RESEARCH ARTICLE OPEN ACCESS

Crop Discrimination and Acreage estimation of Major Crops for Veppanthattai Taluk, Perambalur District using Multi Temporal Sentinel 1A SAR data

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ABSTRACT
Crop discrimination and Acreage estimation are essential for planning and policy making at various administrative levels. Remote sensing is presently the only technology that can provide timely and accurate crop inventory information. The main objective of this study is to evaluate the performance of Sentinel 1A (VV, VH, VV+VH) Synthetic Aperture Radar imageries for crop discrimination and acreage estimation in Veppanthattai Block of Perambalur District in Tamil Nadu. Perambalur District is one of the largest cotton and maize producing district in Tamil Nadu.This study also compares the performance of classification algorithms such as Maximum Likelihood Classification, Minimum Distance Classification, Support Vector Machine Classification and Neural Net Classification algorithm for Sentinel -1A SAR imageries in order to find the best classifier. The Temporal backscattering coefficient of crops for VV & VH polarization are extracted using training data. For this study 15 date Sentinel-1A SAR data used for classification and acreage estimation of crops. Ground truth data collected randomly over the study area, in that 60% data used for training and 40% data used for testing the classification. In Sentinel-1A SAR data, Dual polarization (VV+VH) data gives higher classification accuracy than single polarization (VV, VH) data. The highest accuracy of Dual Polarization (VV+VH) Sentinel 1A SAR data, 87.44% achieved using Support Vector Machine and Neural Net classification algorithm.

Keywords - Acreage estimation, Crop discrimination, Maximum Likelihood Classification, Minimum Distance Classification, Neural Net Classification, Sentinel-1A, Support Vector Machine Classification, SAR.

Date of Submission: 18-10-2021 Date of Acceptance: 02-11-2021

I. INTRODUCTION

Agriculture is the backbone of India's economy, which accounts for almost 30 percent of GDP and employs 70 per cent of the population. Timely and reliable information on crop area and production for tactical and strategic decisions is necessary for all stakeholders in agriculture and the government. With the global shift in the market economies, reliable and advanced agricultural information has gained more importance than ever before. Crop discrimination is crucial for many agricultural monitoring systems. Acquiring annual crop information using traditional survey methods is not cost efficient especially for covering large areas.

Remote sensing is presently the only technology that can provide timely and accurate crop inventory information. SAR has the ability to capture crop characteristics which is not possible by optical instruments. The discrimination potential of SAR data is based on the sensitivity of the radar backscattering to the dielectric properties of the objects and to their geometric structure (i.e., the size, shape, and orientation and distribution of the scatter).

Over the time crop identification and crop area estimation was mostly successful using remote sensors operated in the visible and NIR regions of the spectrum (Brisco et al.,1998, Dadhwal et al., 2000 and Fisette et al., 2005). Various research conducted over the past has clearly shows the immense potential of SAR images for crop acreage estimation and crop monitoring (Choudhury and Chakraborty, 2006, Shang et al., 2009, Moran et al., 2011, and McNairn et al., 2013). The ability of SAR for discriminating of crop type has been also previously discussed in lots of research (Boerner et al., 1987 and Haldar et al.,2012).

The performance of the sensors depends on polarisation used for identifying the crops. The phenology of the crop is a vital role for these studies (Skriver, 2012). The nature of back scattering differs between broad leaves crops and narrow leaves crops

(Bargiel & Herrmann, 2011). Crops with broader leaves usually have higher backscattering than crops with narrow leaves (Macelloni, et al., , 2001). Recently in the Perambalur region some research was conducted in the aim of crop acreage estimation (Ashmitha Nihar M et all., 2019 and Ramalingam K et all., 2019).

II. OBJECTIVE

The primary aim and objective of this study is to evaluate the performance of Multitemporal Sentinel 1A SAR imagery for crop discrimination and acreage estimation in Veppanthattai Block of Perambalur District in Tamil Nadu and also find the best classifier among the four-classification algorithm such as Maximum Likelihood, Minimum Distance, Support Vector Machine and Neural Net Classification algorithm.

III. MATERIALS AND METHODS

3.1 STUDY AREA

Veppanthattai block of Perambalur District is a centrally located inland area of Tamil Nadu. This area is located between 11°16' N to 11°31' N and 78°38' E to 79°0' E, covering an area of 580 sq.km. It has an agricultural area of 432 sq.km. This Veppanthattai block has 39 revenue villages. The mean yearly precipitation of territory is 908 mm, in which 475 mm is received from North East Monsoon, and 314 mm is received from South West Monsoon. The atmosphere is hot, sub moist to semi-dry. The mean yearly most extreme and least temperature are 32.60˚C and 22.20˚C, respectively. Black cotton soil, clay loam, and red sandy soil are the predominant soil types. In this area, significant crops grown are Cotton, Maize, Paddy, Tapioca, Sorghum, Onion, Groundnut, and Sesamum. Here, cotton and maize are the dominant crops.

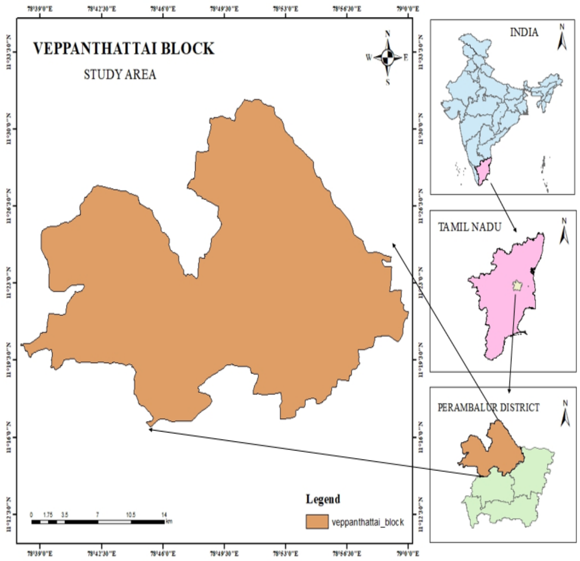


Figure 1. Map of the study area

3.2 DATA USED

In this research, Level -1 Ground Range Detected (GRD) sentinel -1 C-band (5.405 GHz) data collected in the Interferometric Wide Swath (IW) mode was used. This mode permits the combination of a large swath width (250 km) with a moderate geometric resolution (10 m). Moreover, it has dual polarization capability (HH+HV or VV+VH) that can provide more ground surface information. 15 SAR images have been used for the period from October 2019 to January 2020, which are freely available from the European Space Agency (ESA) through Sentinels Scientific Data Hub (https://scihub.esa.int/dhus/). The time interval of the acquired images was 12 days. The IW mode is the default acquisition mode over land.

Ground Truth data randomly collected in the study area of the Veppanthattai block during the vegetative stage. In this data, 60% of data is used for training the classification process, and 40% data is used for testing the classifier results.

IV. METHODOLOGY

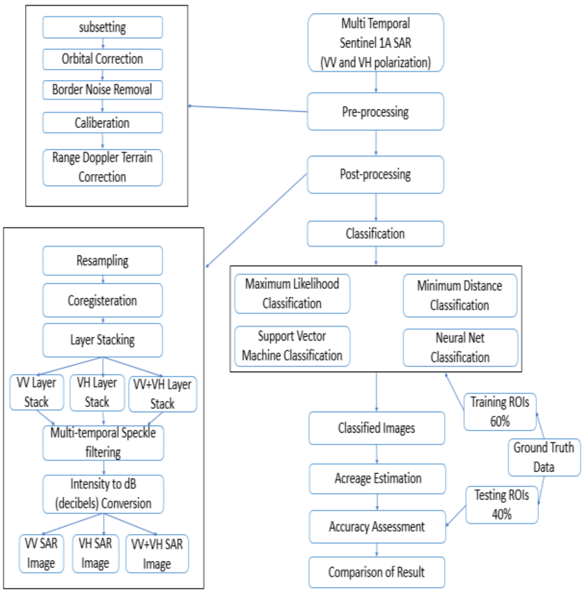


Figure 2. Methodology

The agricultural extent of the study is extracted from the base map, and the raster images were subsetted to an agricultural extent. Subsetting of raster data reduces the time in further processing.The orbit file correction was carried out to update the metadata with precise orbit vectors. Radiometric correction is processed using bi-linear interpolation to calibrate the pixel values. These calibrated images are maintained as an intensity image for further processing. The geometric correction process was applied to the image using the Range Doppler Terrain method. Re-sampling was carried out using the Nearest Neighbor Algorithm to closely preserve the spectral integrity of the image pixel. The images were co-registered with the first date master image. Then multi temporal images were layer stacked separately - VV, VH, and combined VV+VH polarization by maintaining the order from 11th August 2019 to 26th January 2020.

Finally, multi temporal speckle filtering was performed. After speckle filtering sentinel, 1A SAR images values are converted into decibels using the linear to dB conversion tool and exported as geo-tiff for further processing.

For training and validation, a ground survey was conducted during January 2020 in the study area. Random sampling methods are used to assign separate training (60%) and validation (40%) datasets from the ground reference data collected during the field observations. For all the classification methods, the same set of training samples and validation samples are maintained.

Maximum Likelihood, Minimum Distance, Support Vector Machine, and Neural Net Classification methods were performed for classifying the crops using 60% training set data. Accuracy assessment was done using a 40% Test data set. This Error matrix and Kappa statistics were used to evaluate and compare the accuracy of these methods. Finally, the acreage of all crops was estimated in that study area.

V. RESULTS AND DISCUSSIONS

5.1 RADAR BACKSCATTERING COEFFICIENT

The Sentinel 1A SAR Data Collected during the entire cropping period from August 2019 to January 2020. The minimum, maximum, and mean temporal backscattering signature for Vertical-Vertical (VV) and Vertical-Horizontal (VH) polarized SAR data for all major crops of Veppanthattai taluk such as Cotton, Maize, Paddy, and Tapioca were derived.

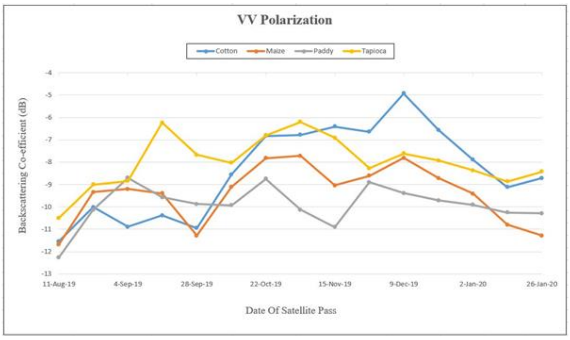


Figure 3: Temporal backscattering of all crops for VV Polarization

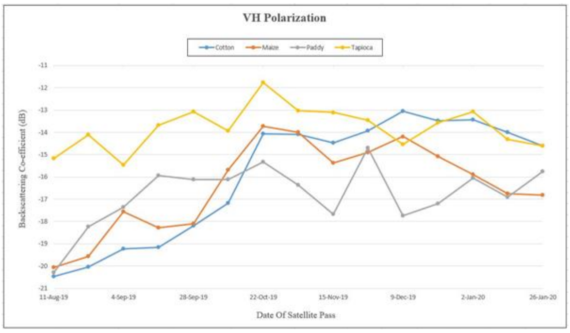


Figure 4: Temporal backscattering of all crops for VH Polarization

5.2 VH POLARIZATION

In VV Polarization, highest Classification accuracy is achieved by Support Vector Machine Classification followed by Maximum Likelihood Classification, Neural Net classification, and Minimum Distance Classification.

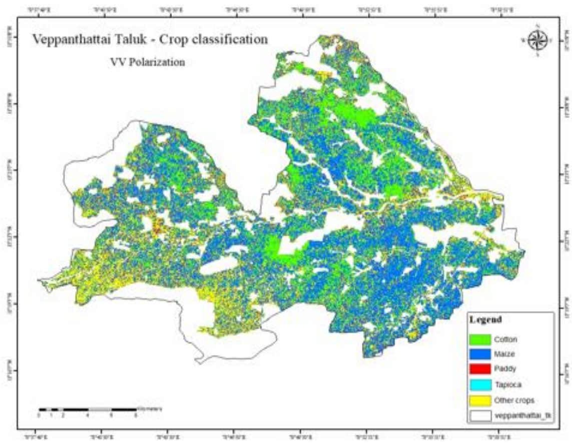
ISSN: 2248-9622, Vol. 11, Issue 10, (Series-IV) October 2021, pp. 14-20

Support Vector classification algorithm gives overall accuracy of 81.57% and kappa coefficient of 0.74, Likewise Maximum Likelihood classification gives overall accuracy of 78.92% and kappa coefficient of 0.70, Neural Net classification algorithm gives overall accuracy of 75.86% and kappa coefficient of 0.66, and Minimum Distance Classification algorithm gives overall accuracy of 73.53% and kappa coefficient of 0.70.

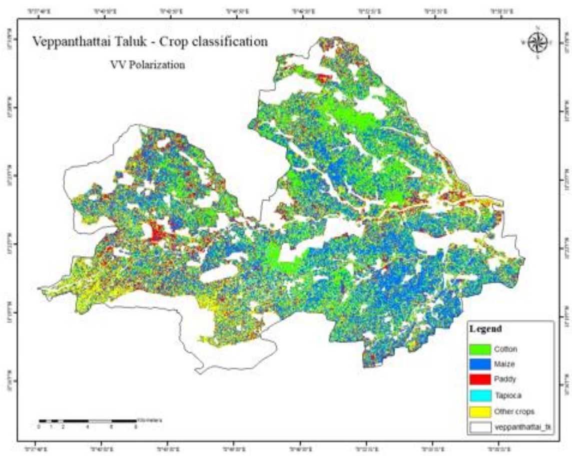
VV Polarized imageries Accuracy Assessment and Acreage estimation are listed in table 2.

Classification Algorithm	Accuracy Assessment		Acreage Estimation (Hectares)				
	Overall Accuracy	Kappa coefficient	Cotton	Maize	Paddy	Tapioca	Other crops
Maximum Likelihood Classification	78.92	0.70	8942.2	21340.8	2205	388	10324.8
Minimum Distance Classification	73.53	0.65	5961.2	15120	14472	3585.6	4060.8
Neural Net Classification	75.86	0.66	9892.8	16934.4	4320	2851.2	9201.6
Support Vector Machine Classification	81.57	0.74	9374.4	15681.6	4838.4	2332.8	10972.8

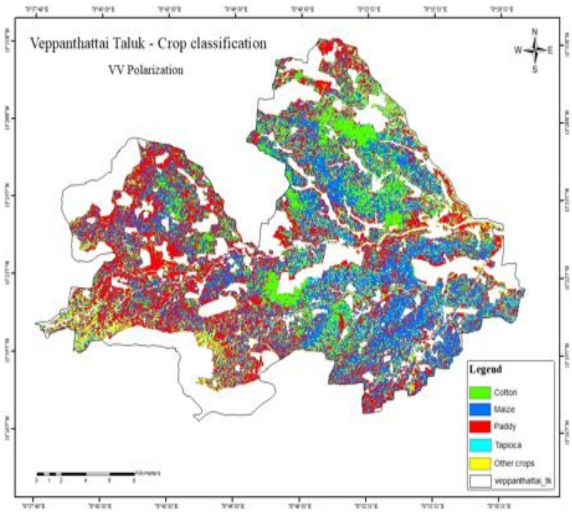
Table 2: Accuracy Assessment and Acreage Estimation for Sentinel 1A SAR - VV Polarization data.



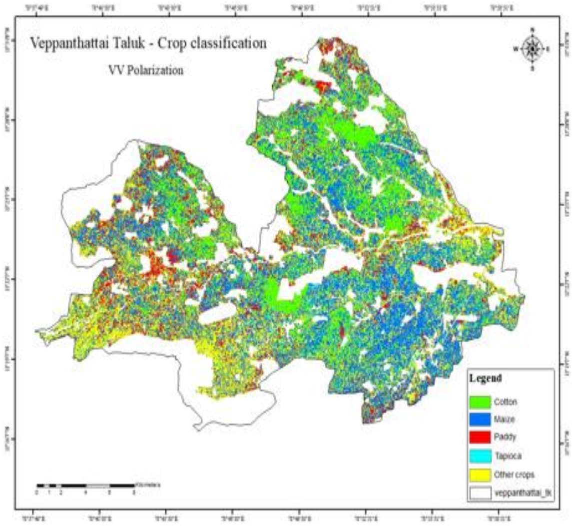
Maximum Likelihood



Neural Net



Minimum Distance



Support Vector Machine

Figure 6: Classified images using different classification algorithm for VV polarization

5.3 VV+VH POLARIZATION

In Dual Polarization (VV+VH) of Sentinel 1A SAR data, highest Classification accuracy achieved by Support Vector Machine Classification and Neural Net Classification followed by Minimum Distance Classification, and Maximum Likelihood Classification.

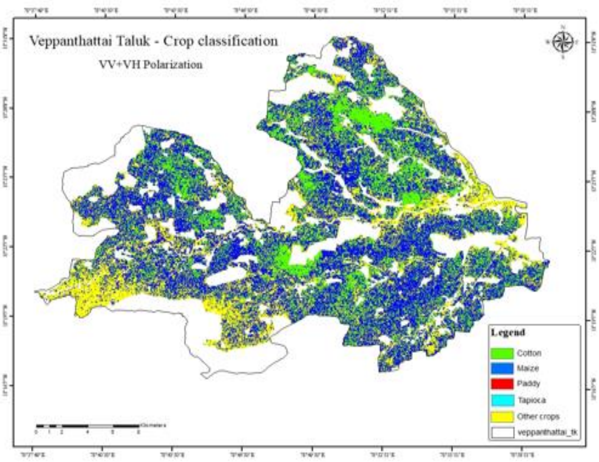
Support Vector Machine and Neural Net classification algorithm gives overall accuracy of 87.44% and kappa coefficient of 0.82, Likewise Minimum Distance Classification gives overall accuracy of 85.27% and kappa coefficient of 0.79, and Maximum Likelihood classification algorithm gives overall accuracy of 84.87% and kappa coefficient of 0.78.

The Dual Polarization SAR data gives higher classification accuracy than single polarization imagery such as VV and VH polarization data.

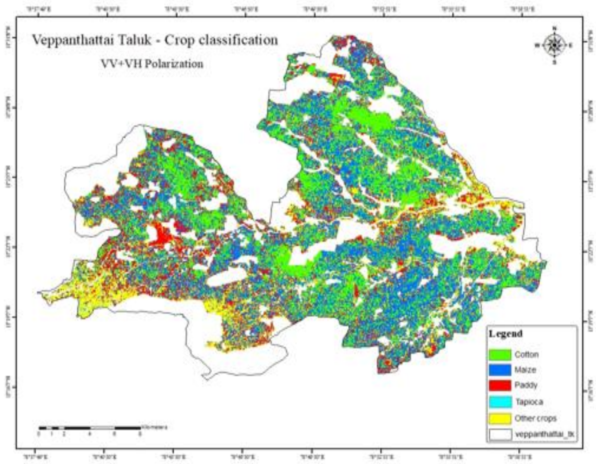
The Dual (VV+VH) Polarized imageries Accuracy Assessment and Acreage estimation are listed in table 3.

Classification Algorithm	Accuracy Assessment		Acreage Estimation (Hectares)				
	Overall Accuracy	Kappa coefficient	Cotton	Maize	Paddy	Tapioca	Other crops
Maximum Likelihood Classification	84.87	0.78	12441.6	20088	86.4	44	10540.8
Minimum Distance Classification	85.27	0.79	7603.2	18792	10195.2	1770.8	4838.4
Neural Net Classification	87.44	0.82	11016	17798.4	5054.4	1684.8	7646.4
Support Vector Machine Classification	87.44	0.82	12312	16113.6	6912	1123.2	6739.2

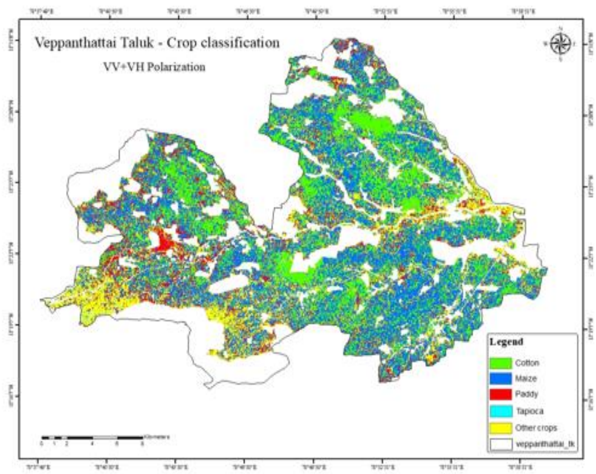
Table 3: Accuracy Assessment and Acreage Estimation for Sentinel 1A SAR – Dual Polarization (VV+VH) Polarization data.



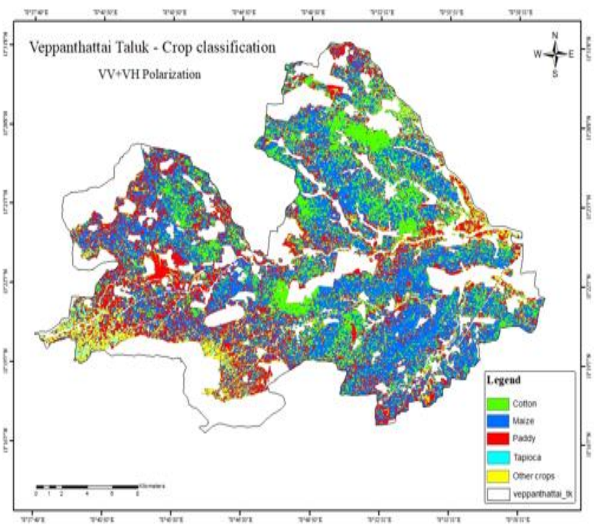
Maximum Likelihood



Support Vector Machine



Neural Net



Minimum Distance

Figure 7: Classified images using different classification algorithm for VV+VH polarization

VI. CONCLUSION

It is apparent from the current examination, due to its weather penetrating capability and high temporal resolution of Sentinel 1-A SAR data, it can be well used for discrimination of major crops such as cotton, maize, paddy, and tapioca, which captures the complete phenology of the crops during the cropping period. It will not be possible in optical data because of the limitation of generating temporal cloud-free optical data. From the present study, in Multitemporal SAR Data Classification, Dual polarized (VV+VH) data gives higher classification accuracy than single polarized data (VV, VH).

Among the four classifiers in Single Polarized data (VV, VH), the highest classification accuracy is achieved through Support Vector Machine Classification Algorithm, and in Dual polarized data, the highest classification accuracy (87.44%) is achieved through Support Vector Machine and Neural Net Algorithm. Based on pixel counts, the acreage of crops is estimated for each classification.

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