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Estimation of Summer Paddy Area using Sentinel-2A Satellite data

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ABSTRACT

A research study was conducted for summer paddy area estimation in Needamangalam and Mannargudi blocks of Cauvery delta zone of Tamil Nadu using Sentinel-2A satellite data. Optical data reflects the biological features of objects and provides spectrum information about the surface. Sentinel-2A satellite data were obtained for the study area during summer seasonand processed using ENVI Software. The paddy area was derived from the processed data using ground truth points collected during the cropping period of the study area. The summer paddy cultivating area in the Needamangalam and Mannargudi blocks of the Cauvery delta zone was estimated as 8082 ha. Needamangalam and Mannargudi blocks are having 5766.25 and 2315.75 ha, respectively as summer paddy area Accuracy assessment of the classification was carried out using the confusion matrix for the collected ground truth points and the overall classification accuracy was 89.6 percent with a kappa scoreof 0.79.

Key words: *Opticaldata, Sentinel-2A, Summer Paddy area,ENVI software*

Introduction

Rice is a staple food for millions of people and is grown in many parts of the world. The entire area under paddy in India is 44.6 million hectares, with an output of 80 million tonnes and an average productivity of 1855 kg per hectare (Sugavaneshwaran *et al.*, 2021). According to the International Food Policy Research Institute, rice demand grows at a rate of 1.8 percent each year (Xiao *et al.*, 2021). So, Paddy area mapping and monitoring are crucial for food security and agricultural mitigation because they allow for the identification and forecasting of rice output. Paddy rice maps with a more frequent update cycle than field surveys are frequently produced using satellite data (Mosleh *et al.*, 2015).

It is now able to offer accurate information on crop area, crop yield, health, damage, and loss thanks to continual advances in remote sensing technologies. Remote sensing has the potential to complement, augment, improve, or even replace survey and statistical methodologies for cost-effective rice area estimates (Gumma *et al.*, 2014). Crop acreage estimation, mapping, crop status monitor-

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ing and identifying biotic and abiotic pressures are all aided by remote sensing technologies (Eugenio *et al.*, 2020). Optical remote sensing systems employ the reflectance of objects in the visible and infrared areas of the electromagnetic spectrum (Forkuor *et al.*, 2014).

Sentinel-2 (S2) is equipped with a wide-swath, high-resolution multispectral imager (MSI) with thirteen spectral bands, which will provide unprecedented views of our land and vegetation. High resolution (up to 10 m), wide coverage (290 km swath width), a minimum five-day global revisit time (with twin satellites in orbit) and novel spectral capabilities (e.g., three red-edge bands plus two SWIR bands) are expected to provide extremely useful information for a variety of land (and coastal) applications (Drusch *et al*., 2016). Optical data with less cloud cover having high accuracy hence the Sentinel-2A satellite data were used for this study to estimate summer paddy area in Needamangalam and Mannargudi blocks of Thiruvarur district.

Materials and Methods

Study area

Needamangalam block lies between 10.6649 N to 79.4507 E and Mannargudi block lies between 10.7733 N to 79.4149 E and mean sea level is 10 m with total area of Needamangalam and Mannargudi blocks are 245.50 and 267.45 sq.km respectively. these blocks are bounded with thanjavur district on the west paddy is the most important crop. other important crops are sugarcane, cotton, pulses, gingelly, groundnut. This study area comes under the river basins of Vennar and Vettar as water source for summer paddy cultivation in this area. Hence Needamangalam and Mannargudi blocks of Thiruvarur district was selected for studying the paddy area. The study area map is shown in Fig.2.1

Satellite data

Sentinel-2 optical data can be accessed at multiple levels, ranging from Level-0 to Level-2A, with Level-1C and Level-2A data available. This research used Level-2A, a telemetry analysis product with features such as telemark generation, decompression, coarse co-registration, radiometric correction, geometric viewing model refining, resampling, and conversion to reflectance data. So Sentinel-2A imageries for month of march 2021 acquired with 10m resolution from Copernicus Open Access Hub (Fig. 2.2.), then used for further process. Sentinel-2A provides 13 different bands in electromagnetic spectrum. Green, Red,Near infrared bands were mostly used for agricultural purposes.

Ground truth collection

Ground truth points were collected in Needamangalam and Mannargudi blocks of Thiruvarur district at Peakvegetative stage of crop. A total of 120 points were collected during ground truth survey which were then used for training and validation purposes. A total of 80 paddy points and 40 non paddy points were collected.

Composite Band Function

To comprehend the spectral reflectance patterns of distinct features, band combinations wereused. For agricultural investigations, the False Color Composite (FCC) is recommended since it provides more information about plants in the infrared band. Because the research requires classifying images to distinguish paddy crops, an FCC was created using the composite band function in ArcGIS software with Sentinel-2's B3, B4, and B8 (Green, Red, Nearinfra red) bands, which was used for further analysis.

Subsetting of images

Subsetting the generated raster data might cut down on the amount of time it takes to perform further research. The research area boundaries was digitized and employed in the subsetting procedure after being taken from Survey of India (SOI) toposheets. The Extract by mask module in ArcGIS was used to subset the Sentinel-2A optical image.

Developing training sites

For extracting information from optical data, supervised and unsupervised classification algorithms are used. When there is prior knowledge of the data being studied, supervised classification is used, and when the area is thought to have unknown features, unsupervised classification is used (Kavzoglu, 2009). The research region was thoroughly inspected, and the features/classes found there were meticulously recorded. As a result, the maximum likelihood supervised classification algorithm was used to estimate the Summer paddy area from Sentinel-2A satellite data.

Supervised classification from Optical data

Using various pixel values, each class in supervised

classification have been determined by selecting representative sample sites of a known cover type known as training sites. To classify the entire image, the computer program employed spectral fingerprints from these training areas. By differentiating reflectance response patterns while classifying an unknown pixel value, the Maximum Likelihood Classification (MLC) algorithm statistically analysed the category's variance and covariance.

Training sites or signature files that reflect the various properties of the study area must be produced in order to do the supervised categorization. The ground truth data gathered during the survey was used to build training sites. Both paddy and non-paddy area signatures were developed to avoid misclassification as far as possible. Around five classes were made from the signatures derived from the ground truth points viz., Paddy, Settlements, Waterbody, Barren lands, other vegetations. The developed training sites were used to analyze the Sentinel-2A data for delineating Summer paddy crop by supervised classification. Refinements of the training sites were done after every run of classification and checking for accuracy of the product.

Accuracy assessment

To examine the accuracy of paddy area maps generated using Sentinel-2A with ground truth data gathering on a rice/non-rice basis, a confusion matrix was created. Overall accuracy, producer's accuracy, user's accuracy and Kappa Coefficient can be computed through this error matrix (Congalton, 1991). The entire methodology followed in this investigation for mapping the paddy area is outlined in the flowchart (Fig. 2).

Results and Discussion

Summer paddy area estimation

Sentinel 2A Satellite data fromJanuary 2021 to May 2021 were analysed and March end data having less cloud cover, so that data was used for the identification of summer paddy crop and area estimation in the Needamangalam and Mannargudi blocks of Cauvery delta zone in Tamil Nadu. The downloaded satellite data was composited and subsetted. The training sites developed from the Sentinel-2A satellite data using the ground truth points were

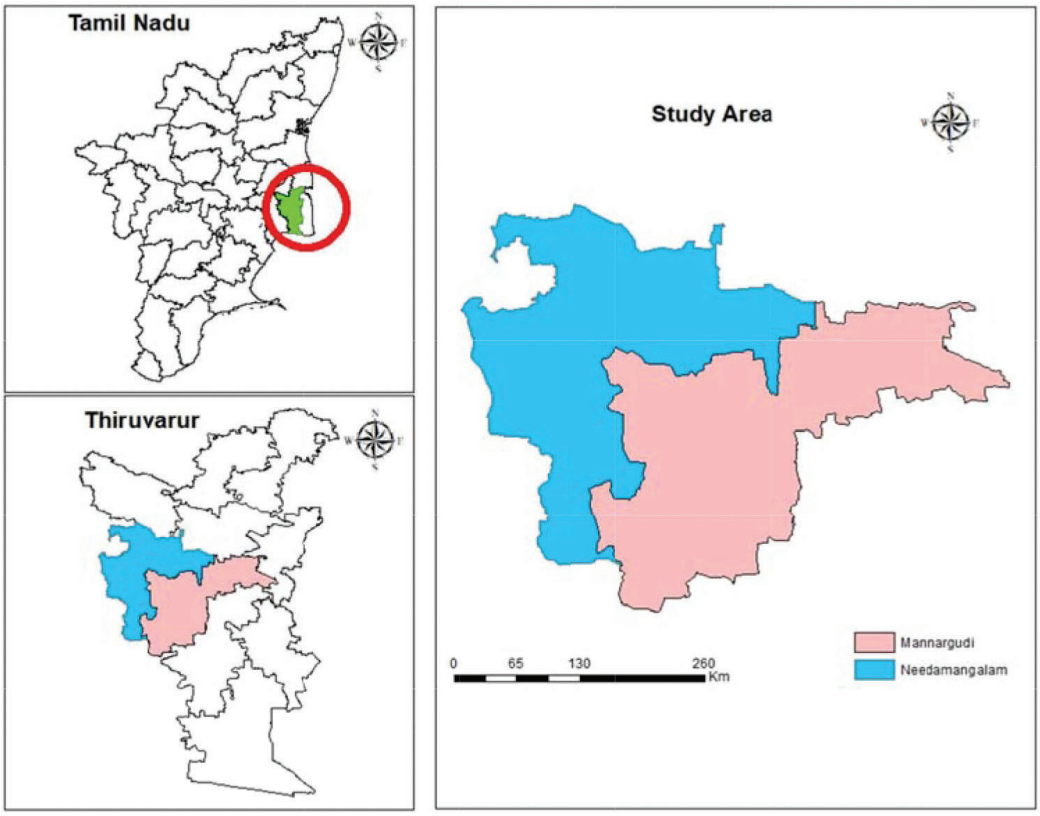

Fig. 1. Study area map of Needamangalam and Mannargudi blocks of Thiruvarur districts

used as an input in the maximum likelihood classifier of ENVI software to generate the paddy area. Refinements of training sites, re-run classification and accuracy assessment were iterated until a considerable accuracy was attained. The results of this study showed that the estimated summer paddy area of Needamangalam and Mannargudi blocks of Thiruvarur districts are 8082 ha. Needamangalam and Mannargudi blocks are having 5766.25 and 2315.75 ha, respectively as summer paddy area. The estimated Summer paddy area of study area are shown in Table .1. From the results it can be inferred that Needamangalam blocks had high summer paddy area compared to Mannargudi block.

The findings were in accordance with the study of Sugavaneshwaran(2021) wherein sentinel-2A optical data was used for *kharif*paddy estimation at cauvery delta zone resultinga total area of 18815.92 hectares at Thiruvarur districts.The paddy area map of the study area is presented in the Fig.1

Table 1. Summer Paddy Area of Needamangalam and Mannargudi

Blocks	Summer Paddy Area(ha)
Needamangalam	5766.25
Mannargudi	2315.75
Total	8082

Accuracy Assessment

The paddy area was characterized from Sentinel-2A Satellite data to construct the accuracy assessment through the use of the confusion matrix, about 80 paddy points and 40 non-paddy sites were used. The results of the confusion matrix found that, a Kappa score of 0.79 which shows a good qualification accuracy (Table .2) and overall accuracy of the paddy map was 89.6 percent. Similarly, mapping wetlands using Sentinel-2 satellite data was done by Kaplan *et al.*, (2017) with an overall accuracy of 99 *per cent* and kappa score of 0.95. Mariana *et al.*, (2017) observed similar results in Cropland map-

Table 2. Confusion Matrix for accuracy assessment

Actual class from the survey	Class	Predicted class from the map		
		Paddy	Non-Paddy	Accuracy (%)
	Paddy	73	7	91.3
	Non-Paddy	5	30	85.7
	Reliability	93.6%	81.1%	89.6
Average accuracy		88.5%		
Average reliability		87.3%		
Overall accuracy		89.6%		
Kappa index		0.79	Good Accuracy	

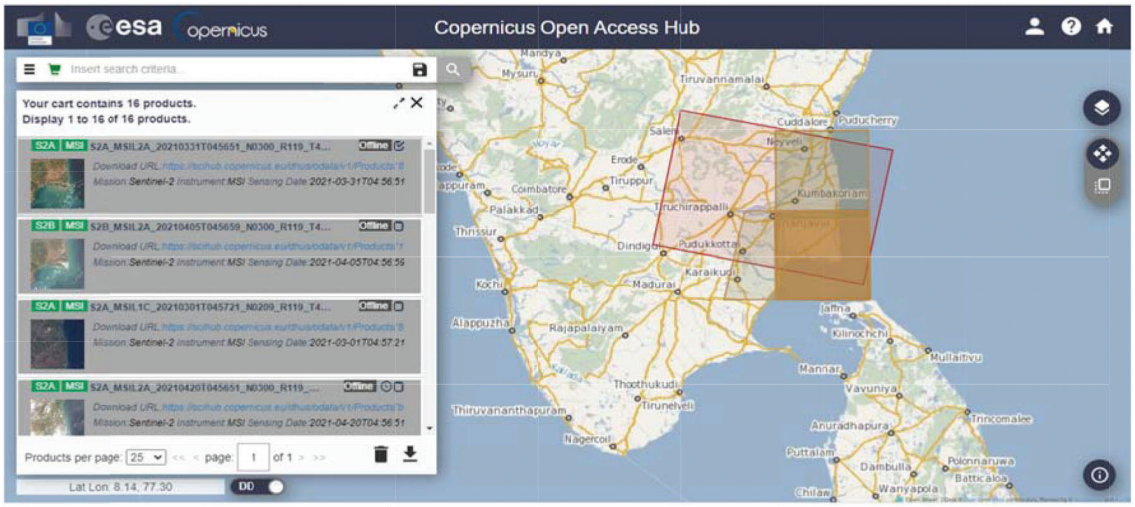

Fig.2. Methodology for Mapping Paddy Area from Sentinel-2 data

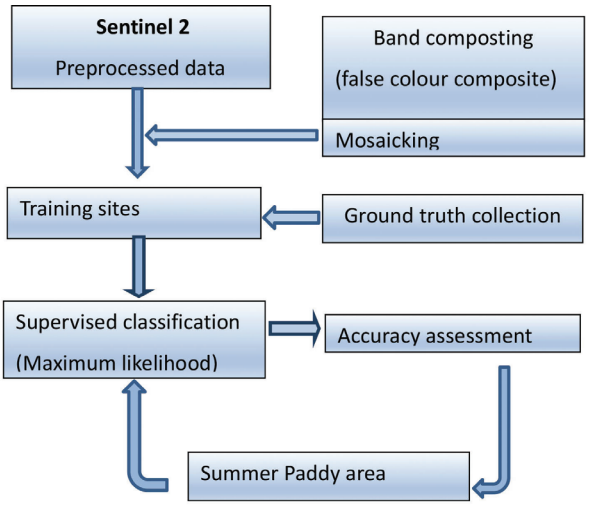

Fig. 2. Methodology for Mapping Paddy Area from Sentinel-2 data

ping in three different climatic conditions, using Sentinel-2 data with accuracy ranging from 78.08 *per cent* to 96.19 *per cent*.

Conclusion

The Sentinel-2A satellite data was used to map the summer paddy area in Needamangalam and Mannargudi blocks of Thiruvarur districts. The estimated Summer Paddy area is 8082 hectares. An overall accuracy of 89.6 *per cent* was achieved with a kappa index of 0.79. The estimated area is found to be in good agreement with actual summer paddy spread. Freely available Sentinel-2A optical data were efficiently used to detect and estimate paddy areawith higher accuracy and reliability. Less cloud cover sentinel-2A satellite data was used for this study which resulted in more accuracy. Policymakers, government officials, farm managers, and farmers could use the information about the paddy area and crop growth conditions to assist them to formulate policies and target interventions. Crop area estimates help the government for providing subsidiesduring disaster.

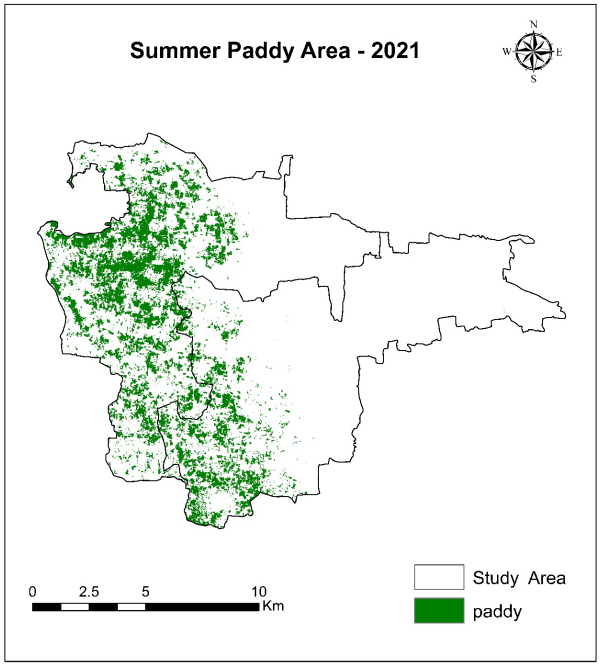

Fig. 3. Paddy Area Map for Needamangalam and Mannargudi blocks of Thiruvarur District

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