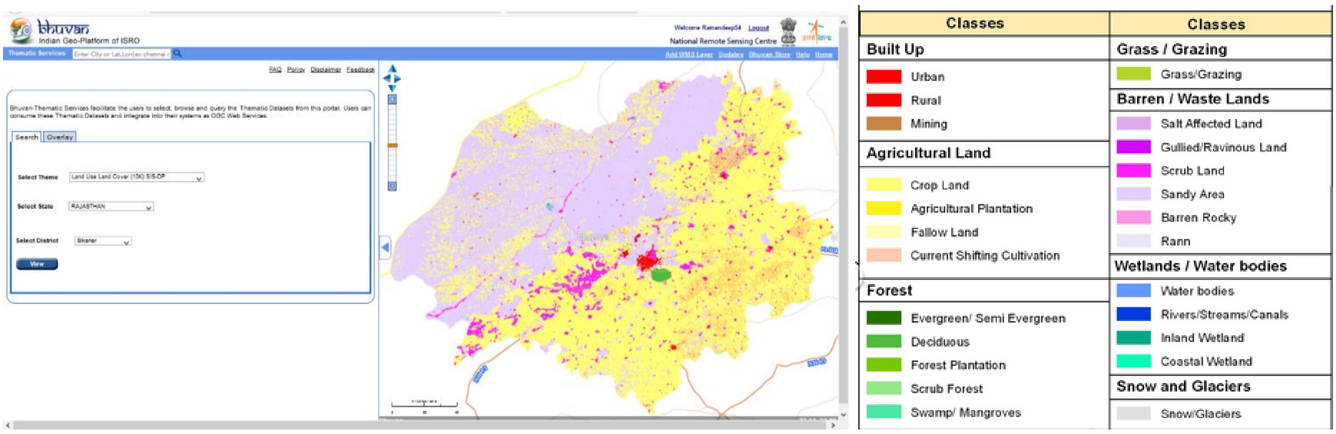


Figure.1 Land use/ Land Cover map of Rajasthan in Bhuvan Portal

5.1.2 Pest/Disease pest survillance:

In this there is provision of Geo Tagging to particular pest or disaese attack in any area. It is bi- directional say, we can use it to get output and provide input of particular Pest/Disease.

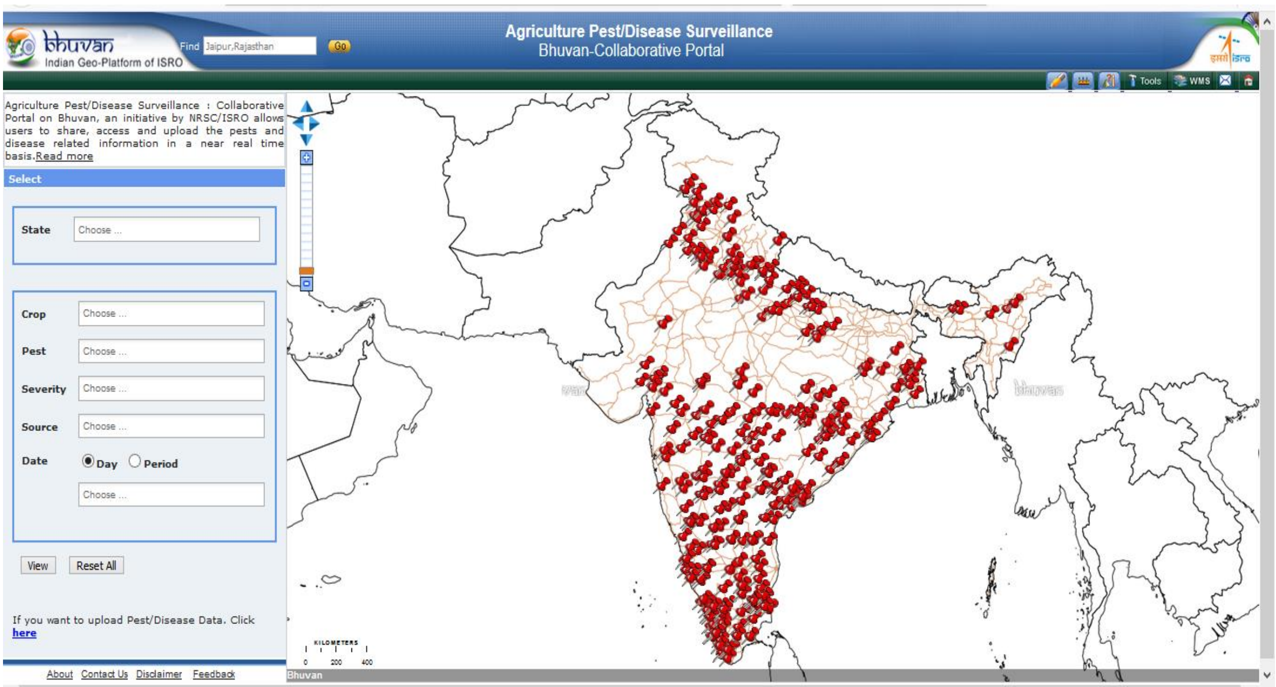


Figure 2 Pest/ Disease pest Surveillance in Bhuvan Portal

5.1.3 Plantations:

It is used for location of tea garden in West Bengal and Assam. Under this we are able to extract information about rubber plantation in Tripura.

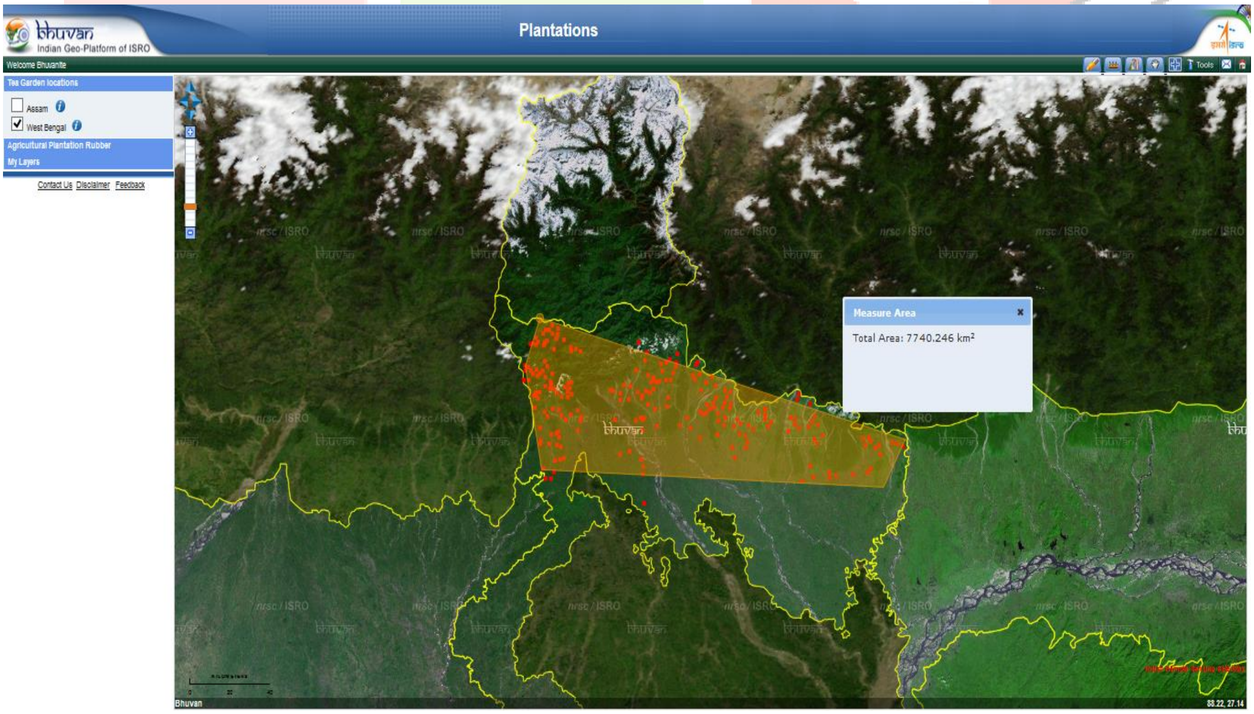


Figure 3 . Plantation tagging of tea garden in Bhuvan Portal

5.2 SENTINEL HUB -2:

- Multi-spectral data with 13 bands in the visible, near infrared, and short wave infrared part of the spectrum
- Repeating the process every 5 days with the same viewing angles. Sentinel-2 swaths overlap at high latitudes, therefore certain places will be examined twice or more every 5 days, although from different viewing angles.
- Three Spatial resolutions of 10 m, 20 m and 60 m
- Wide field of view of 290 km
- Free and open data policy

5.2.1 NDVI (LANDSAT-8):

The normalized difference vegetation index, abbreviated NDVI, is defined as

NDVI:=Index(NIR,RED)=NIR−REDNIR+RED.NDVI:=Index(NIR,RED)=NIR−REDNIR+RED.

For Sentinel-2, the index looks like this:

NDVI: =Index (B8, B4) =B8−B4B8+B4.

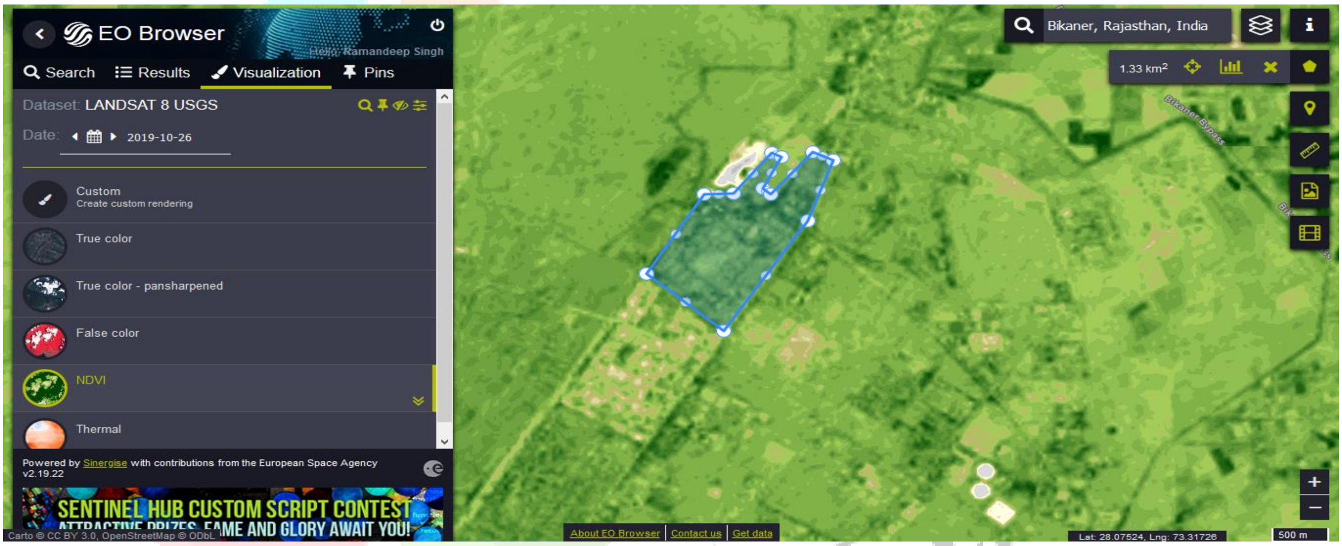


Figure 4 . NDVI Visualisation by LANDSAT-8 of particular areal

5.2.1.1 NDVI Index Map:

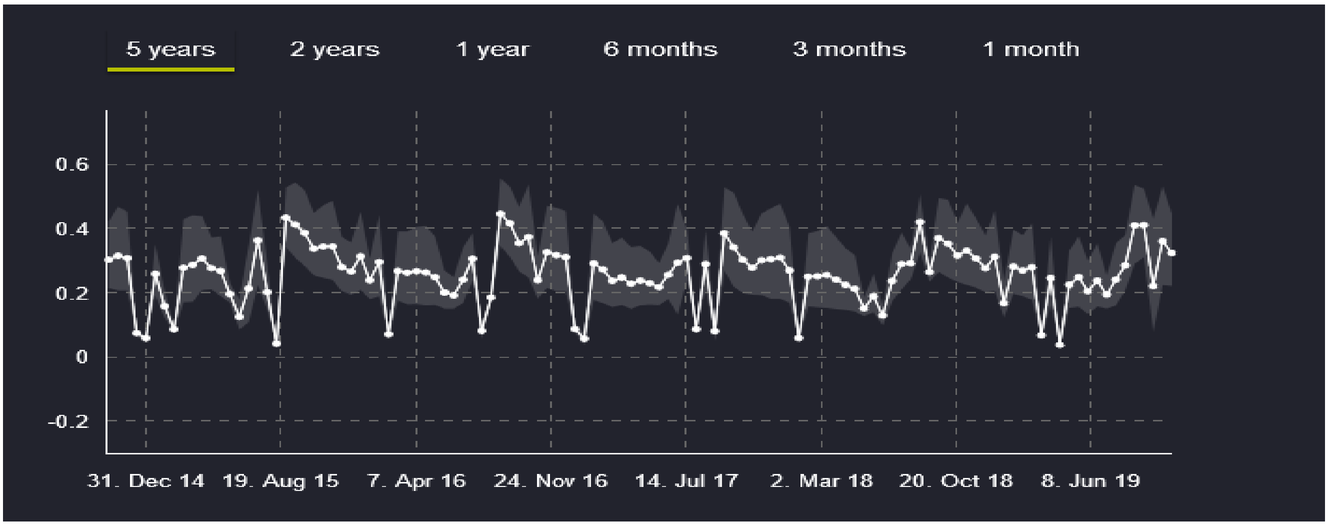


Figure 5 .NDVI Map of An Area upto last 5 Year of Same time.

This most known and used vegetation index is a simple, but effective for quantifying green vegetation.

It normalizes green leaf scattering in the Near Infra-red wavelength and chlorophyll absorption in the red wavelength.

Values description: The value range of an NDVI is -1 to 1.

- Negative values of NDVI (values approaching -1) correspond to water.
- Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow.
- Low positive values represent shrub and grassland (approximately 0.2 to 0.4)
- while high values indicate temperate and tropical rainforests (values approaching 1)

5.2.2 Moisture Index:

The NDMI is a normalized difference moisture index, that uses NIR and SWIR bands to display moisture. The SWIR band reflects changes in both the vegetation water content and the spongy mesophyll structure in vegetation canopies, While leaf interior structure and leaf dry matter content alter NIR reflectance, water content has almost no effect. The use of the NIR and SWIR together eliminates differences caused by leaf internal structure and leaf dry matter content, enhancing the accuracy in retrieving vegetation water content. The spectral reflectance in the SWIR region of the electromagnetic spectrum is substantially controlled by the amount of water available in the interior leaf structure. As a result, SWIR reflectance is inversely proportional to leaf water content. The near infrared (NIR) and short-wave infrared (SWIR) reflectances are used to calculate the NDWI:

NDWI = (B08 - B11) / (B08 + B11)

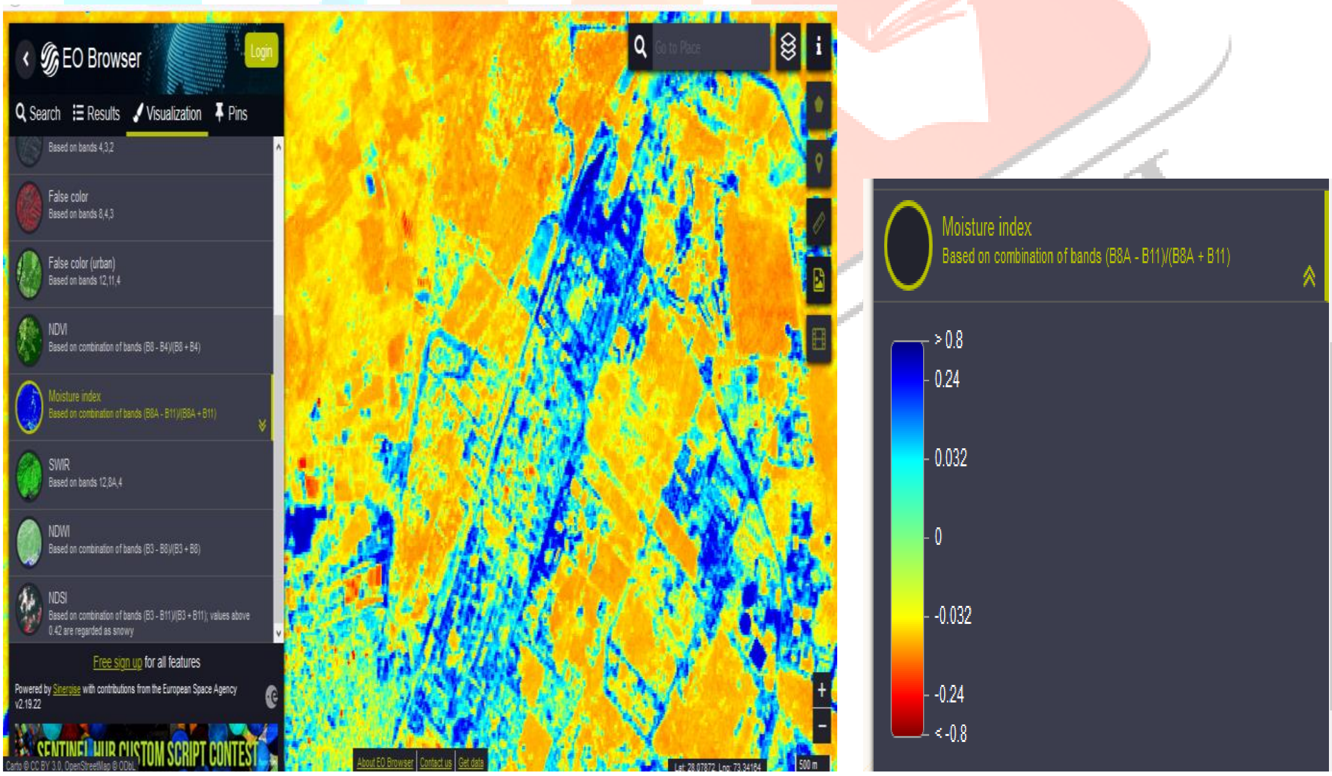


Figure 6. NDWI (Moisture Index) of the defined area

5.2.3 Thermal Imaging:

This thermal visualization is based on the Landsat 8's thermal band 10. At the central wavelength of 10895 nm it is in the thermal infrared, or TIR – it detects heat. Instead of measuring the temperature of the air, like weather stations do, band 10 reports on the ground itself, which is often much hotter. Thermal bands 10 and 11 are collected at 100 metres and are effective for delivering more precise surface temperatures.

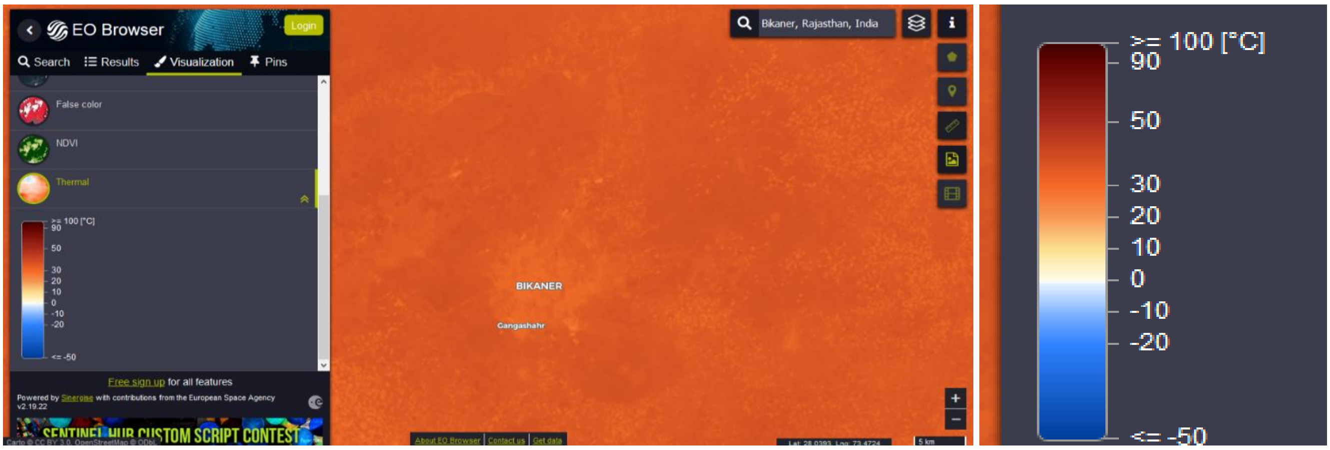
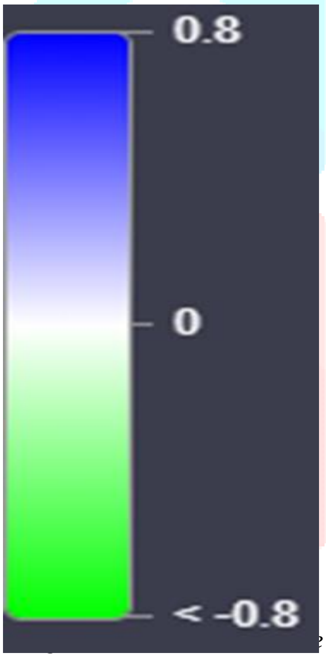


Figure 7. Thermal Imaging of defined area by LANDSAT-8

5.2.4 Normalized Difference Water Index:



obtained by Sentinal-2LA

The NDWI is useful for water body mapping, as water bodies strongly absorb light in visible to infrared electromagnetic spectrum. NDWI uses green and near infrared bands to highlight water bodies. It is sensitive to built-up land and can result in over-estimation of water bodies.

Normalized Difference Water Index (NDWI) may refer to one of at least two remote sensing-derived indexes related to liquid water:

One is used to monitor changes in water content of leaves, using near-infrared (NIR) and short-wave infrared (SWIR) wavelengths, proposed by Gao in 1996.

NDWI = (B08 - B11) / (B08 + B11)

Another is used to monitor changes related to water content in water bodies, using green and NIR wavelengths, defined by McFeeters (1996).

NDWI = (B03 - B08) / (B03 + B08)

Values description: Index values greater than 0.5 usually correspond to water bodies. Vegetation usually corresponds to much smaller values and built-up areas to values between zero and 0.2.

5.2.4.1 NDWI Map:

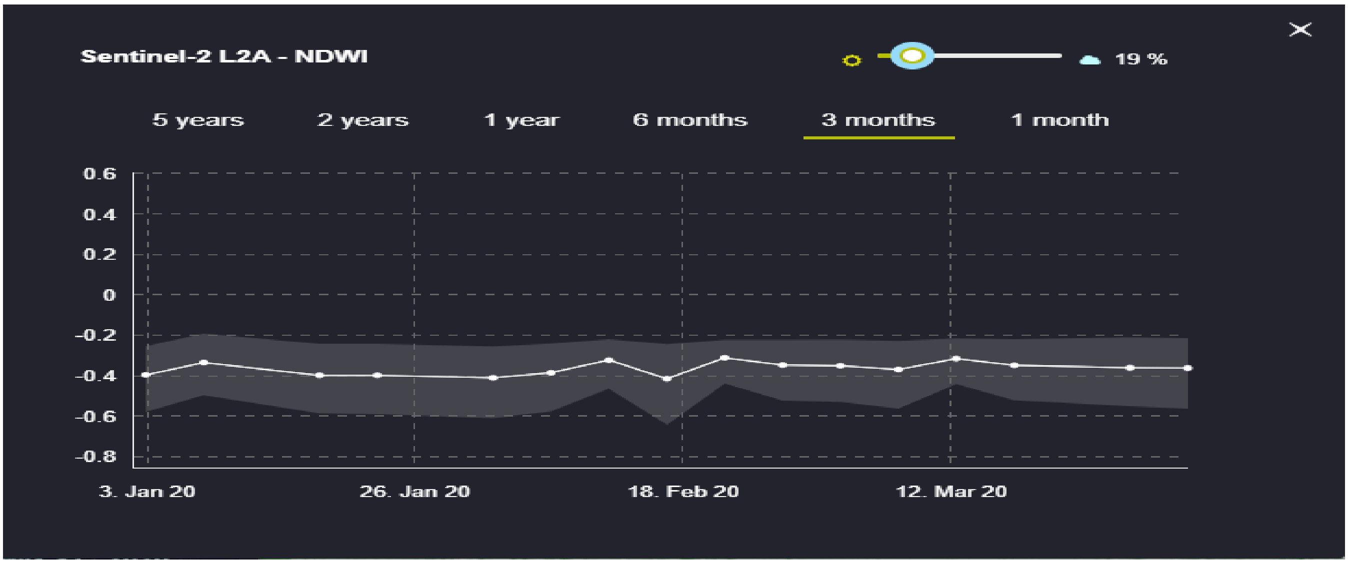


Figure 9. NDWI Map of A defined Area upto last 3 months

5.2.5 Short Wave Infrared:

Short wave infrared (SWIR) bands 11 and 12 can help scientists estimate how much water is present in plants and soil, as water reflects SWIR wavelengths. Shortwave-infrared bands are also useful for distinguishing between cloud types (water clouds versus ice clouds), snow and ice, all of which appear white in visible light. Newly burned land reflects strongly in SWIR bands, making them valuable for mapping fire damage. Each rock type reflects shortwave infrared light differently, making it possible to map out geology by comparing reflected SWIR light. In this composite, B8A is reflected by vegetation and shown in the green channel, while the reflected red band, highlighting bare soil and built up areas, is shown in the blue channel.

6. Challenges:

- Satellite Mapping is used for larger areas. In Forest surveys the forest area to be mapped should be more than 1 Ha and should have minimum 10% canopy density
- Analysis of data leads to complexity due to imagery data instead of numerical data.
- Remotely sensed data are expensive
- The ground verified report needs to be in line with the data taken through remote sensing.
- In developing country like India, where Agriculture fields are small, Segregated and having heterogenous crops, it is hard to get information of small area or even a single farm results.
- There is desynchronising between space research authorities and Agricultural experts which leads to delay in the demanded results.

7. Future Prospective:

Remote Sensing has very bright and upcoming future in Agriculture, as it is a need of hour to use such technologies to make Agriculture a six-sigma profession.

Remote Sensing ultimately deals with the information. We know information is worth nothing if it comes too late. The problem of information can be reducing to minimum with the use of such advanced technologies.

Decision is meant to be a decision when it is taken wisely, timely and effectively.to make a decision one should have accurate Real time Information and the effectiveness of such information. This kind of technology ultimately results into taking the wise decisions.

As advanced technological sensors and radars are built up, which are very accurate and effective for Agricultural Purpose. The Day is not So far that we will get the accurate data of Pest and disease in farmer's field with exact population and attack on that field with several advanced technologies like Radar, thermal sensors.

We should take help of Village knowledge centres for providing exact information and data of that area analysed by remote sensing technologies which ultimately enhanced farmers to adopt several measures on time to time.

There is need to diversified the crop selection of farmer of particular area which is suitable to the local conditions this will help in the homogeneity of crops and thus leads to accuracy in the visualisation of remote sensing.

8. Conclusion:

The remote sensing is used for exploration of inaccessible areas. The areas of study which has to be taken under umbrella of remote sensing are Agriculture, Defence, Natural Resource Management etc. The ISRO'S geoportal Bhuvan is providing visualisation services and earth observation data to users in public domain. The NDVI index map is used for extraction of data for water bodies, barren areas of rock, grassland, tropical rainforest and moisture estimation. The application of lower wavelengths for remote sensing transmission can open the doors for advanced application of remote sensing in agriculture. Affordability, accuracy and precision, Congruence with ground report are some roadblocks which if addressed can open the toolbox for agriculture researchers in the field of remote sensing. Linkage of Farmers with the help of Village Knowledge Centres and various e-Centres to the Remote Sensing data will provide a faster track to access Real time Information, ultimately enhanced decision making power of Farmers.

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10. Appendices

Term	Definition
AVHRR	Advanced Very High Resolution Radiometer
EO	Earth Observation
EOS	Earth Observation Satellites
ESA	European Space Agency
ETM+	Enhanced Thematic Mapper (Landsat-7 sensor)
GPS	Global Positioning System
GYURI	General Yield Unified Reference Index
ISRO	Indian Space Research Organisation
JAXA	Japan Aerospace Exploration Agency
LAI	Leaf Area Index
LiDAR	Light Detection and Ranging
LULC	Land Use and Land Cover
MSI	Multi-spectral Instrument
NDMI	Normalized Difference Moisture Index
NDVI	Normalised Difference Vegetation Index
NDWI	Normalized Difference Water Index
NIR	Near-infrared
NOAA	National Oceanic and Atmospheric Administration
PVI	Perpendicular Vegetation Index
RADAR	Radio Detection and Ranging. By usage: data from radar systems
SAR	Synthetic Aperture Radar
SMAP	Soil Moisture Active Passive
SVI	spectral vegetation index
SWIR	Shortwave Infrared
TCI	Temperature Crop Index

TIR	Thermal Infrared Sensor
TM	Thematic Mapper
UAV	Unmanned Aerial Vehicle
USGS	United States Geological Survey
VCI	Vegetation Condition Index
VNIR	Visible Near-infrared
VPM	Vegetation Phenology Metrics
VRT	Variable rate technology