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Rice Mapping and Various Stages of Rice Growth using Sentinel-1 SAR Data-A case study of Mahabubnagar District, Telangana

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***Abstract:** Space Based technology both optical and microwave SAR Data is used to monitor the Earth at regular intervals which has its application in various fields viz., agriculture, water, urban and so on. Synthetic Aperture Radar (SAR) has its advantage to penetrate through clouds, day-night imaging, all weather conditions and high resolution making it an effective system for crop monitoring, especially during Monsoon Season, as Optical Sensors doesn't provide cloud free data. Sentinel-1 data has been used in recent studies to map and monitor rice-growing areas. The Sentinel-1 IW GRD data were used to monitor the rice-growing area over Mahabubnagar District of Telangana State, which was processed in SNAP Software. Few plots were selected by conducting field survey during Kharif 2021. The Radar Vegetation Index (RVI) have been used to monitor the fluctuations in various stages of rice growth. This paper explains how multi temporal SAR observations can be used to monitor rice growing stages, as well as how to interpret σ°VHand σ° VV back scattering co-efficient.*

***Keywords:** SAR, Backscattering, Polarization, Sigma Naught, Radar Vegetation Index*

I. INTRODUCTION

The most popular rice, Oryzasativa, is an important stable crop for people around the world, especially in Asian countries [1,2]. India, China, Indonesia, Bangladesh and Thailand lead the production and consumption of rice in Asian countries [3,4]. In India, rice is widely cultivated in the Southern and Northern states viz, Punjab, Haryana. The important crops grown in Telangana are Rice (14.19) lakh ha, Maize (6.63) lakh ha, Pulses (6.11) lakh ha, Groundnut (1.89) lakh ha, Cotton (18.13) lakh ha, Chillies (0.83) lakh ha and Sugarcane (0.41) lakh ha [5]. Synthetic aperture radar (SAR) data are well suited for monitoring rice crops, especially in tropical and subtropical regions. Areas where ubiquitous clouds during the rainy season prevent the use of optical data. Also, SAR observations are sensitive to growth stage, LAI and biomass, crop height, soil moisture, and flood frequency and period [6,7]. Therefore, SAR is mainly useful for mapping rice area and rice growth monitoring.

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SAR Data has many usages like flood mapping, oil palm plantations, oil spill monitoring, rice monitoring etc. It can monitor the crops at district level and as well as at farm level. This paper focuses on temporal analysis of backscatter co-efficient VH & VV values for monitoring the rice growth during Kharif Season (2021) on selected plots in Mahabubnagar District of Telangana State.

II. STUDY AREA

Mahabubnagar is one of Telangana's districts. Palamooru and Mahabubnagar are two names for the same place. The city was once known as "Rukmammapeta." Itis 98 kilometres from Hyderabad, 130 kilometres from Kurnool, and 105 kilometres from Raichur. The eastern longitudes of the district are 77°15' and 79°15'E, and the northern latitudes are 15°55' and 17°20'N. Rice, jowar, bajra, and ragi are the main foodgrain crops in Mahabubnagar, while groundnut, castor, chillies, and tobacco are the main commercial crops. The main pulse crop is red gram. It is known for its several diamond mines, including the Golconda mine, and is thought to be the birthplace of the renowned Kohinoor diamond. Figure 1 depicts the location map.

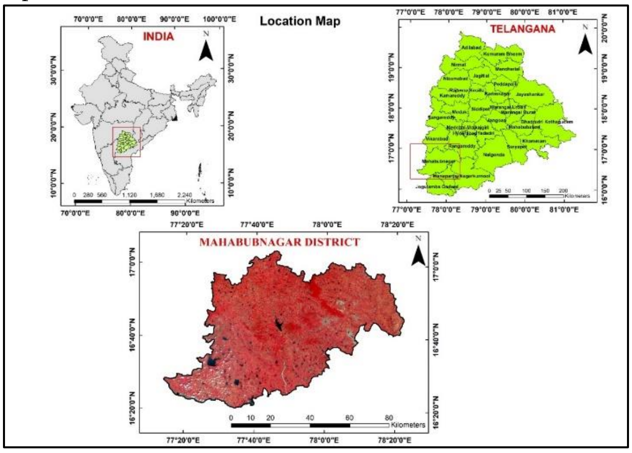

Figure 1. Location Map of the Study Area

III. DATASETS

Sentinel-1 is a constellation of twin satellites S1A and S1B with C-band (5.405 GHz frequency) imaging capability which was launched on 3rd April 2014 and 25th April 2016 respectively. The revisit time of a single satellite is 12 days whereas the two combined together makes a revisit of 6 days.

Sentinel-1A are sun-synchronous, near polar and circular at an altitude of 693 km.

There are four modes in Sentinel-1: Interferometric Wide swath mode (IW), Wave mode (WV), Strip mode (SM) and Extra wide swath mode (EW). Swath width of IW mode is 250km and spatial resolution is 10m. In this research, Sentinel-1 SAR IW mode Ground Range Detected (GRD) Products have been used. Sentinel-1 is downloaded from Copernicus Sentinel Data Hub which is freely downloadable.

The time-series datasets for VH (dual polarization; vertical transmit; horizontal receive)& VV (co-single polarization; vertical transmit; vertical receive) for Monsoon Season (May to Sep) with acquisition dates used are: 1st May 2021, 13th May 2021, 25th May 2021, 6th June 2021, 18th June 2021, 25th June 2021, 12th July 2021, 24th July 2021, 5th Aug 2021, 17th Aug 2021, 29th Aug 2021 and 10th Sep 2021.

IV. METHODOLOGY

Pre-processing of Sentinel-1 imagery was performed with SNAP. SNAP is an open-source software used for processing SAR Data.

The steps were carried out in Batch Processing Module available in SNAP “Graphical Builder”. To generate sigma naught (σ°) images, radiometric calibration has been carried out. To remove the speckle noise, Lee Sigma filtering (5 X 5 kernel) method was adopted and Range Doppler Terrain corrections were carried out with the help of SRTM DEM (30m resolution).

The data was converted from linear to decibels (dB) domain after being radiometrically ortho-rectified and terrain corrected. Terrain corrected Sigma naught images(σ°) of VV and VH polarizations were used for deriving polarization index. Figure 4 shows the methodology adopted for SAR Data processing in SNAP Software. Rice fields in Mahabubnagar District, Telangana State, was visited on 6th September 2021 during harvesting phase (Figure 2), and about6 rice field polygons were made in the field using the GL and Measure App.

These polygons were then saved to KML format, which can be easily viewed in software like ArcMap or QGIS (Figure 3).

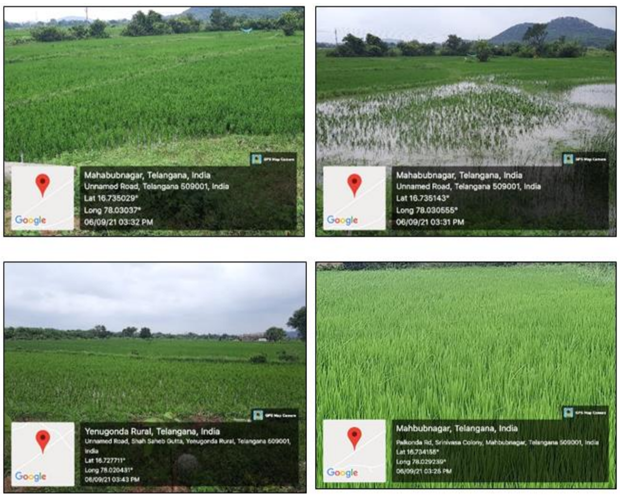

Figure 2: Rice Fields (Images from Field Visit)

Figure 3: Plots drawn using Gland Measure App, visualized in ArcMap

SAR data were downloaded and analyzed in SNAP software from sowing to harvesting (May to September), as shown in the flowchart. Sigma Naught (σ°) VH and VV (in db) have been calculated for each plot's respective dates. Then σ° db values are converted to Linear in SNAP for calculation of Radar Vegetation Index. The index is based on measured linear scattering intensities from co- and cross-polarization. Radar Vegetation Index (RVI) is given by:

$$RVI = (4 * VH) / (VV + VH)$$

RVI ranges from 0 to 1. It is near to zero for smooth bare surface and increases with vegetation growth [8].

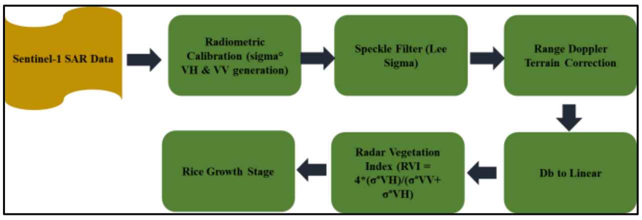

Figure 4. Flowchart Methodology

V. RICE GROWING STAGES

Rice is mostly grown in irrigated or lowland rainfed environments. Different rice types have a total growing period ranging from 90 to 140 days. The primary phenological stages of rice during this growth season are (1) leaf development; (2) tillering; (3) stem elongation; (4) heading; and (5) grain development and ripening [9].

VI. RESULTS & DISCUSSIONS

Figures 5 and 6demonstrate the SAR backscatter response in linear cross-pol (VH) and co-pol (VV) over the growth season. The backscatter intensities of VH (dB) change dramatically for different plots on a given date and over time. After the 25th of May, all plots show an increase in VH and VV backscatter. This is due to an increase in rice wet biomass during the tillering and stem development stages. As demonstrated in Figures 5 and 6, the cross-pol (VH) and co-pol (VV) backscatter intensities increase from May 25th with the primary vegetative growth, such as tillering and stem elongation for rice crops.

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Backscatter is proportional to a target's dielectric constant, hence backscatter normally increases as the amount of water in the vegetation increases [10]. Similarly, as wet biomass drops, the backscatter intensity falls, as seen after August 29th with rice ripening stage. Microwave responsiveness is also influenced by soil conditions (moisture and roughness). The contribution of the soil, on the other hand, will be determined by penetration depth, which is influenced by frequency and canopy development.

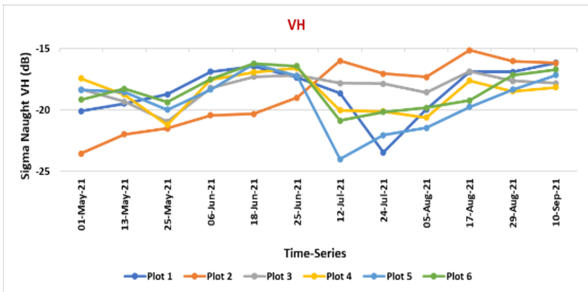

Figure 5: Temporal response of cross-pol (VH) backscatter coefficients for different plots

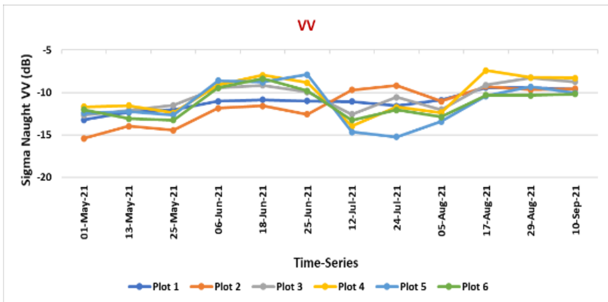

Figure 6: Temporal response of co-pol (VV) backscatter coefficients for different plots

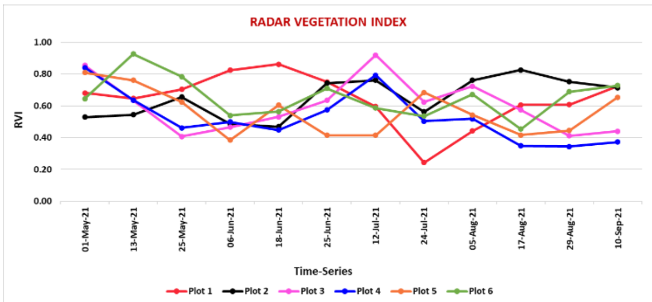

Figure 7: Rice Growth Profile based on Radar Vegetation Index

The above figure shows rice across profile across the time-series from May to 10th Sep 2021. From the index profile it is seen that the growth started after 12th July and ready to harvest by end of Aug – Sep (Figure 7).

VII. CONCLUSION& SUGGESTION

Sentinel-1 Backscattering values of VH and VV were used to identify the various stages of rice growth. However, the RVI shows better result, the changes observed during various stages of rice growth from sowing to harvesting. According to the field visit and information obtained from farmers, "Transplanted Rice" cultivation is practised throughout the majority of the state. This type of cultivation requires more water consumption, more labourers, more manual work hours. Hence, new technologies should be adopted to boost rice production and conserve natural resources. Two new technologies are: Direct Seeded Rice Technology and System of Rice Intensification (SRI). However, further research and analysis needs to be carried out for these two new technologies.

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AUTHOR'S PROFILE

Aloshree Choudhury is an experienced Remote Sensing and GIS professional with 8+ years of total experience in Water Resources and Agriculture Domain. Currently, working at Grow Indigo as Remote Sensing Scientist in Agriculture Domain. Prior to that, she worked at National Remote Sensing Centre – ISRO, Hyderabad as Research Fellow for NICES project and Research Scientist for National Hydrology Project under Water Resources Group from 2015 to 2020. She has completed her Masters in Remote Sensing and GIS from S.R.M. University, Chennai in the year 2014 with Distinction and Bachelors in Civil Engineering in the year 2012 from S.R.M. University with Distinction. She's pursuing her Ph.D. from Andhra University, Vishakhapatnam in Civil Engineering Department.

Dr. Vazeer Mahammood is a professor of Civil Engineering in Andhra University. Currently he is serving as Head of the Department in Geo-Engineering. He previously served as Assistant Principal of AUCO Eduring 2008-2010. He also rendered his services as a Deputy Director of the Regional Centre for Educational Development of Minorities for A.P state Govt. He held the position of Associate director, A.U. Admissions, during 2013-2017. Since 2017 he has been assigned as Dean (Engineering Works).

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Dr. K. H. V. Durga Rao, Designation: Group Head, Disaster Management Support Group, RSA National Remote Sensing Centre (NRSC), ISRO, Hyderabad Have been working with NRSC, ISRO for the last 27 years in various capacities

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Fellow, Indian Water Resources Society
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Expertise and Area of Research:
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