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**Sugavaneshwaran Kannan**  
PG Scholar, Department of  
Remote Sensing and GIS,  
TNAU, Coimbatore, Tamil  
Nadu, India

**Ragunath Kaliaperumal**  
Assistant Professor (SS and AC),  
Department of Remote Sensing  
and GIS, TNAU, Coimbatore,  
Tamil Nadu, India

**Pazhanivelan S**  
Professor and Head, Department  
of Remote Sensing and GIS,  
TNAU, Coimbatore, Tamil  
Nadu, India

**Kumaraperumal R**  
Assistant Professor (SS and AC),  
Department of Remote Sensing  
and GIS, TNAU, Coimbatore,  
Tamil Nadu, India

**Sivakumar K**  
Assistant Professor (SS and AC),  
Department of Remote Sensing  
and GIS, TNAU, Coimbatore,  
Tamil Nadu, India

**Corresponding Author:**  
**Sugavaneshwaran Kannan**  
PG Scholar, Department of  
Remote Sensing and GIS,  
TNAU, Coimbatore, Tamil  
Nadu, India

## Paddy area estimation in Nagapattinam district using sentinel-1A SAR data

**Sugavaneshwaran Kannan, Ragunath Kaliaperumal, Pazhanivelan S, Kumaraperumal R and Sivakumar K**

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### Abstract

A Research study was conducted to estimate the paddy area in the Nagapattinam district of Tamil Nadu using Sentinel 1A SAR data through multi-temporal feature extraction. Multi-temporal Sentinel 1A data of GRD data at VH polarizations were obtained for the study area at 12 days intervals. Collected data were processed using MAP scape-RICE software. Sentinel 1A is an active SAR microwave data, which captures the crop characteristics irrespective of the weather condition and illumination. Ground truth observations collected during cropping period were used to derive the paddy signature from the processed satellite images. The dB values extracted as signature then subjected to the multi-temporal feature extraction method for delineating the paddy growing areas. Around 99, 00, 700 ha was mapped as the paddy growing area in Nagapattinam district. Accuracy assessment was done with 40 percent of the ground truth data. The overall classification accuracy was 94 percent with a kappa score of 0.88.

**Keywords:** Paddy, synthetic aperture radar (SAR), sentinel 1A, area estimation, multi-temporal feature extraction

### 1. Introduction

Paddy is the globe's important food crop and is the staple food for more than 2.7 billion people. India has a paddy area of 44.6 m ha with total production of 80 million ton es. The spatial estimation of the paddy region would ensure technology transfer and better policy decisions to sustain production at different levels. The most significant step in agricultural monitoring is crop discrimination. With the ongoing innovations in remote sensing technology, it is possible to provide accurate information on crop area, crop production, health, damage and loss. In crop tracking, the use of optical remote sensing has been increased. To achieve accuracy that restricts the use of optical data, because many images obtained at a specific time of the crop growth cycle are required but cloud cover can prevent or delay image acquisition during the growth phases of the crop. Space borne SAR images can therefore be used to monitor the surfaces of the earth regardless of the weather conditions and maintain the temporal frequency of the images during the crop growth period (Boerner *et al.*, 1987). SAR data has a proven ability to detect the crop employing the distinctive temporal signature of the crops backscattered values. The use of SAR backscattering values in paddy, groundnut, maize, mango and banana was successfully demonstrated for their identification and discrimination by Suga and Konishi, (2008) [7]; Bouvet *et al.*, (2009) [1]; Pazhanivelan *et al.*, (2015) [3, 5, 6, 8]; Mugilan *et al.*, (2017); Ragunath *et al.*, (2019) and Venkatesan *et al.*, (2019) [8].

### 2. Materials and Methods

#### 2.1. Study area

Nagapattinam district of Tamil Nadu lies under 10°10' to 11°20' in the east, 79°15' to 79°50' in the north and 9 metre above mean sea level with an area of 2715.8 km<sup>2</sup>. Nagapattinam is bounded by the Bay of Bengal on the east, Palk Strait on the south, Tiruvarur and Thanjavur District on the West and Northwest respectively while Cuddalore District on the North. Paddy is the most important agricultural crop in the district. In addition to that groundnut, pulses, gingelly, sugarcane and cotton are also grown. Hence Nagapattinam district was selected for studying the paddy area.

#### 2.2. Satellite data

Sentinel 1A imageries for months of May to October 2019 acquired at 12 days intervals having 20 m resolution.

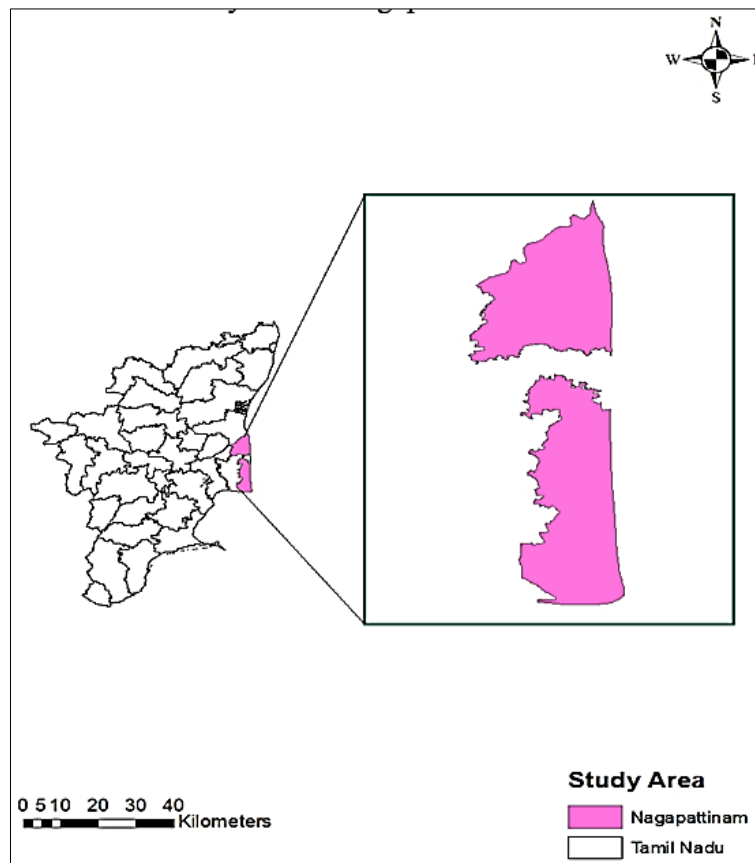


Fig 1: Study area – Nagapattinam district

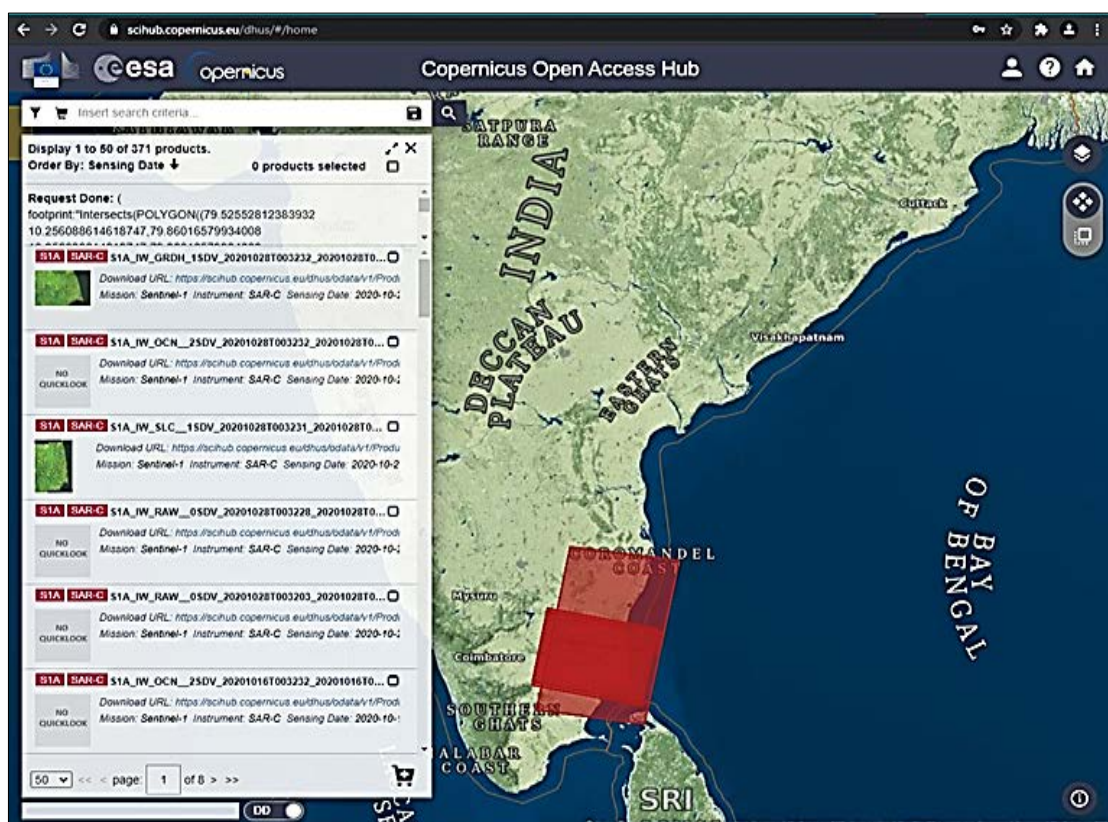


Fig 2: Sentinel-1A data acquisition for Nagapattinam district

### 2.3. Ground truth collection

Ground truth points were collected in the study area at different crop growth stages. Totally 150 paddy points with

non-crop points have been collected. Among these 40 percent ground truth points were used for training and 60 percent for validation processes.

## 2.4. Pre-processing of SAR data

A fully automated processing chain developed by Holecz *et al.*, (2013)<sup>[3]</sup> was used to convert SAR GRD multi-temporal data to terrain geo-coded  $\sigma^0$  values. The processing chain itself is a module within the MAPscape-RICE software. The basic processing includes the following steps.

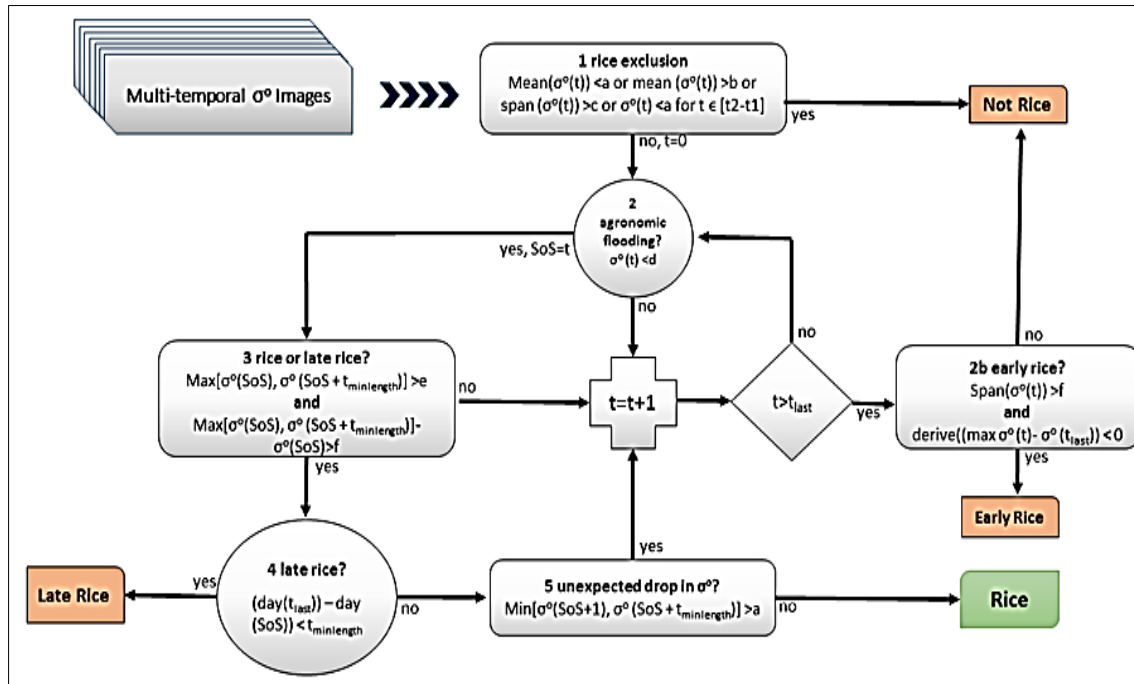
- Strip mosaicking: To facilitate the overall data processing and data handling,
- Co-registration: Images acquired with the same observation geometry were co-registered in slant range geometry.
- Time-series speckle filtering: To balance differences in reflectivity between images,
- Terrain geocoding: Radiometric calibration and

normalization,

- ANLD filtering: To get smoothed homogeneous targets,
- Removal of atmospheric attenuation:  $\sigma^0$  values were corrected utilizing an interpolator.

## 2.5. Multi-temporal feature extraction

Multi-temporal features *viz.*, minimum, maximum, mean, minimum date, maximum date and span ratio of VV, VH polarization and minimum, maximum data were extracted using feature extraction tool in MAPscape-Rice software. These multi-temporal features are having a certain range regarding rice crop, which were extracted using the point sampling tool of QGIS 2.18.20.



a = lowest mean, b = highest mean, c = maximum variation, d = maximum value at SoS, e = minimum value at maximum peak, f = minimum variation  
 t = time, t2-t1 = maximum time underwater, tmin length = minimum number of days of season length, tmax length = maximum number of days of season length, tlast = date of the last acquisition, SoS = Start of season

Fig 3: Rule-based rice detection algorithm for multi-temporal C-band  $\sigma^0$  in MAPscape-Rice

## 2.6. Crop classification

The image classification aims to categorize the image pixels into land cover categories based on the pixel value. This section explains the classification methodology used in this study for rice crop area identification and classification.

### 2.6.1. Parameterized classification

The parameterized classification algorithm quantitatively evaluates the variance and covariance of the category by spectral response pattern while classifying an unknown pixel. In this study, image classification was carried out using parameterized classification algorithm with extracted multi-temporal features from GRD SAR images for the identification of rice. Values extracted from multi-temporal features for rice crop was used to create training polygons. The multi-temporal features used are  $VH_{max}$ ,  $VV_{min}$ ,  $VH_{maxdate}$ ,  $VV_{mindate}$ ,  $CC_{min}$  (VV), and  $CC_{mean}$  (VV).

## 2.8. Accuracy assessment

The error matrix and Kappa statistics are used for evaluating the accuracy of the estimated rice area.

$$\text{Overall Accuracy} = \frac{\sum(\text{Correctly classified classes along diagonal})}{\sum(\text{Row Total or Column Total})}$$

$$\text{User's Accuracy} = \frac{\text{Number of correctly classified item in a row}}{\text{Total number of items verified in that row}}$$

$$\text{Producer's Accuracy} = \frac{\text{Number of correctly classified class in a column}}{\text{Total number of items verified in that column}}$$

$$\hat{K} = \frac{NA - B}{N^2 - B}$$

## 3. Results and Discussion

It has become feasible with the advances in remote sensing technology through microwave SAR data and automated

chain processing in crop identification and mapping. Sentinel 1A SAR available for free data acquired at a 12 days interval from May 2019 to October 2019 was used for the

investigation for the identification of rice crops and the area estimation in the Nagapattinam district of Tamil Nadu.



**Fig 4:** Area map for *kharif* paddy during 2019 in Nagapattinam district of Tamil Nadu

For the ground truth points chosen randomly over the study area, temporal backscattering values were extracted. Backscattering values have been found to range from -15.99 to -9.56 dB and -16.23 to -6.32 dB in the early and later stages of VV polarization. In the case of VH polarization, the dB values at the early stage were -22.9 dB to -13.6 dB and -23.1 dB to 11.8 dB at the later stage. At the early stage, the backscatter values were minimum and at later stages observed as maximum. During *Kharif* 2019 at Nagapattinam district, maximum, minimum, and meantime backscattering values for Vertical-Vertical (VV) and Vertical-Horizontal (VH) polarized SAR data for rice were collected and backscattering signatures were produced. The estimated Rice area in Nagapattinam district was 99, 00, 700 ha.

### 3.1. Accuracy assessment

The rice area characterized from SAR data using the MTF (Multi-temporal Feature Extraction) method was evaluated with the leftover points of ground truth. To construct the accuracy assessment through the use of the confusion matrix, about 60 rice points and 22 non-rice sites were used. The results of the confusion matrix found that, a Kappa score of 0.88 and overall accuracy of the rice map was 94 percent.

### 4. Conclusion

The detection and estimation of the rice area had been carried out with reliable accuracy from SAR satellite data in the study area, showing the prospect of using SAR data for area estimation. SAR data may be used to conquer the

unavailability of optical data for crop area estimation during extreme weather conditions and cloud cover. For policymakers and Precision agriculture, the acquired crop region can be helpful.

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