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MAPPING BANANA GROWING AREA IN TAMIL NADU USING SAR DATA

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ABSTRACT
Radar remote sensing plays a major role in agricultural crop area mapping and monitoring. SAR back-scattering is a primary function that is used in the process of mapping land use and land covers, monitoring and target identification of ground features that lies within the area of interest. A study on 'Mapping banana growing area in Tamil Nadu using SAR data' was conducted in major banana growing districts of Tamil Nadu during 2017 to 2018 using Sentinel-1A SAR data. Multi-temporal Sentinel-1A satellite data with VV and VH polarization at 20 m spatial resolution was acquired between August 2017 to May 2018 at 12 days interval and processed using MAPscape-RICE software. Continuous monitoring was done for crop parameters and validation exercise was done for accuracy assessment. Spectral dB curve of Banana was generated using temporal Sentinel 1A SAR data. The dB values do not show much variation both under VV and VH polarization. The total banana cultivated area was estimated for Tiruchirappalli, Karur and Erode districts were 5457 hectare, 3865 hectare, and 9432 hectare respectively The estimated area was assessed for accuracy obtained were 86.3and 88.6respectively for Tiruchirappalli, Karur and Erode districts.

KEYWORDS: VV and VH Polarization, Sentinel-1A, SAR, Banana, Accuracy.

INTRODUCTION
Agriculture is the important occupation of the Indian families as it contributes to 7.3% of gross domestic product (GDP). A primarily agriculture based country is like India reliable, accurate and timely information on crop area and production with help for tactical and strategic decision making In the past, information on crop type and crop area has often been compiled by conducting ground level interactions with farmers or by ground surveys. It is incorrect and late. Conventional method of data collection, compilation and publication are reliable but fails to serve the information in real time for overcoming this situation, the use of remote sensing technology proved extensively can be incorporated that providing timely and accurate information along with high revisit frequency and spatial resolution.

The introduction of remote sensing technology and wide use of optical sensors, to measure the surface reflectance of an object or an area under the visible and infrared regions of electromagnetic spectrum, where the properties of surface reflectance is a function of bio-physical characteristics such as canopy moisture, leaf area, vegetation greenness, vegetation browning *etc*. of the reflecting target. The use of optical remote sensing in crop mapping studies has been carried out on the fact that different crops at different vegetation stages exhibits dissimilar bio-physical characteristics. However, utilizing the information's provided by the optical sensors and the optical remote sensing technology has its own limitation in image acquisition during cloudy or rainy conditions.

The microwave remote sensing is an indispensable earth observation technology that receives and analyses signatures backscattered from features with wavelength primarily ranging from 1mm to 100cm. Microwave remote sensing system has the ability to collect data any time during a day and any season during the year. Synthetic Aperture Radar (SAR) imagery which helps in regular crop monitoring and mapping and back-scattering is a primary function that is used in the process of mapping land use and land covers, monitoring and target identification of ground features that lies within the area of interest. SAR images are being widely used for the purpose of crop area mapping in different countries. Le Toan *et al*. (1997) utilized the multi temporal SAR imaginary for monitoring rice planting areas and growth stages in Indonesia. Lam-Da *et al*. (2007) for monitoring and mapping rice cropping system in Giang Province, Mekong river delta applied ENVISAT ASAR data with dual polarization *viz.*, HH polarization and VV polarization with these background knowledge the present study was carried out to map banana crop in Tiruchirappalli, Karur, and Erode districts of Tamil Nadu using Sentinel-1A SAR data .

MATERIALS AND METHODS
Study area
The study area comprises of major banana growing districts of Tamil Nadu *viz.*, Tiruchirappalli, Karur, and Erode.

The Sentinel-1A mission is a European Radar Observatory for the Copernicus joint initiative of the European Commission (EC) and the European Space Agency (ESA). The Sentinel-1A mission includes C-band imaging operating in four exclusive imaging modes with different resolution (down to 5m) and coverage (up to 400km swath). It provides dual polarization capability (VV and VH), very short revisit times and rapid product delivery.

For each observation, precise measurements of spacecraft position and altitude are available.

Sentinel-1A has four standard operational modes, designed for interoperability with other system. In the present study, level 1 ground range (GRD) product obtained by interferometric wide (IW) swath mode of 20m resolution with 12 days of temporal resolution was used.

Pre-Processing of SAR data

A fully automated processing chain developed by Holecz *et al.* (2013) was used to convert SAR GRD multi-temporal data to terrain geo-coded σ° values. The processing chain itself is a module within the MAPscape-RICE software. The basic processing includes the following steps.

a. **Strip mosaicking-** to facilitate the overall data processing and data handling.
b. **Co-registration-** Images acquired with the same observation geometry were co registered in slant range geometry.
c. **Time-series speckle filtering -**to balance differences in reflectivity between images
d. **Terrain geocoding -**Radiometric calibration and normalization.
e. **Anisotropic non-linear diffusion (ANLD) filtering –** to getsmoothened homogeneous targets.
f. **Removal of atmospheric attenuation** - σ° values were corrected by means of an interpolator.

Multi-Temporal Feature extraction

Multi-temporal features *viz.,* Minimum, Maximum, Mean, Minimum date, Maximum date of VV, VH polarizations and Minimum, Maximum and Mean features were extracted using feature extraction tool in MAPscape-RICE software. These multi-temporal features were having certain range regarding Banana crop which were extracted using point sampling tool of QGIS 2.18.20.

Accuracy assessment

Mapping process in incomplete without evaluating the accuracy of the outcome generated. So, for evaluating the accuracy two sources of information *viz*., remote sensing derived classified data and the reference data are required. Using the relationship between these sets of information error matrix is calculated where reference data are shown as column and classified data are represented in rows. Error matrix is the most commonly used method to assess classification accuracy (Congalton, 1991).

The process mainly involved overall, producer and user accuracies. The producer accuracy is based on the reference data there by providing error of omission while user accuracy is based on the total number of pixel classified in specific classes and provided error of commission (Jensen, 1996). Ground truths were performed in the study area to identify the banana. Totally 94 banana points and 52 non-banana points were collected during the ground survey for training and validation purposes

Kappa Coefficient

Kappa coefficient is another measure of classification accuracy. It is a measure of the proportional improvement by the classifier over a purely random assignment to classes.

RESULTS AND DISCUSSION

Radar backscattering signature

Radar back scattering expressed as backscattering coefficient (dB or σ^0) derived from the vegetation surface is a measure of crop biomass, leaf area, plant height and soil properties especially moisture content. Sentinel-1A SAR data acquired during the cropping period were analysed to derive backscattering signature so as to identify banana and non-banana features. Training pixels collected during ground truth verification was used to extract the unique temporal backscattering signature for banana. This was performed by stacking the multi temporal SAR data acquired over the study area.

Tiruchirappali and Karur

The radar back scattering co-efficient (dB) for Tiruchirappali and Karur district derived from VV polarized range from -9 to -4 at different dates of data actuation. The dB values were high in initial stages of Banana crop (-9 to -4) and increased as the growth advances

The dB value for VH polarization ranged from -15 to -11.The trend was similar as that of VV polarization data during growth period.

Erode district

In Erode district the backscattering co-efficient (dB) derived from VV polarization ranged from -9.0 to -6.0, whereas, for VH polarization the dB value ranged from -17.500 to -13.249.

The backscattering co-efficient (dB) during the crop growth period *viz*., October 2017 (planting) to September 2018 (maturity/ harvest) shows slight and gradual increase.

Aubert *et al*. (2011) reported that VV polarization mode of data acquisition is more sensitive to surface variation than the VH polarization mode. The backscattering values were low at the end of the cropping period or at maturity as reported by Lilesand and Kiefer (1994) wherein the decrease in backscatter may be caused by maturity of the crop, or vegetation biomass as reported by Skriver *et al.* (1999) and or related to the reduced volumetric scattering due to maturity as reported by Panigrahy and Mishra (2003).

The temporal behavior of backscattering of banana for Tiruchirappali, Karur and Erode districts derived from VV and VH polarization are shown in Figs. 1-2, respectively. The temporal backscattering signature do not shows much variation both under VV and VH polarization, this is presumably due to the persistence of greenness throughout the cropping period and broad leaf features as reported by Wang Xiaoqin *et al*. (2009).

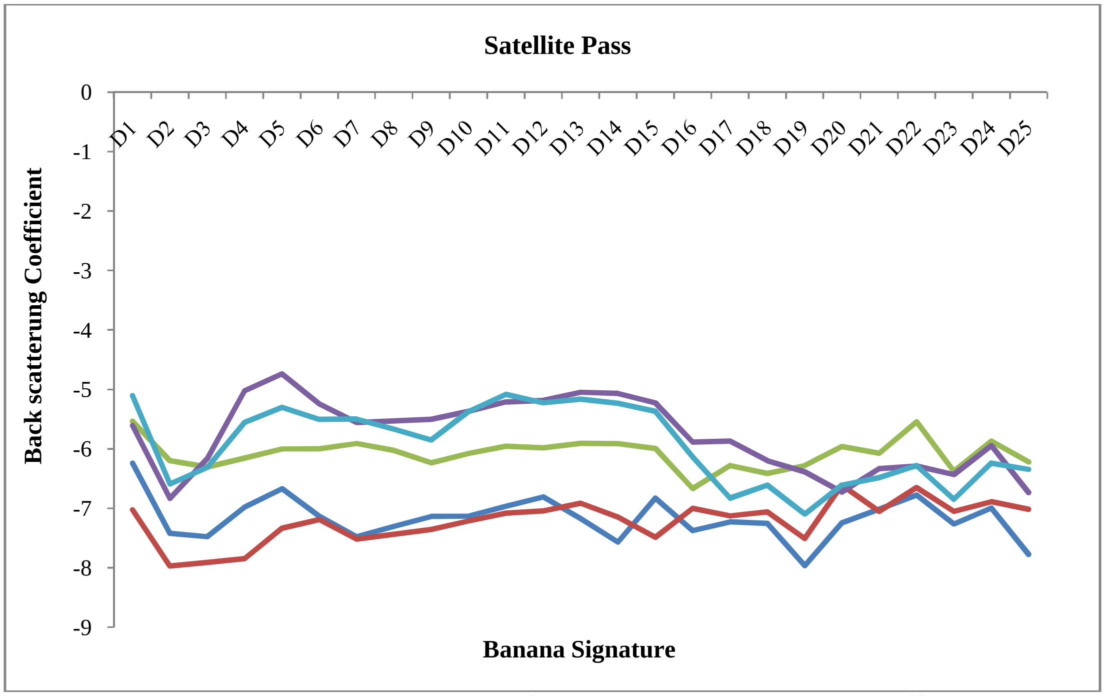

FIGURE 1. Temporal Back scattering signature of banana crop in VV polarization at different GT points

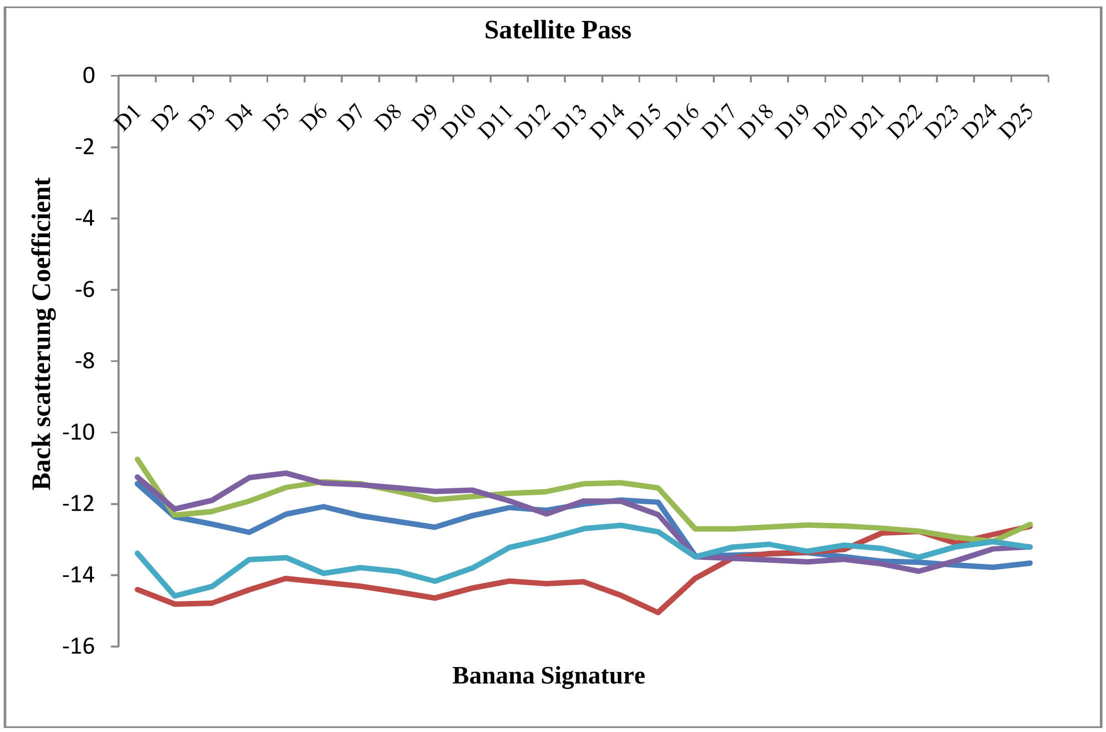

FIGURE 2 . Temporal back scattering signature of banana crop in VH polarization at different GT points

Banana area estimation

The banana area derived from multi-temporal SAR imagery of Sentinel-1A through parameterized classification algorithm for Tiruchirappali, Karur and Erode districts. The total banana cultivated area was estimated for Tiruchirappalli and Karur districts were 5457 hectare and 3865 hectare, respectively (Figs. 3-4).

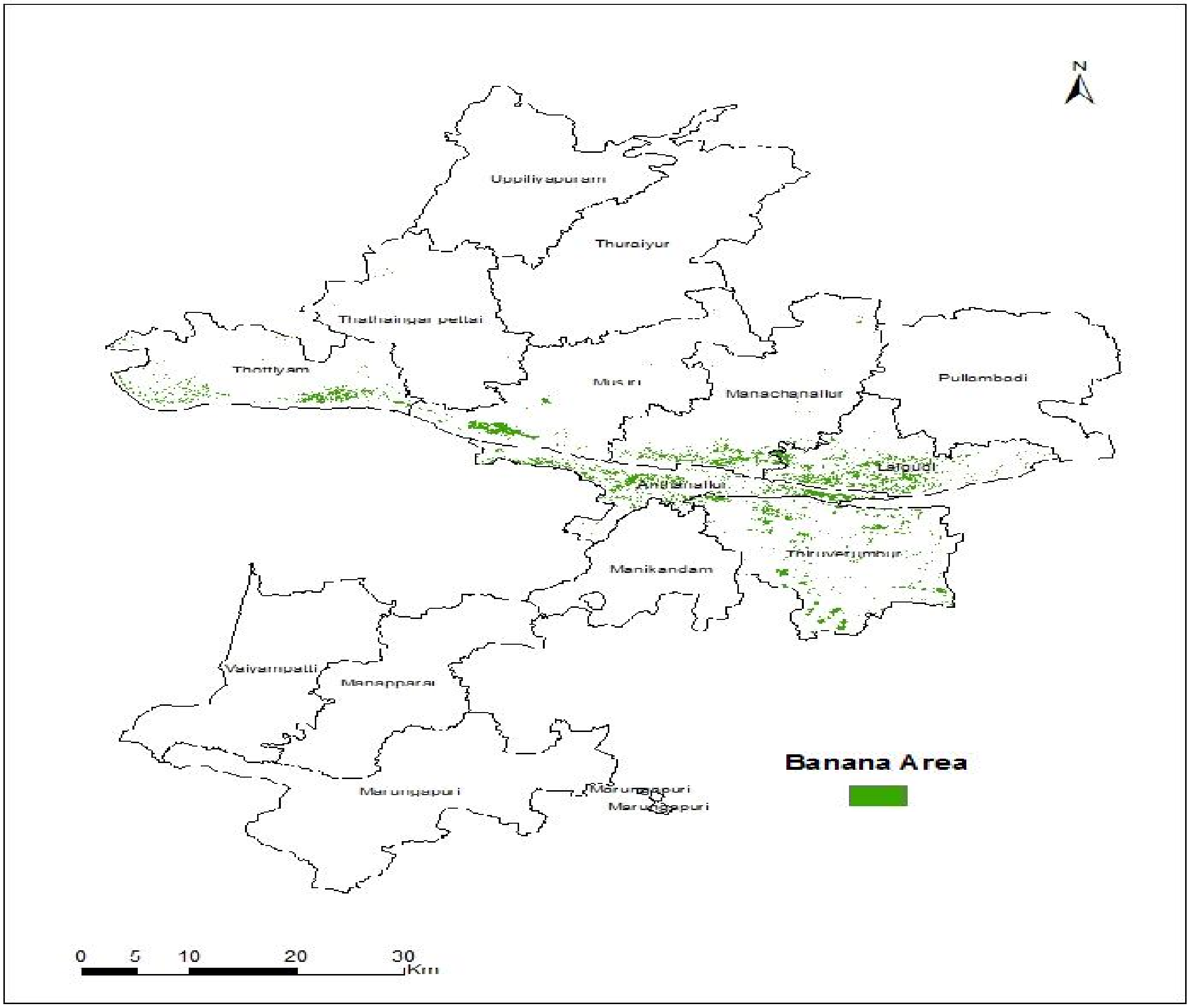

FIGURE 3. Banana Growing Areas in Tiruchirappali District of Tamil Nadu

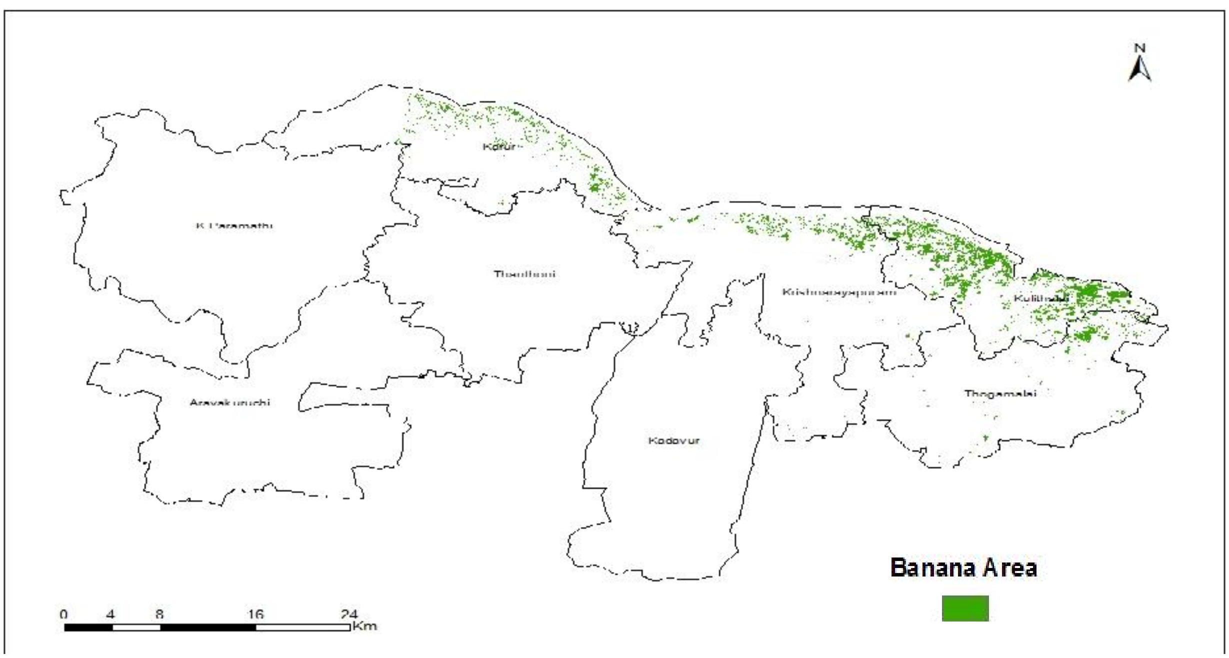

FIGURE 4. Banana Growing Areas in Karur District of Tamil Nadu

Block wise statistics for Tiruchirappali district showed that Tiruverambur recorded the highest banana area of 1524 hectare followed by Andanellur with 1257 hectare, Lalgudi with 969 hectare and Musiri with 683 hectare. The least area was found in Tattayangarpettai with 30 hectare of banana cultivated area. In Karur district, Kulithalai block recorded the highest banana area of 2516 hectare followed by Krishnarayapuram, Thogamalai and Karur with banana area of 555 hectare, 467 hectare and 327 hectare, respectively (Table 1).

TABLE 1. Banana area estimation for Tiruchirappalliand Karur districts

District	Block	Estimated Area (in Hectare)
Tiruchirappalli	Tattayyangarpettai	30
	Musiri	686
	Manachanallur	581
	Thottiam	500
	Lalgudi	969
	Andanallur	1257
	Thiruverambur	1524
	Total Area	5457
Karur	Karur	327
	Krishnarayapuram	555
	Kulithalai	2516
	Thogamalai	467
	Total Area	3865

In Erode district the estimated area (Fig. 5) under banana was 9432 hectare and the highest area observed at Anthiyur block (3936 hectare) followed by Sathyamangalam (2998 hectare) (Table 2).

TABLE 2. Banana area estimation for Erode district

District	Block	Estimated Area (Hectare)
Erode	Anthiyur	3987
	Thalavadi	216
	Sathyamangalam	2098
	T.N. Palayam	1353
	Bhavani	362
	Gobichettipalayam	254
	Bhavanisagar	512
	Nambiyur	90
	Perundurai	561
	Total Area	9432

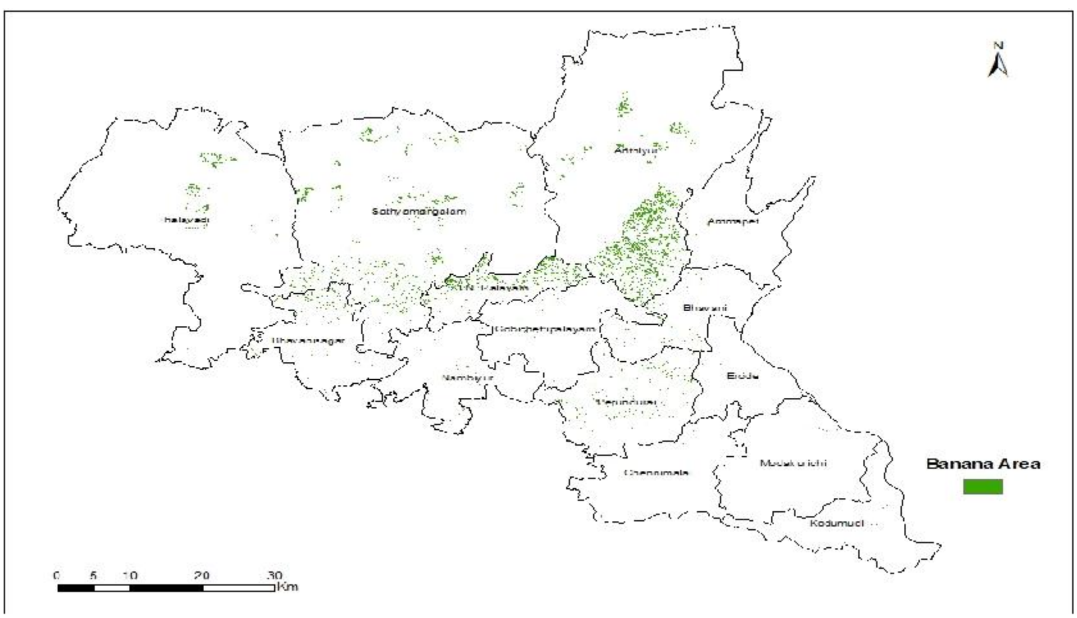

FIGURE 5 . Banana Growing Areas in Erode District of Tamil Nad

Accuracy assessment

The accuracy of the banana area estimated from Sentinel 1A SAR data through parameterized classification method was assessed through confusion matrix. Ground truth points collected during survey used estimate the accuracy. For Tiruchirappalli and Karur districts totally 80points were collected wherein 50 points for banana and 30points were for non-banana features. The confusion matrix showing the classification accuracy for Tiruchirappalli and Karur districts is presented in Table 3. The average accuracy obtained was 86.3%; reliability and overall accuracy were 85.1% and 86.3%, respectively. The Kappa index which is a measure of quality of classification for Tiruchirappalli and Karur districts was 0.73.

TABLE 3. Confusion matrix showingthe accuracy of classification for Tiruchirappalli and Karur district

	Predicted class from the map			
Obtained Actual class from survey	Class	Banana	Non-Banana	Accuracy
	Banana	43	7	86.0%
	Non Banana	4	26	87.7%
	Reliability	91.5 %	78.8 %	86.3%
Average accuracy				86.3%
Average reliability				85.1%
Overall accuracy				86.3%
Kappa index				0.73

The accuracy of the classified banana area estimated for the Erode district was assessed through confusion matrix. Ground truth points collected during survey used estimate the accuracy. Totally 66 points were collected wherein 44 points for banana and 22 points were for non-banana features. The confusion matrix showing the classification accuracy is presented in Table 4. In Erode district the average accuracy obtained was 88.6%, reliability and overall accuracy were 86% and 87.9%, respectively. Whereas, the Kappa index obtained for classifying Erode district was 0.76

Unlike field crops *viz*., rice, maize, cotton and groundnut not much work has been done to map horticultural crops especially banana. However, Li and Yeh (2004) made an attempt to map cultivable lands with multiple crops including banana and obtained a user's and producer's accuracy of 74% and 72%, respectively with maximum likelihood classification. Wand Xiaoqin *et al.* (2009) mapped banana fields in Fujian Province of china using ENVISAT-ASAR data and achieved a classification accuracy of 83.5 percent and Kappa index of 0.81. Hebbar *et al.* (2014) utilized LISS IV data and achieved a classification accuracy of 70-80 for banana, mango and citrus crops through object-oriented classification approach.

TABLE 4. Confusion matrix showingthe accuracy of classificationfor Erode district

	Predicted class from the map			
Obtained Actual class from survey	Class	Banana	Non-Banana	Accuracy
	Banana	38	6	86.4%
	Non Banana	2	20	90.9%
	Reliability	95.0 %	76.9 %	87.9%
Average accuracy				88.6%
Average reliability				86.0%
Overall accuracy				87.9%
Kappa index				0.76

In the present study the overall accuracy and kappa index were 86.3% and 0.73, respectively for Tiruchirappalli and Karur districts and for Erode district it was 87.9 percent and 0.76. The findings are in accordance with the accuracy obtained by Wang Xiaoqin *et al.* (2006).

CONCLUSION

In the study area during 2017-18 the radar backscattering co-efficient (dB) value were maximum during initial crop growth stage as well as during later stage or maturity irrespective of polarization type (VV or VH).The unique backscattering signature derived against ground truth points in all the locations shows similar trend and helped to classify the SAR data and extract the banana area with good classification accuracy.

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