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Rice Monitoring Using Sentinel-1 data in Google Earth Engine Platform†

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Abstract: Rice is the most essential and nutritional staple food crop worldwide. There is a need for accurate and timely rice mapping and monitoring which is a pre-requisite for crop management and food security. Recent studies utilize Sentinel-1 data for mapping and monitoring rice grown area. The present study was carried out in the Google Earth Engine (GEE), where the Sentinel-1data were used for monitoring the rice grown area over Kulithalai taluk of Karur district, located along the Cauvery delta region. Normally, the production of rice in the study area starts in the late Samba Season where the long duration variety Cr1009 (130 days) is extensively grown. The results exhibit a low backscattering values during the transplanting stage of VV and VH Polarization (-15.19 db and -24 db), whereas maximum backscattering is experienced at peak vegetation stage of VV and VH Polarization (-7.42 and -16.9 db) and there is a decrease in the backscattering values after attaining the maturity stage. Amongst VH and VV Polarization, VH Polarization provides a consistently increasing trend in backscatter coefficients from the panicle initiation phase to the early milking phase after which the crop attains its maturity phase, whereas in the VV Polarization early peak of backscatter coefficients are seen at much earlier during the flowering phase itself. Thus, in this study, VV Polarization gives better interpretation than VH Polarization in the selected rice crop fields. The obtained results were cross-validated by collecting the ground truth values during the satellite data acquisition time, throughout the crop growing period from the selected rice fields.

Keywords: Rice Monitoring, Sentinel-1, Google Earth Engine, Growing Stages, Backscatter

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1. Introduction

Oryza sativa, the most widely grown rice is an important stable crop for the people living in world that too especially for those in the Asian countries [1, 2]. India, China, Indonesia, Bangladesh and Thailand, tops the production and consumption of rice among the Asian countries [3, 4]. In India, the rice is extensively grown in the delta zones of southern and eastern states. The Cauvery delta zone (CDZ) present in the eastern part of Tamil Nadu has been playing a major role in the production of rice in South India, owing to the presence of fertile alluvial soil and supply of water for irrigation from the Cauvery River. As the crop requires more water and is planted during the summer, water from the Cauvery River greatly supports the production of rice in the CDZ. However, in recent years, due to the impact of various anthropogenic activities and climate change, there is a decrease in the availability of sufficient water in the Cauvery River to support the irrigation of crops especially rice. This eventually decreased the production of rice over the CDZ. Thus, proper mapping and monitoring of rice crop in the whole CDZ can help in taking conservative measures against the decrease in the rice crop production. There are two ways that helps in producing maps of rice croplands, which is: (i) through manual identification of each rice crop field using cadastral map and (ii) through heads-up digitization of cropland using high resolution optical and infra-red sensor images. Both of these methods are tedious and time consuming [4]. In this scenario, Synthetic Aperture Radar (SAR) based crop monitoring techniques have been highly utilised as an alternative which signals also penetrate the clouds and illumination situations [5,6]. In recent years, researchers have highly utilised SAR images that have a great advantage in the phenological monitoring of crops [7, 8]. High resolution Sentinel-1 SAR images have been recently in mapping and monitoring the rice fields [9, 10]. However, the pre-processing of Sentinel-1 SAR (time series analysis) for monitoring of crops can be a time consuming task where a cloud platform could ease the process. Massive computational power of Google Earth Engine (GEE) cloud platform can be used for monitoring and mapping of crops over a larger region where large amount of Earth Observation (EO) data is available for analysis [11-13]. Rice crops were mapped and monitored all over the Northeast India and Bangladesh using Sentinel-1 SAR images with the help of GEE platform [14].

In this study, a small rice cropland has been selected as a case study in the CDZ, for understanding VV and VH backscatter during different phenological stages of rice crop. Google Earth Engine (GEE) cloud platform is used in this study to analyze multiple SAR images, as it reduces the space and time for data acquiring and processing. The backscatter results from this study can be used in classifying the rice croplands in the CDZ using decision tree technique where thresholds can be set for classifying the rice fields.

2. Study Area

A small rice grown cropland is selected as a study area which is situated over the Kulithalai taluk of Karur district, located in the Cauvery delta region. The study area covers a total area of about 0.0631 km^2. The region receives high rainfall during north-east monsoon during the months of October to December. Normally, the production of rice in the study area starts in the late Samba Season where the long duration variety Cr1009 (130 days) is extensively grown. The study area extends from 10° 57′ 30″ N latitude to 10° 54′ 31″ N latitude and from 78° 24′ 26″ E longitude to 78° 26′ 54″ E longitude.

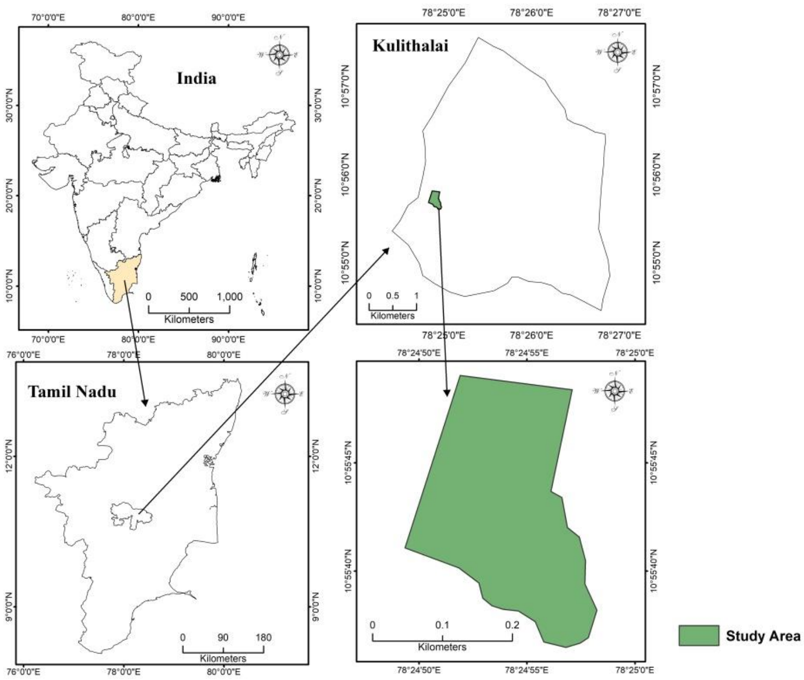

Figure 1. Geographical location of the study area

3. Dataset

Sentinel-1A Interferometric Wide (IW) Level 1 GRDH (ground-range detected, high resolution) product was utilised in this study. The 12-day repeat cycle data during the late samba growing season of 2018 from 09th September to 26th December was used in this study, when the rice crop is started growing in the study area. The spatial resolution of the data product is 10 m.

4. Methodology

The whole study was carried out in GEE cloud platform where the pre-processing steps were carried out as same as Sentinel-1 toolbox. This pre-processing helps in determining the backscatter coefficients in decibels (db) from each pixel. After pre-processing through GEE platform, the backscatter Sentinel-1 time series SAR images were filtered using the multi-temporal speckle filter in order to remove the noise due to speckle. Smoothing was carried out using boxcar kernel followed by band stacking, to retrieve the temporal backscatter values of VV and VH Polarization over the rice field during the different phenological stages of rice. The ground points have also been corrected in order to verify and validate the calculated backscatter coefficients. **Figure 2** represents the workflow carried out in this study.

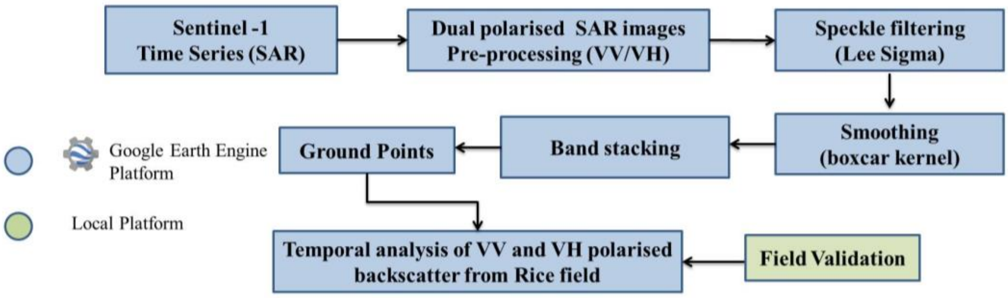

Figure 2. Methodology

The shapefile of selected rice crop field was ingested in GEE (Figure 3) and a web-based Interactive Development Environment (IDE) code was written using JavaScript (https://code.earthengine.google.com/d84a378043dc3df53666b285d2b53bb8), in order to estimate the backscatter coefficient values in decibels from the rice field. As GEE is a cloud platform, the pre-processing power of Sentinel-1 SAR images is utilised in this study. Major advantage of GEE is that, it can totally reduce the space and time required for data acquiring and pre-processing. This makes GEE suitable for mapping and monitoring the rice fields throughout the CDZ using the estimated backscatter coefficients from the rice field.

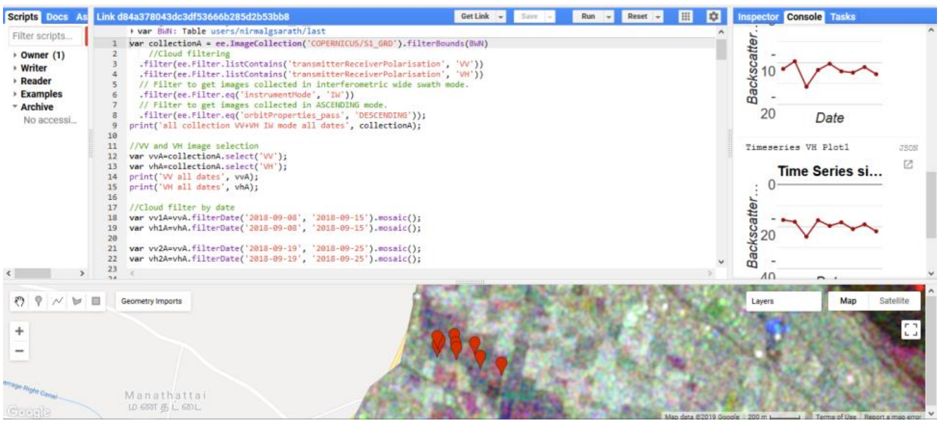

Figure 3. Deriving backscatter coefficients using Google Earth Engine

4. Results and Discussion

The sowing of seeds took place during 09th September 2018 while transplantation was carried out on 21 September 2018 followed by attaining vegetative stage at 03rd October 2018, where the stem elongation took place on 28th October. The reproductive stage started with booting on 08th November followed by heading stage on 20th November whereas the ripening stage is witnessed with flowering during 14th December and the harvest was carried out on 26th December 2018.

Generally, VV backscattering is higher than the VH backscattering and the backscattering coefficients progressively intensify during the crop growing stage and attains the peak between the beginning of the ripening stage and at the end of the reproductive stage after which again the backscatter coefficients starts dipping through the mature stage (Figure 4). The VV and VH Polarization backscatter images selected over the rice field are shown in the Figure 5 (a) and (b). The field photographs of the rice field are shown in the Figure 6. The results of VV and VH mean backscatter are shown in the Figure 7.

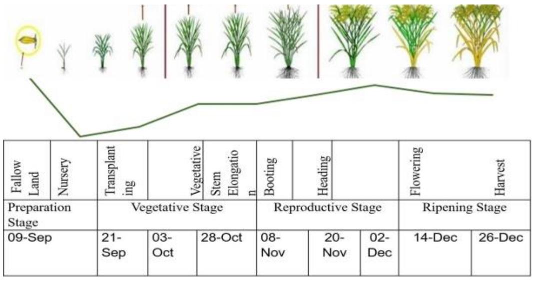

Figure 4. Backscattering trend through different phenological stages of rice

It is evident from the result that, a much lower backscattering compared to VV Polarization is witnessed in the VH Polarization, after sowing (during 09th September 2018). This lower backscattering from VH Polarization can be due to the presence of bare soil surfaces in the rice field during sowing (Figure 6).

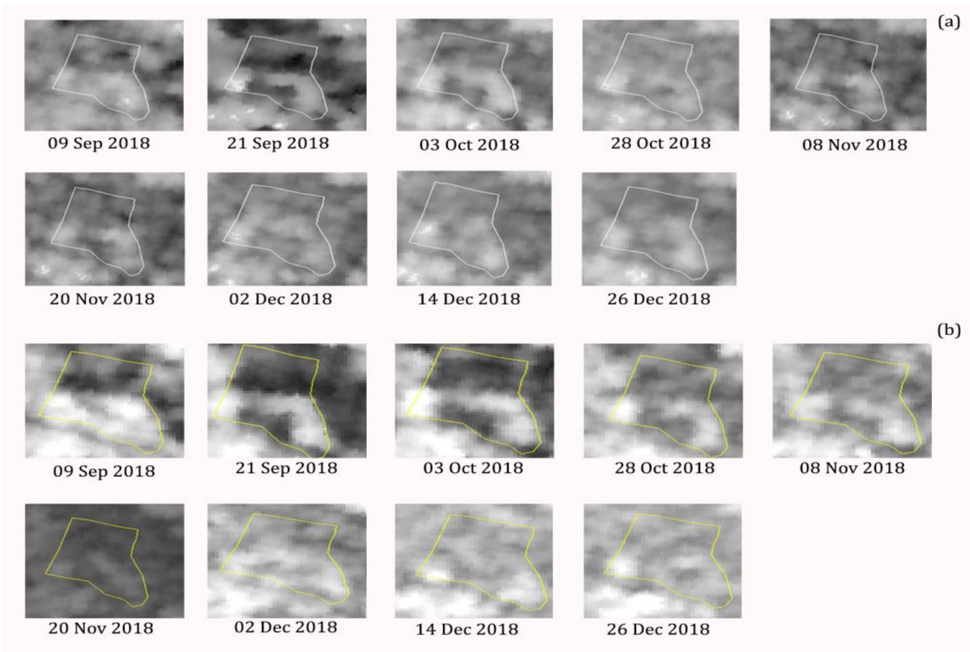

Figure 5. (a) VV Polarization backscatter images and (b) VH Polarization backscatter images

Figure 6. Optical rice field photographs

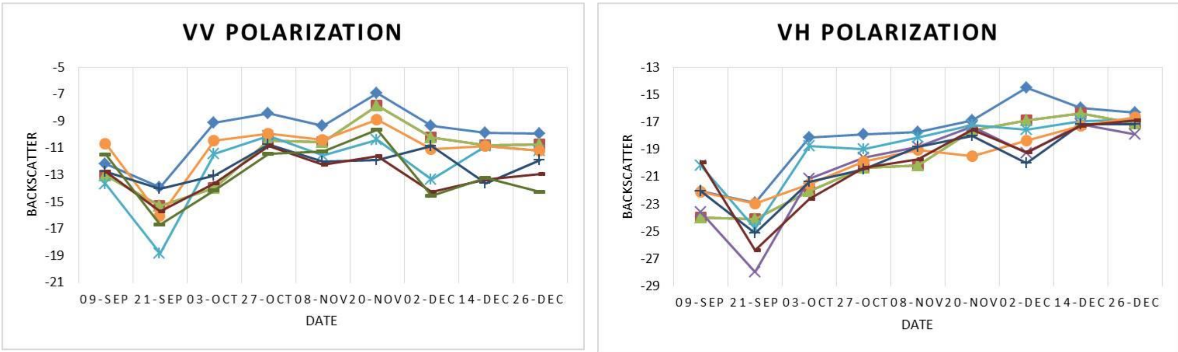

Figure 7. VV and VH Polarization backscattering coefficients during different phenological stages of rice.

The results from the study shows that the backscattering coefficients gradually increase over the phenological development of rice crop in the field (Figure 7). There is a sudden decrease in the backscattering during 21 September 2018, as there is water over the cropland, since the crop requires stagnant water in the field during transplantation, this mark a dip in the backscattering of VV and VH Polarization. The results exhibit a low backscattering values during the transplanting stage of VV and VH Polarization (-15.19 db and -24 db), whereas maximum backscattering is experienced at peak vegetation stage of VV and VH Polarization (-7.42 and -16.9 db) and there is a decrease in the backscattering values after attaining the maturity stage. Amongst VH and VV Polarization, VH Polarization provides a consistently increasing trend in backscatter coefficients from the panicle initiation phase to the early milking phase after which the crop attains its maturity phase, whereas in the VV Polarization early peak of backscatter coefficients are seen at much earlier during the flowering phase itself. Thus, it is clear that VV Polarization backscattering can be used over VH Polarization backscattering in order to classify the rice croplands.

5. Conclusion

The present study has been carried out in order to calculate the backscattering of VV and VH polarized images during different phenological stages of rice in the study area using the GEE cloud platform. The results from this clearly shows that VV Polarization has high backscattering coefficients using which the length of growing period and the rice grown crop fields can be mapped and monitored. It became evident from this study, that the usage of GEE platform helped in quick pre-processing and reduced the space for the data acquisition. Using the parallel power of GEE platform, rice cropland present in every Delta Zone of the whole country can be mapped easily.

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