Automated *kharif* rice mapping using SAR data and machine learning techniques in GEE platform

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The present study employs temporal C-band Sentinel-1 synthetic aperture radar (SAR) data within the Google Earth Engine (GEE) platform to evaluate discriminability and estimate acreage of *kharif* rice across major Indian states. Utilizing multi-temporal Sentinel-1 C-band SAR data, including time-series cross-polarization vertical–horizontal channels, the research spanned states such as Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Telangana, Andhra Pradesh, West Bengal, Odisha and Assam. Employing five machine learning algorithms on GEE, with random forest demonstrating high performance, achieved 98.59% accuracy and 0.92 kappa coefficient (κ) in Odisha. Subsequently, the RF algorithm was applied for *kharif* rice acreage estimation, yielding overall accuracies from 88.48% to 97.28% and κ between 0.87 and 0.96 with deviations from reported acreage ranging from 0.95% to 12% across diverse states. The study underscores the efficacy of SAR data and machine learning within GEE for precise large-scale automated mapping of *kharif* rice.

Keywords: Google earth engine, large-scale rice mapping, machine learning, multi-temporal, SAR.

AGRICULTURAL lands, being the principal ecosystem, generate crucial information for food security, land management practices[3], crop phenological stages[4] and crop detection over large-scale regions[5] can be achieved through remote sensing. To provide an accurate classification of the crop, it is necessary to utilize multi-temporal data over the entire growing season to identify crop-specific temporal signatures that characterize the key phenological stages (vegetation stage 30–60 days, reproductive stage 30 days, ripening stage 30 days). The challenge posed by cloud cover obstructing optical data acquisition during the monsoon season can be effectively mitigated through the utilization of synthetic aperture radar (SAR) data, given its capability to penetrate cloud cover with minimal attenuation, thus offering a more reliable alternative compared to optical data[6]. Several studies have been conducted to demonstrate the potential of Sentinel-1 data in mapping *kharif* rice[7]. In India too researchers have explored SAR data from different sources to map rice at different scales under different programmes like Forecasting Agricultural output using Space, Agrometeorology and Land based observations (FASAL), Crop Acreage and Production Estimation (CAPE) and Coordinated Programme on Horticultural Assessment and Management using Geo-informatics (CHAMAN)[8–14]. Asian Rice Crop Estimation and Monitoring (Asia-RiCE) aims to promote the widespread utilization of earth observation satellites (EOSs) for comprehensive, timely, and precise forecasts of rice production at national, regional, and global levels