Hybrid AI Models and Synthetic Coherence for SAR-Based Rice Yield Modelling in Northwest Selangor, Malaysia.

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Accurate and timely estimation of rice yield is essential for ensuring food security and supporting sustainable agricultural management in tropical regions. This study develops a SAR-based framework for rice yield prediction using multi-temporal RADARSAT-2 data integrated with above-ground biomass (AGB), vegetation indices, and synthetic coherence features. The proposed framework combines machine learning and deep learning approaches to capture crop structural characteristics and temporal dynamics throughout the growing season. Synthetic coherence is predicted from SAR backscatter and vegetation indices, providing a biologically meaningful alternative that enhances yield prediction without requiring interferometric processing. A stepwise modelling strategy is employed, progressing from baseline models to feature-enhanced hybrid architectures. Results indicate that hybrid CNN–MLP models achieve the highest predictive performance (R^2 ≈0.75, MAE ≈0.28 t/ha), outperforming conventional single-sensor models. Feature importance analysis highlights the critical contribution of synthetic coherence and AGB in improving model accuracy and robustness. The findings demonstrate that SAR-derived features, when combined with advanced hybrid modelling, enable reliable and weather-independent rice yield estimation across multiple growth stages. This approach provides a scalable, data-driven solution for operational agricultural monitoring and decision-making, supporting sustainable crop management and food security. The proposed framework shows strong potential for implementation in cloud prone tropical regions and can serve as a model for integrating SAR-based predictive analytics into precision agriculture systems.

Keywords: SAR Remote Sensing, RADARSAT-2, Rice Yield Prediction, Synthetic Coherence, Machine and Deep Learning, Above-Ground Biomass

