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A Comprehensive Study of Remote Sensing Technology for Agriculture Crop Monitoring

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ABSTRACT

With the rapid advancement of Remote Sensing Technology, monitoring the agricultural land has become a facile task. To surveil the growth of paddy crops and provide detailed information regarding monitoring soil, drought, crop type, crop growth, crop health, crop yield, irrigation, and fertilizers, different types of remote sensing satellites are used like Landsat 8, Sentinel 2, and MODIS satellite. The main aim of Landsat 8, Sentinel 2 and MODIS satellites is to monitor the land and vegetation area and to provide data regarding agricultural activities. Each of these satellites possesses a different spectral band, resolution, and revisit period. By using the remote sensing spectral indices, different types of vegetation indices are calculated. This survey paper provides comprehensive about Remote Sensing and the major parameters that influence for growth of paddy crops, like soil and water, and the future scope of agriculture and its demand in research is discussed.

INTRODUCTION

A large variety of crops are grown in our country to meet the daily requirements of food. India is one of the fastest-growing populated countries. With the rapid increases in the population, the supply and need in the agro-based industries are getting higher level. The major food crops in India are rice, wheat, maize, and millet. Among all the crops, rice is considered a stable food crop. For the cultivation of the rice soil, temperature, rainfall, and humidity must be maintained at an appropriate level. Rice is the staple crop in India, which is consumed by age people in day-to-day life. The demand for food is always increasing due to population. On an average survey, rice is consumed three times a day, mostly by all the people. However, due to some unpredictable natural disasters, most of the crops are getting destroyed. The early stage of prediction and identifying the problem may help us to store the crops and food. In India, there are three main cropping seasons for agriculture purposes and to cultivate the rice crop, they are known as the Kharif season, Rabi season, and Zaid season. Among these three seasons, Rabi and Kharif are suitable for the cultivation of paddy crops. To improve the productivity and profitability of rice, a structural inequity must be established, and more attention should be focused on technology development (Prasanna et al. 2009).

With the Evolution of Remote Sensing Technology and satellites, we can easily tackle all these problems. Many satellites are developed specifically for monitoring the land and resources that are present on the Earth's surface. Early prediction of the yield, diseases, and insufficient fertilizers helps to take an appropriate step for food management. The satellite information obtained from the image provides a transparency of activities regarding agriculture. The majority of the farmers have adequate knowledge of modern rice cultivation techniques; many different kinds of practices should be reached to the farmers for future generation rice cultivation process they are quality of the seed, spacing between the crops, seedling, time taken for transplanting, maturity of seedling, storing, fertilizer required for the crops, pest control, harvesting, and variety (Uddin et al. 2017). Keeping in mind the increase in population, the need for food is also getting increasing. In upcoming years like 2030, 2040, and 2050, the demand and the supply of the rice will be in a huge manner. India ranks second place in producing rice for food safety and control. Rice plays a vital role, and it remains constant forever (Mondal et al. 2022). Remote sensing plays a major role in agriculture. The satellites that are roaming around the Earth help to obtain information regarding the area that is covered by it. By analyzing and detecting the physical characteristics of changes happening in the area, we can easily predict upcoming changes. Remote Sensing is used for analyzing and depicting the agricultural crop by using satellite images. Nowadays, remote sensing is used in various fields like forest, transport, Navy, and agriculture also, with the rapid development of these technologies, prediction and decision-making tasking have become facile (Jovanovic et al. 2014).

Remote sensing data is widely used in agricultural areas, like analyzing the nutrient content in the soil, crop production, crop yield, and forecasting (Table 1) (Wojtowicz et al. 2016). With the evolution of Remote Sensing (RS) technologies monitoring agriculture activities has become an easy task.

MATERIALS AND METHODS

Different Remote Sensing satellites are developed to monitor the agriculture, forest, and weather conditions from the regional level to the national level. Each of these satellites has a different bandwidth, resolution, central wavelength, and sensors. Some of the satellites are listed below.

1. Sentinel 2
2. Landsat 8
3. MODIS

Description of Sentinel 2

The Sentinel 2 satellite is integrated with two polar-orbiting satellites, which are placed in the same sun-synchronous orbit and are stepped at 180 degrees to each other's. It is a European-wide swath that has a high resolution. The specification of the Sentinel 2 satellite is it is and twin satellite flying in the same orbit. The revisit period of this satellite is 5 days with cloud-free conditions. The Sentinel 2 satellite provides a variety of services like monitoring the land, agriculture, risk mapping, and disaster control.

The Sentinel 2 consists of 13 spectral bands from B1 to B12. Each of these has different resolutions, wavelengths, and specific features.

The spectral band's meter ranges from 10 to 60 meter pixel size.

The Sentinel 2 is the Multispectral Imager (MSI).

The Two polar-orbiting satellites provide a high resolution of optical imagery.

The Sentinel 2 data is used to highlight the different parameters for the plant growth like leaf area index, chlorophyll, and water content.

Fig. 1 and Fig. 2 represent the sentinel band details.

The Sentinel 2 dataset is free, and it is openly available for all users.

Description of Landsat 8

The Landsat 8 satellite was developed by NASA and USGC (U.S. Geological Survey) in collaboration. Landsat 8 orbits the Earth in a sun-synchronous, polar orbit at 98.2 degrees. It completes the one-earth orbit for 99 minutes itself. The revisit period and repeat cycle for acquiring data is 16 days one's. Multispectral Image Data is provided for global land mass.

Landsat 8 data is sufficiently consistent in terms of spectral characteristics, data availability, calibration, coverage, and output product quality.

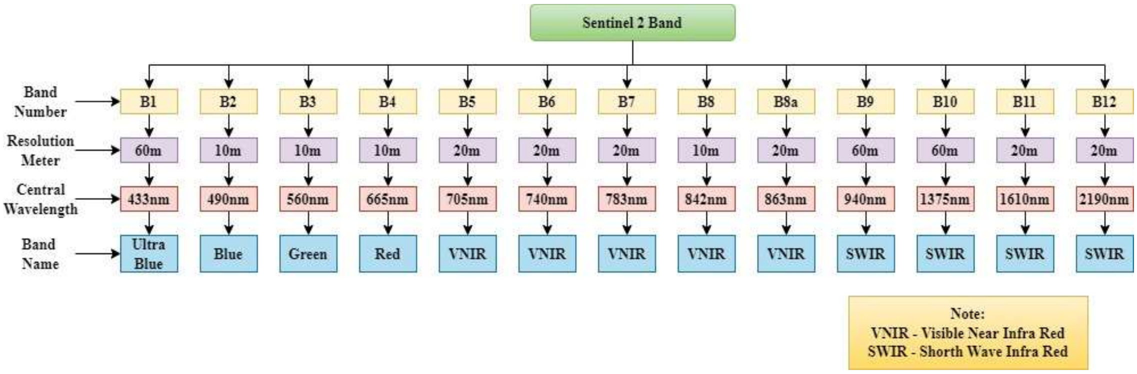
The Landsat 8 satellite consists of two sensors known as

1. Operational Land Imager (OLI)
2. Thermal Infrared Sensor (TIRS)

The Landsat two sensors (OLI, TIRS) provide global landmass coverage at spatial resolutions of 30m, 100m, and

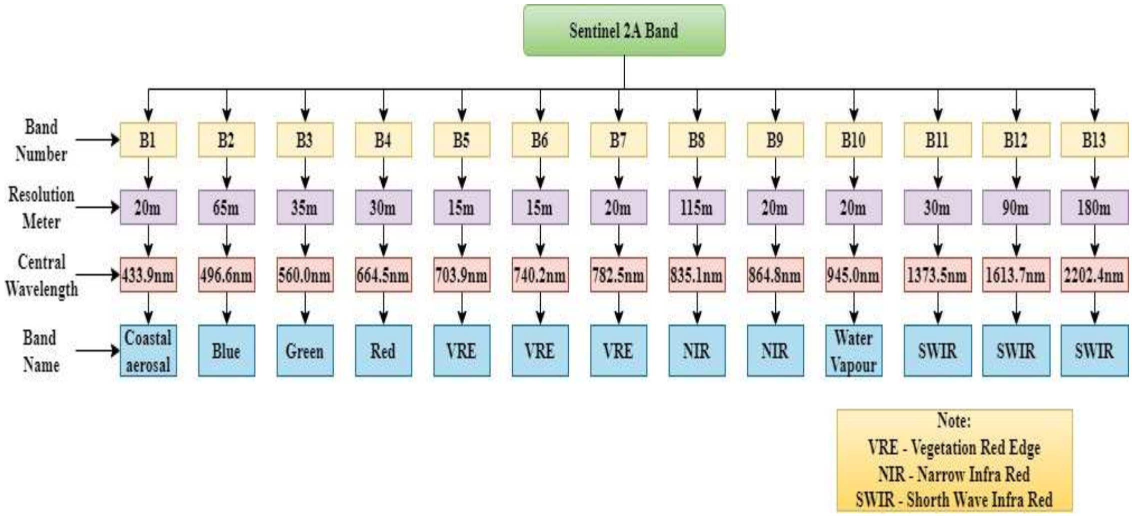
Table 1: Uses of remote sensing.

Application	Remote Sensing Usage
Crop Condition	By using the Normalized Difference Vegetation Index (NDVI) healthy crop area is reflected in green.
Forecasting Crop Production	By using the Remote Sensing technology prediction and yield of the crop production for an estimated field can be done easily. Before the harvest stage, we can detect with the help of remote sensing.
Soil Moisture	The satellite consists of both Active and passive Sensors, these sensors are used to determine the soil moisture content.
Crop stress and damage condition	The withhold capacity of the crop is used to estimate the crop stress condition, and the damaged crop is identified by the reflectance of radiation in the farmland.
Crop Health Analysis	By evaluating the overall crop yield, health analysis is determined for the crops. The fertilizer cost and Time factor are saved.
Water and Drought Monitoring	The remote sensing technology identifies the water content needed for the field crop, and the information is gathered to forecast the rainfall by comparing the rainfall pattern for the given area; the drought is Monitoring.



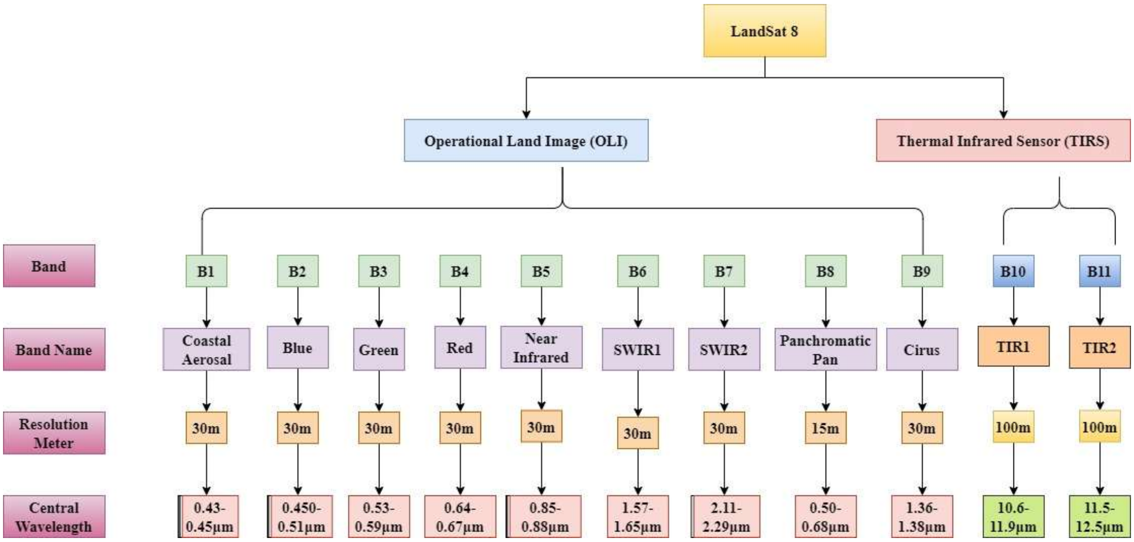
Band Number	B1	B2	B3	B4	B5	B6	B7	B8	B8a	B9	B10	B11	B12
Resolution Meter	60m	10m	10m	10m	20m	20m	20m	10m	20m	60m	60m	20m	20m
Central Wavelength	433nm	490nm	560nm	665nm	705nm	740nm	783nm	842nm	863nm	940nm	1375nm	1610nm	2190nm
Band Name	Ultra Blue	Blue	Green	Red	VNIR	VNIR	VNIR	VNIR	VNIR	SWIR	SWIR	SWIR	SWIR

Fig. 1: Sentinel 2 Band details.



Band Number	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13
Resolution Meter	20m	65m	35m	30m	15m	15m	20m	115m	20m	20m	30m	90m	180m
Central Wavelength	433.9nm	496.6nm	560.0nm	664.5nm	703.9nm	740.2nm	782.5nm	835.1nm	864.8nm	945.0nm	1373.5nm	1613.7nm	2202.4nm
Band Name	Coastal aerosal	Blue	Green	Red	VRE	VRE	VRE	NIR	NIR	Water Vapour	SWIR	SWIR	SWIR

Fig. 2: Sentinel 2A Band.



Band	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
Band Name	Coastal Aerosal	Blue	Green	Red	Near Infrared	SWIR1	SWIR2	Panchromatic Pan	Cirus	TIR1	TIR2
Resolution Meter	30m	30m	30m	30m	30m	30m	30m	15m	30m	100m	100m
Central Wavelength	0.43-0.45µm	0.450-0.51µm	0.53-0.59µm	0.64-0.67µm	0.85-0.88µm	1.57-1.65µm	2.11-2.29µm	0.50-0.68µm	1.36-1.38µm	10.6-11.9µm	11.5-12.5µm

Fig. 3: Landsat 8 Band details.

Table 2: MODIS band details. (Band 1&2 has 250m of spatial resolution, Band (3 to 7) has 500m of spatial resolution, and Band (8 to 36) has 100m of spatial resolution).

Band Number	Band Name	Resolution Meter (m)	Central Wavelength (µm)
B1	VIS	250m	0.620-0.670 µm
B2	NIR	250 m	0.841-0.876 µm
B3	VIS	500 m	0.459-0.479 µm
B4	VIS	500 m	0.545-0.565 µm
B5	NIR	500 m	1.230-1.250 µm
B6	SWIR	500 m	1.628-1.652 µm
B7	SWIR	500 m	2.105-2.155 µm
B8	VIS	1000 m	0.405-0.420 µm
B9	VIS	1000m	0.438-0.448 µm
B10	VIS	1000 m	0.483-0.493 µm
B11	VIS	1000 m	0.526-0.536 µm
B12	VIS	1000 m	0.546-0.556 µm
B13	VIS	1000 m	0.662-0.672 µm
B14	VIS	1000 m	0.673-0.683 µm
B15	VIS	1000 m	0.743-0.753 µm
B16	NIR	1000 m	0.862-0.877 µm
B17	NIR	1000 m	0.890-0.920 µm
B18	NIR	1000 m	0.931-0.941 µm
B19	NIR	1000 m	0.915-0.965 µm
B20	MWIR	1000 m	3.660-3.840 µm
B21	MWIR	1000 m	3.929-3.989 µm
B22	MWIR	1000 m	3.929-3.989 µm
B23	MWIR	1000 m	4.020-4.080 µm
B24	MWIR	1000 m	4.433-4.498 µm
B25	MWIR	1000 m	4.482-4.549 µm
B26	SWIR	1000 m	1.360-1.390 µm
B27	TIR	1000 m	6.538-6.895 µm
B28	TIR	1000 m	7.175-7.475 µm
B29	TIR	1000 m	8.400-8.700 µm
B30	TIR	1000 m	9.580-9.880 µm
B31	TIR	1000 m	10.780-11.280 µm
B32	TIR	1000 m	11.770-12.270 µm
B33	TIR	1000 m	13.185-13.485 µm
B34	TIR	1000 m	13.485-13.758 µm
B35	TIR	1000 m	13.785-14.085 µm
B36	TIR	1000 m	14.085-14.385 µm

Band Name Abbreviations: VIS**:** Visible, NIR: Near-Infrared, SWIR: Short Wave Infrared, MWIR: Midwave Infrared, TIR: Thermal Infrared

15m. The Landsat 8 consists of 11 bands in which the first nine spectral bands belong to OLI and the last two spectral bands belong to TIRS.

Fig. 3 represents Landsat 8 band details.

The Landsat 8 dataset is free and it's openly available for all users.

Description of MODIS

The MODIS satellite is known as (Moderate Resolution Imaging Spectroradiometer) which was launched by NASA. The swath width of MODIS is 2,330 km which can view the entire Earth's surface in two days. It can able to provide information regarding land, atmosphere, and ocean. The MODIS satellite contains 36 spectral bands and can able to obtain the data at three different spatial resolutions: 250m,500m, and 1000m.

The MODIS dataset is free, and it's openly available for all users. The MODIS band details are mentioned in Table 2.

Comparison of Different Satellites and Their Parameters

A comparison has been made between MODIS, Landsat 8, and Sentinel 2, which is represented in Fig. 4. which highlights the different features and unique characteristics of each satellite.

Different Types of Spectral Indices

With the help of remote sensing, different kinds of spectral indices are used to evaluate the growth of the crop. When it

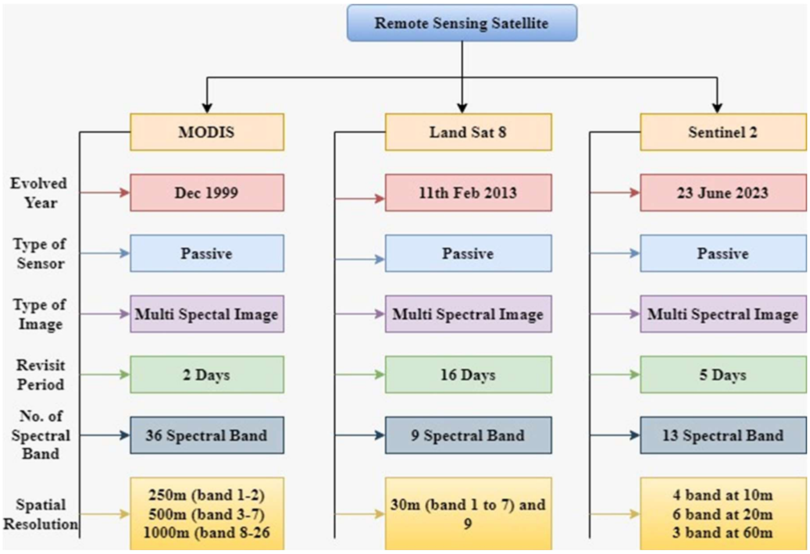


Fig. 4: Satellite features and metrics.

comes to monitoring the crop, the spectral indices which are listed below are the most important things, which include the physical Input like Sunlight, Rainfall, Temperature, and soil.

The spectral indices calculation is done for Landsat 8 and Sentinel 2, and the formula is derived by using the band numbers that are used specifically for the particular satellite.

1. Normalized Difference Vegetation Index(NDVI)
2. Enhanced Vegetation Index(EVI)
3. Advanced Vegetation Index(AVI)
4. Bare Soil Index(BSI)
5. Soil Adjusted Vegetation Index(SAVI)
6. Green Coverage Index(GCI)
7. Normalized Difference Water Index(NDWI)
8. Normalized Pigment Chlorophyll Ratio Index(NPCRI)

Normalized Differences Vegetation Index (NDVI)

The NDVI is computed by using the Red and Near Infrared spectral bands. For identifying the vegetation the NDVI is used. The NDVI can also be used for identifying the crop and its health. Higher the reflectance of Near Infrared implies dense and healthy vegetation.

The standard formula for estimating the

$$\mathrm{NDVI} = (\mathrm{NIR} - \mathrm{Red})/(\mathrm{NIR} - \mathrm{Red})$$

The spectral bandwidth and color differ according to the satellite

Enhanced Vegetation Index (EVI)

EVI is almost familiar with NDVI; the EVI is used to calculate the vegetation greenness and does the atmospheric correction, and the EVI is used to remove the canopy background noise in dense vegetation areas.

The standard formula for estimating the

$$\mathrm{EVI} = \mathrm{G} * \frac{(\mathrm{NIR}-\mathrm{R})}{(\mathrm{NIR}+\mathrm{C1}*\mathrm{R}-\mathrm{C2}*\mathrm{B}+\mathrm{L})}$$

The spectral bandwidth and color are differed according to the satellite.

Where L denotes the canopy background; C denotes the Coefficient for atmospheric resistance

Advanced Vegetation Index (AVI)

The AVI is used to monitor the crops and forest changes over a period of time. The AVI is also similar to NDVI; by using the multi-temporal combination of both AVI and NDVI we easily identify the types of vegetation, and the crop phenology characteristics are extracted.

The standard formula for estimating the

$$\mathrm{AVI} = [\mathrm{NIR} * (1 - \mathrm{RED}) * (\mathrm{NIR} - \mathrm{RED})]^{1/3}$$

The spectral bandwidth and color are differed according to the satellite.

Bare Soil Index (BSI)

The Bare Soil Index (BSI) is used for soil mapping and crop identification by combining NDVI. To identify the soil variation, different combinations of spectral bands are used, like blue, red, near-infrared, and short-wave infrared. To aggregate the mineral composition of the soil short-wave infrared and red spectral bands are used.

The standard formula for estimating the

$$\mathrm{BSI} = ((\mathrm{Red} + \mathrm{SWIR}) - (\mathrm{NIR} + \mathrm{Blue}))/((\mathrm{Red} + \mathrm{SWIR} + (\mathrm{NIR} + \mathrm{blue}))$$

The spectral bandwidth and color are differed according to the satellite.

LANDSAT 8	SENTINEL 2
NDVI = (B5 – B4)/(B5 + B4)	NDVI = (B8 – B4)/(B8 + B4)

LANDSAT 8	SENTINEL 2
$\mathrm{EVI} = 2.5 * \frac{(\mathrm{B5} - \mathrm{B4})}{(\mathrm{B5} + 6 * \mathrm{B4} - 7.5 * \mathrm{B2} + 1)}$	$\mathrm{EVI} = 2.5 * \frac{(\mathrm{B8} - \mathrm{B4})}{(\mathrm{B8} + 6 * \mathrm{B4} - 7.5 * \mathrm{B2} + 1)}$

LANDSAT 8	SENTINEL 2
$\mathrm{AVI} = [\mathrm{B5} * (1 - \mathrm{B4}) * (\mathrm{B5} - \mathrm{B4})]^{1/3}$	$\mathrm{AVI} = [\mathrm{B8} * (1 - \mathrm{B4}) * (\mathrm{B8} - \mathrm{B4})]^{1/3}$

LANDSAT 8	SENTINEL 2
$\mathrm{BSI} = \frac{(\mathrm{B6} + \mathrm{B4}) - (\mathrm{B5} + \mathrm{B2})}{(\mathrm{B6} + \mathrm{B4}) + (\mathrm{B5} + \mathrm{B2})}$	$\mathrm{BSI} = \frac{(\mathrm{B11} + \mathrm{B4}) - (\mathrm{B8} + \mathrm{B2})}{(\mathrm{B11} + \mathrm{B4}) + (\mathrm{B8} + \mathrm{B2})}$

Soil Adjusted Vegetation Index (SAVI)

The SAVI is used to strive for the vegetation index by minimizing the soil brightness and its correct the low vegetation area. SAVI is mostly used in arid regions where vegetation cover is low to identify. The standard formula for estimating the SAVI is:

$$\mathrm{SAVI} = \frac{(\mathrm{NIR} - \mathrm{R})}{(\mathrm{NIR} + \mathrm{R} + \mathrm{L}) * (1 + \mathrm{L})}$$

NIR = pixel values from the near-infrared band

Red = pixel values from the near-red band

L = green vegetation cover, the value of L depends on the following: where

L = 0.5 (Moderate Green Vegetative Cover)

L = 0(High Vegetation Cover)

L = 1(No green Vegetation Cover)

The spectral bandwidth and color differ according to the satellite

Green Coverage Index (GCI)

The Green Chlorophyll Index is used to identify the chlorophyll present in different species of plants by which the vegetation state is measured. The chlorophyll value directly reflects the vegetation. The standard formula for estimating the GCI is:

$$\mathrm{GCI} = \frac{(\mathrm{NIR})}{(\mathrm{Green}) - 1}$$

The spectral bandwidth and color are differed according to the satellite.

Normalized Difference Water Index (NDWI)

The NDWI is used to enhance the features of the water bodies in the satellite image. The primary aspect of using the NDWI is to detect the water and monitor the changes in the water bodies. The NDWI uses NIR and SWIR spectral bands.

The following ranges can evaluate the NDWI,

-1 to -0.3 indicates a Drought area

-0.3 to -0.0 indicates Moderate Drought area

0.0 to 0,2 indicate Flooding and Humidity

0,2 to 1 indicate Water Surface Area

The standard formula for estimating the

$$\mathrm{NDWI} = \frac{(\mathrm{NIR} - \mathrm{SWIR})}{(\mathrm{NIR} + \mathrm{SWIR})}$$

The spectral bandwidth and color are differed according to the satellite.

Normalized Pigment Chlorophyll Ratio Index (NPCRI)

Identifying the chlorophyll pigment in the crop is one of the important parameters by which we can determine the physiological changes in the crop. The NPCRI is used to evaluate the chlorophyll content by using the red and blue spectral bands. The information driven by the NPCRI is used to measure chlorophyll and nitrogen. The standard formula for estimating the NPRCI is:

$$\mathrm{NPCRI} = \frac{(\mathrm{Red} - \mathrm{Blue})}{(\mathrm{Red} + \mathrm{Blue})}$$

The spectral bandwidth and color are differed according to the satellite.

LANDSAT 8	SENTINEL 2
$\mathrm{SAVI} = \frac{(\mathrm{B5} - \mathrm{B4})}{(\mathrm{B5} + \mathrm{B4} + 0.5) * (1.5)}$	$\mathrm{SAVI} = \frac{(\mathrm{B8} - \mathrm{B4})}{(\mathrm{B8} + \mathrm{B4} + 0.428) * (1.428)}$

LANDSAT 8	SENTINEL 2
$\mathrm{GCI} = \frac{(\mathrm{B5})}{(\mathrm{B3}) - 1}$	$\mathrm{GCI} = \frac{(\mathrm{B9})}{(\mathrm{B3}) - 1}$

LANDSAT 8	SENTINEL 2
$\mathrm{NDWI} = \frac{(\mathrm{B3} - \mathrm{B5})}{(\mathrm{B3} + \mathrm{B5})}$	$\mathrm{NDWI} = \frac{(\mathrm{B3} - \mathrm{B8})}{(\mathrm{B3} + \mathrm{B8})}$

LANDSAT 8	SENTINEL 2
$\mathrm{NPCI} = \frac{(\mathrm{B4} - \mathrm{B2})}{(\mathrm{B4} + \mathrm{B2})}$	$\mathrm{NPCI} = \frac{(\mathrm{B4} - \mathrm{B2})}{(\mathrm{B4} + \mathrm{B2})}$

An Overview of Remote Sensing and its impact

The land is a gift from nature that the land wants to be preserved, protected, and valued for future generations. The Land that is used for agricultural purposes is known as Cultivable land. The land is the only thing on the Earth that protects all the valuable natural resources like water, soil, forest, and coal. Due to the population increase, the demand and need for food products are getting increasing a lot. The land that is used for production is decreasing day by day due to the Infrastructural development of urban places. In India, 51.09% of the land is only used for cultivation purposes. The Land should reside two important factors which are useful for agriculture purposes known as soil and water.

The Literature survey has been categorized into two different sections. In each of these sections, the different parameters that directly are indirectly influence the growth of the paddy crop are discussed.

Section I: Soil

Soil is an essential part of agriculture. Soil provides formalistic support for agricultural purposes, and it also can be categorized into two different types, physical and chemical based on their properties. Soil health and soil Quality are two major factors that influence the growth of the crop. Soil health represents finite and non-renewable resources. Soil quality represents nutrients, which is held in that healthy soil is identified by the growth of the crops and its nutrition properties. These nutrients are inherited by the crops from the soil and produce nutritious food (Laishram et al. 2012). The soil that is most suitable for agricultural purposes is known as alluvial soil, which is whole and very fertile, and this is the loamy type, which is highly productive for the growth of the crop. The pH of soil ranges from 3.5 to 10. In higher rainfall areas, the pH range of the soil ranges from 5 to 7. Soil quality management will ensure a great impact in guaranteeing agricultural sustainability. Thus we must pay more attention to the land and soil also to ensure the environmental quality will be in a stable position.

The purpose of Soil Moisture Active Passive (SMAP) purpose is to establish high-resolution soil moisture, which has suffered disdainfully due to the failure of the L -the band Synthetic Aperture Radar. To overcome this problem, the author (Entekhabi et al.2010) evaluated the capability of ingesting ISRO's Radar Imaging Satellite-1 (RISAT-1) C-band SAR observation. The SMAP active, passive algorithm obtains the soil moisture at 1, 3, and 9 km over the agricultural region dominant by paddy that experiences seasonal flooding.

A phenology-based algorithm (Li et al. 2020) was developed to identify the unique features of the paddy. One of the major factors that influence the growth of paddy is soil, and this parameter is considered for the different seasonal paddy crops cultivated. The Normalized Vegetation Index and Soil Vegetation Index are used to highlight the changes in the temporal differences. The growth phase of the paddy based on soil from the initial stage to the heading stage of the paddy is evaluated. For the regional scale estimation, this algorithm is better by comparing the statistical data and Landsat data, where higher accuracy is achieved.

Gasmi et al.2020 propose a new method known as Multilayer Perceptron with Backpropagation Learning Algorithm, which is used to evaluate the soil and the clay prediction by using satellite data. By combining the spectral, temporal, and spatial resolution of the satellite data, a fused image is derived where the prediction of soil obtained a higher accuracy value by adding the soil property to the soil clay map, which is used to derive the spectral index of the satellite image. Since different combinations of satellites are used together to obtain the satellite image, the multispectral bands are one of the most important tools to map the soil parameters.

Jun et al. (2020) proposed a new algorithm for monitoring the paddy soil. It is known as an improved Surface Energy Balance Algorithm for land (SEBALR), and this method is used to identify the paddy field evapotranspiration. This is useful for monitoring and controlling the water management system. An accurate estimate for paddy growth and its evapotranspiration is done by using SEBAL.

Soil is an important factor in the growth of paddy fields. To evaluate the soil Dynamic (Tang et al. 2023), use the CFD-DEM coupling method, which is used to identify the soil characteristics, properties, and resistances with a high accuracy level and to identify the surface energy level of the paddy field. The coupling method is combined with spherical particles Johnson-Kendall-Roberts (JKR) only 10% of the relative error rate is achieved for the soil disturbance characteristics.

Soil plays a massive role in the growth of the paddy crop (Liu et al. 2023). The Mean Residence Time (MRT) of the accumulation of carbon in the soil helps to upland paddy crops, keeping in the aspect of global warming, the accumulation of carbon, can be reduced by paddy. The author of the paper estimates the average percentage of Carbon(C) increases by 7% during the monsoon time in the Asia region.

Section II: Water

Water is one of the most valuable natural resources for agriculture. Plants and crops continuously need water for better yield and growth. Without water, the agriculture sector can't remain for future generations. In ancient times, agriculture mainly depended on rainfall, but nowadays, many places in India depend on groundwater for agricultural purposes. Water is the most basic thing to produce a healthy crop. In India 17% of GDP is contributed by agriculture, in which the irrigated agriculture serves 20% and the total cultivated land serves 40%. Our Globe is canopied by 71% of water but the availability of fresh water is less than 1%. Efficiently utilizing and managing water resources can lead to the progressive development of our country (Ramasubbu & Rajendran 2020). By increasing agricultural water productivity for future generations, some of the issues can be resolved, like food demand, economic growth impact to reduce poverty, and ensuring the water is available for environmental usage (Molden et al. 2011).

To overcome the shortage of water in agricultural activities NASA develops a Terrestrial Observation and Prediction System (TOPS) for remote sensing satellites like Landsat and MODIS (Melton et al. 2012). The Satellite Irrigation Management Support, when combined with TOPS, provides data regarding water resources, soil moisture, and irrigation, which is useful for the end user, and this framework is also useful for identifying crop water requirements.

Water plays an important role in agriculture. Water management must be done for future generations to improve agricultural activity and supply food based on demand. Different kinds of technologies are effectively involved in this, like IOT, Cloud computing, and Wireless Sensor Networks (Saad et al. 2020). To overcome the drawbacks that we face in traditional methods to and effectively utilize water resources, the current technologies are very useful.

Water Quality (WQ) is the most important factor for all the regular activities present on the surface of the land. Ensuring the quality of the water for water resource management is not an easy task. The author (AI-Sulttani et al. 2021) uses different kinds of Ensemble models like QRF, SVM, RF, GBM, and GBM_H2O to predict the accuracy of the water quality two different feature algorithms like Principal Component Analysis (PCA) and Genetic Algorithm are incorporated with these models in which PCA perform better than Genetic Algorithm.

Using the advanced microwave Scanning Radiometer 2 (AMSR2) (Jiang et al. 2022) proposed a predicting water vapor, but its results in high spatial coverage with low temporal resolution. To overcome this, the Global Navigation Satellite System (GNSS) is used, which results in high temporal resolution and low spatial coverage; by combining these two technologies, a new Back Propagation Neural Network (BPNN) is introduced, which clearly retrieves the water vapor for global scale. The Global Navigation Satellite System is used to provide data regarding water vapor and to measure the water vapor in spatial resolution within a city limit. The Integrated Water Vapour (IWV) (Marut et al.2022) is used to determine precise changes in the weather model. The GNSS is used to capture the wet and dry changes and their conditions, but the IWV is the first and foremost to analyze the regional scale changes.

For agriculture, ground water is the most important criterion to supply water for the field. Decreases in groundwater lead to depending on the rainfall and other modes of water for the field. To tackle this issue, the author (Leonard et al. 2023) proposes a new concept known as Groundwater Dependent Vegetation (GDV), and this concept is used to identify the groundwater by using Sentinel 2 data. The wet area, which remains green in the dry period, is identified. The hydrogeological parameters are taken into consideration for deriving an accurate result. The vegetation area for agriculture purposes with groundwater is identified as 90% using GDV.

The primary need for agriculture is water based on a good irrigation system. The need and supply of water to the land can be achieved effortlessly. The author (Zhao et al.2023) proposed water-saving Irrigation Technology (WSI), which is known as alternative wetting and Drying Irrigation (AWD). The rainfall after irrigation is considered a waste of natural source water. Collecting the rainfall can be helpful to supply during the demand period, and AWD achieves this. During the Dry period the AWD has achieved excellence in water facility.

Section III: Remote Sensing Impact for Monitoring the Paddy Crop

The primary role of remote sensing in agriculture is to provide information about the physical characteristics of the land, and the sensors which are present that measure the wavelengths of the light absorbed and reflected by green plants. There are various applications of remote sensing like monitoring weather, forestry, agriculture, etc.. In general, remote sensing images are characterized by spectral resolution, spatial resolution, temporal resolution, and radiometric resolution, which is represented in Fig 5.

(Jo et al. 2020) uses three different kinds of deep learning applications to overcome the problems in Paddy for classifying the labeled data. Deep learning applications like data augmentation, semi-supervised classification, and domain-adapted architecture. By using this application, a pixel-based comparison and statistical evaluation is done, which results in the diverse classification of paddy through satellite images.

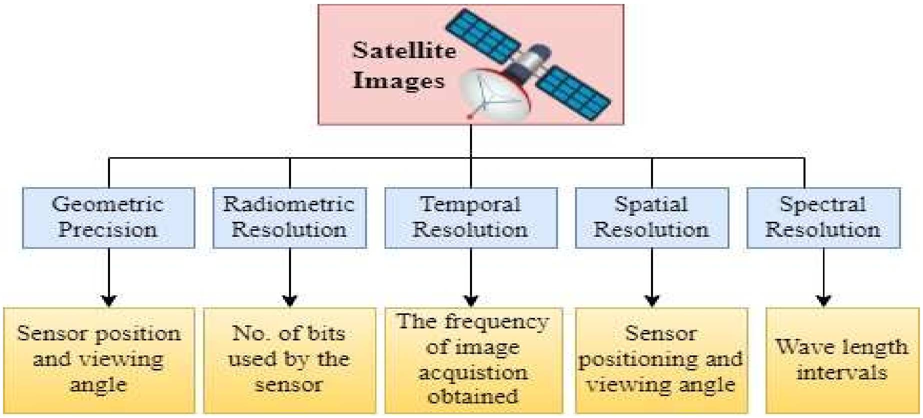


Fig. 5: Parameters influences for the satellite image.

Rice is considered one of the staple crops. Still, its growth and production consist of multifarious activities (Ramadhani et al.2020) that describe various factors that make us understand the shortage of rice production, like water, land, and climate. Accurate mapping of the rice growth stage via satellite image is difficult when it is covered with a cloud. To overcome this problem, an Automatic mapping of rice in real-time with a multitemporal map of the rice growth stage is proposed with the help of remote sensing data like Sentinel 1,2 and Mod13Q1. With this fusion of remote sensing data, good accuracy has been achieved, which helps to map the rice growth at local, national, and regional levels.

A gradient-boosted regression (GBR) is proposed by (Arumugam et al. 2021), which is used to estimate the rice yield from 500m of spatial resolution in India. This approach estimates an accurate crop yield with near real-time estimates.

Remote sensing is a powerful tool for yielding rice estimates from the farm to the regional level. The estimation done by Remote sensing is reliable and more accurate level, (Dela et al. 2021) propose three different models to estimate the rice yield, which are known as the Empirical model, the Semi-empirical model, and the Process-based crop model. The Empirical model is used larger scale in estimating the rice yield. A semi-empirical model is used to estimate the harvest yield, and a Process-based crop model is used to identify crop growth.

To overcome the problem in both spatial semantic information of Landsat and the finest training dataset used to segregate the paddy rice mapping, the author (Lang et al. 2022) proposed a new network known as Full Resolution Network (FR- NET). By using the different band combinations, an excellent performance is achieved in the FR-NET. This FR-NET is most suitable for identifying the paddy rice mapping in the initial stage and last stage. The Multi-resolution Fusion Unit (MRFU) is used for segmenting the fine data from the Landsat. The FR-NET is composed of multiple MRFUs, which is useful for analyzing more features when compared to any other model. These MRFU are used for maintaining high-resolution stream of this model.

Yang et al. 2022 proposed a Temporal Feature Based Segmentation (TFBS), which is used for classifying paddy rice. This TFBS significantly performs well when compared with LSTM. By using the Synthetic Aperture Radar (SAR), different stages of crop growth are obtained by remote sensing images. The SAR provides the temporal and spatial features of the crop which is relatable for mapping the crop in a large area. The TFBS has achieved high accuracy in multicrop classification, and the best highlighting part of TFBS is the detachment of rice and non-rice features of the paddy crop.

Monitoring the rice at the regional level is not an effortless task (Xin et al. 2022). A new algorithm known as Feature Selection combines the sentinel 1 and sentinel 2 satellite images to predict on a large scale. Using the rice phenology characteristics like water and the color of the paddy helps to recognize the time of harvest. In general, there is a time interval period for the paddy crop to ensure the growth from the planting stage to the heading stage, and by using the rice phenology calendar, the harvest date is estimated. This algorithm is useful for regional-level estimation of paddy and the farmer.

RESULTS AND DISCUSSION

In the production of rice, India ranks second place among the leading countries. The production and the demand for rice are increasing globally since rice is considered an important source of food, and it's economically affordable for all people.

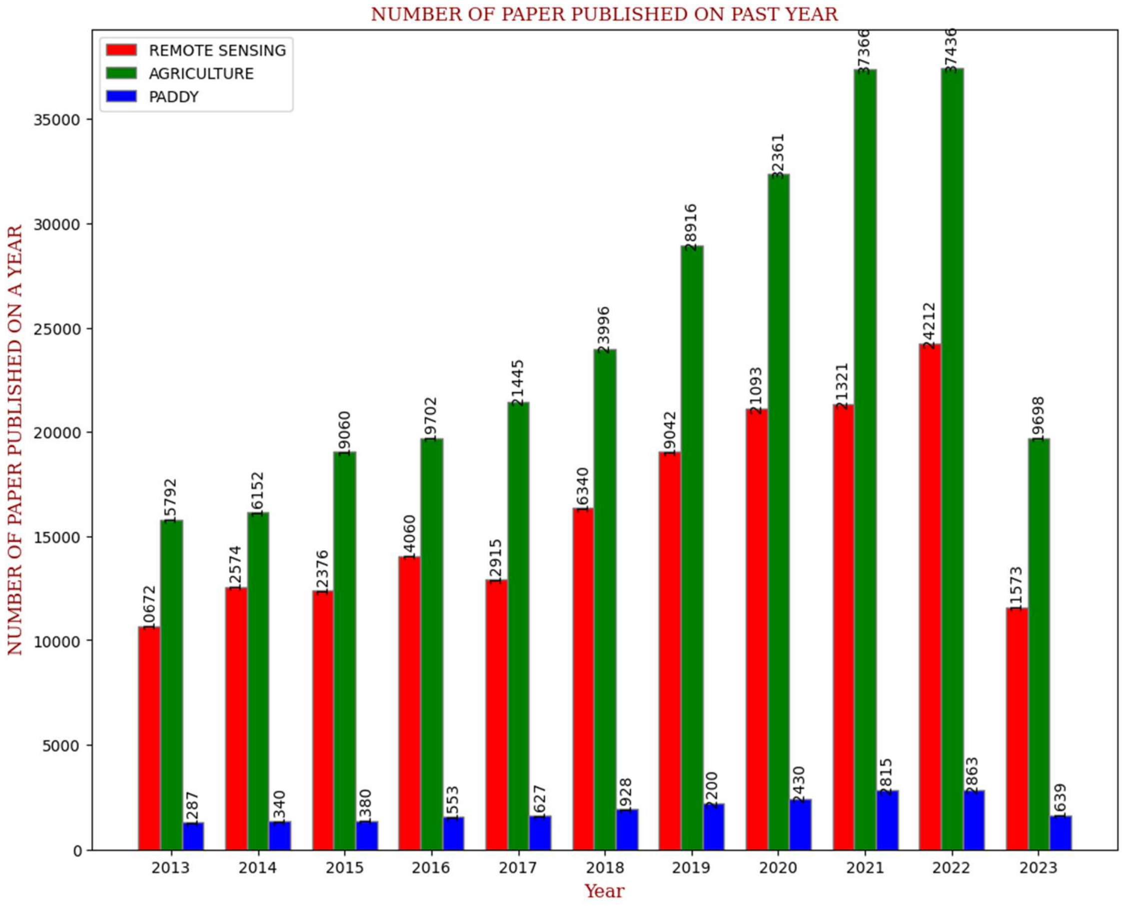


Fig. 6: Number of papers published on remote sensing, agriculture, paddy.

With the development of the Remote sensing technology, monitoring the crops has become an easy task with different methodologies and innovative algorithms for the prediction of crops; its yield forecasting the problems that occur for the crop has also become an effortless task. Different researchers in this field are proposing new ideas, in this decade, the number of papers published in this area is relatively high. A statistical report is taken from the Scopus database by entering keywords like 'Remote Sensing,' 'Agriculture,' and 'Paddy.' The Database retrieves a number of papers published in the last decade; prominent evidence is shown in Fig. 6. Due to the growth of technology and the importance given to agriculture, year by year, the number of papers published in this area is also increasing.

CONCLUSION

This paper has highlighted the importance of rice and the evolution of remote sensing in the agriculture field. With the development of these satellite technologies, monitoring the agricultural land has become an easy task, and monitoring the early stage of crop growth, crop production, yield, and crop damage helps to take necessary prevention steps for food control. Since rice is a highly consumed food by all genders of people in India, demand for this paddy crop is growing day by day, and equal importance should be given to soil and water because these two greatly influence the growth of the paddy crop.

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