



Integrating UAV-Derived Enhanced Disease Detection Index and Texture Features for Monitoring Southern Corn Rust Severity

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1 Introduction

Southern Corn Rust (SCR) is a high-incidence disease that seriously threatens corn yield and global food security. Traditional field-based assessments are time-consuming and unsuitable for large-scale monitoring. Unmanned Aerial Vehicles (UAVs) combined with multispectral remote sensing offer a practical and efficient approach for crop health monitoring.

2 Methods

The design of Enhanced Disease Detection Index (EDDI) is based on hyperspectral analysis showing that as SCR severity increases, chlorophyll content decreases, leading to changes in the visible and near-infrared spectrums.

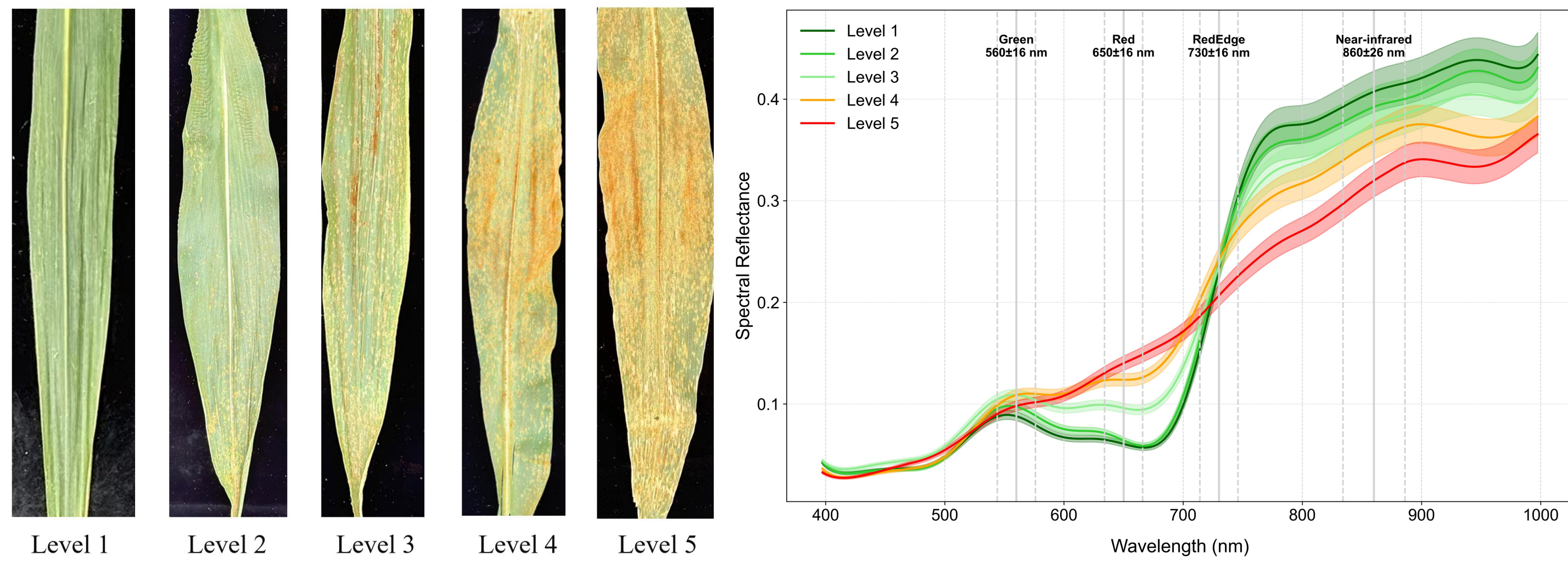


Figure 1 Visual representation of Southern Corn Rust severity, ranging from Level 1 to Level 5 and average hyperspectral reflectance curves of different severity measured by Specim IQ camera in the wavelength range of 400-1000 nm.

EDDI synergistically integrates information from four spectral bands by multiplying two sub-indices:

$$EDDI = \frac{R_{NIR} - R_{RedEdge}}{R_{NIR} + R_{RedEdge}} \times \frac{R_{Green} - R_{Red}}{R_{Green} + R_{Red}}$$

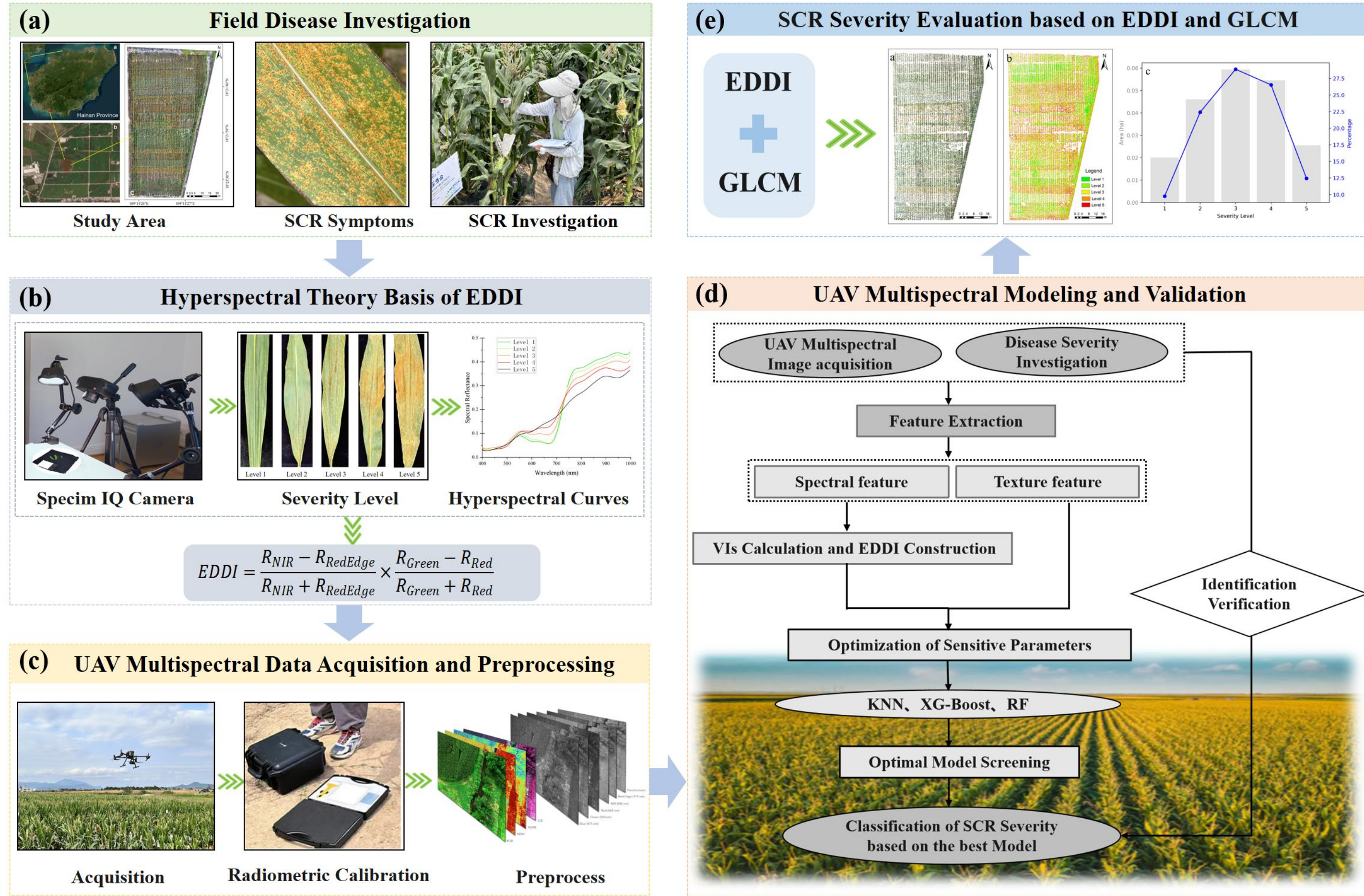


Figure 2 Technology roadmap for SCR severity evaluation using UAV multispectral data, including (a) Field disease investigation. (b) The basis of hyperspectral theory for constructing the Enhanced Disease Detection Index (EDDI). (c) UAV multispectral data acquisition and preprocessing. (d) Modeling and validating multispectral data, and (e) Classifying SCR severity level based on the EDDI and the gray-level co-occurrence matrix (GLCM) of UAV images.

Modeling and Validation:

- Feature Combinations: Four input schemes were tested: texture features only (GLCM), traditional vegetation indices only (VIs), EDDI only, and a combination of EDDI and texture features (EDDI+GLCM).
- Machine Learning Models: The performance of three algorithms—XGBoost, K-Nearest Neighbors (KNN), and Random Forest (RF)—was systematically compared.

3 Results

Superior Performance of EDDI:

- EDDI showed a very high negative correlation with SCR severity, with a Pearson Correlation Coefficient of -0.90, which was higher than traditional VIs.
- Compared to traditional indices, EDDI demonstrated higher separability between all five disease severity levels.

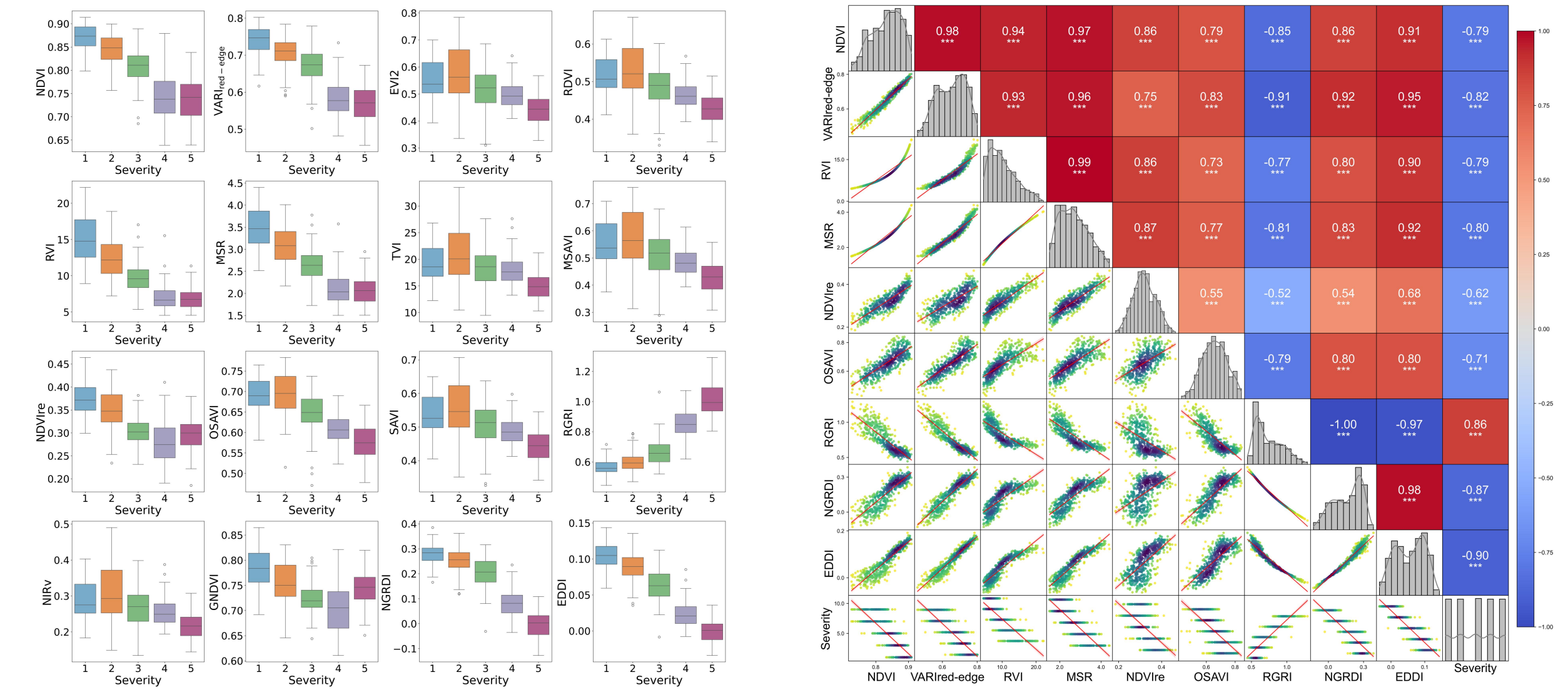


Figure 3 Boxplots of Vegetation Indices at different Southern Corn Rust severity levels and Pearson Correlation Coefficient between Vegetation Indices and Southern Corn Rust severity.

Feature Fusion Improves Accuracy:

- The combination of EDDI and texture features (EDDI+GLCM) produced the most accurate classification results.
- The XGBoost model using EDDI+GLCM was the top performer, achieving an F1-Score of 0.72 and an AUC of 0.95.
- This combined model increased the F1-score by 9.0% over using EDDI alone and by 102.8% over using texture features alone.

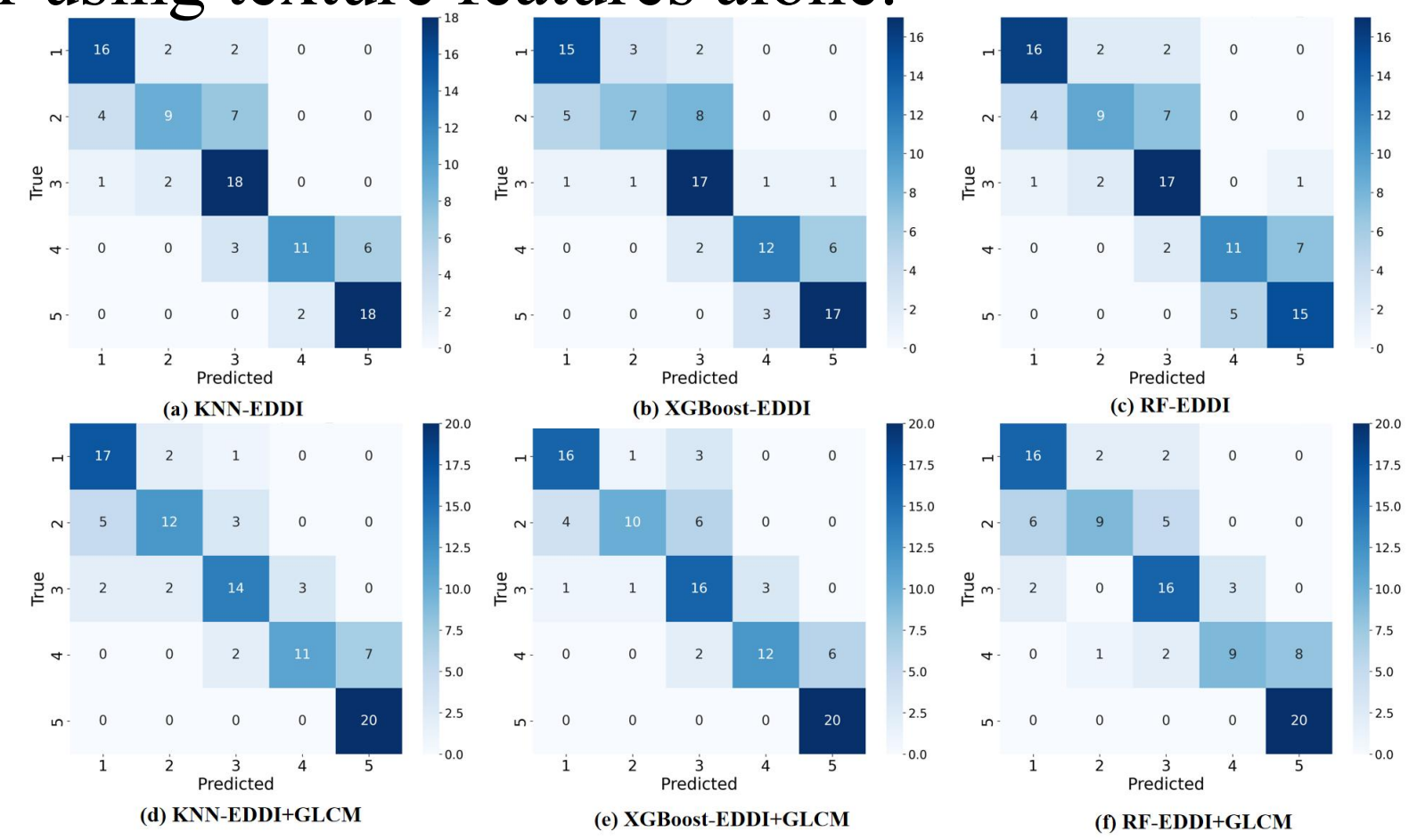


Figure 4 The confusion matrices for the KNN, XGBoost, and RF models with different inputs. (a) KNN-EDDI (b) XGBoost-EDDI (c) RF-EDDI (d) KNN-EDDI+GLCM (e) XGBoost-EDDI+GLCM (f) RF-EDDI+GLCM.

Spatial Distribution Mapping:

- The optimal model was used to successfully generate a spatial distribution map of SCR severity across the entire study area.
- The map revealed that Level 3 (Moderately Resistant) was the most prevalent, accounting for 34.0% of the area, followed by Level 4 (Susceptible) at 25.2%. This provides crucial data for breeders.

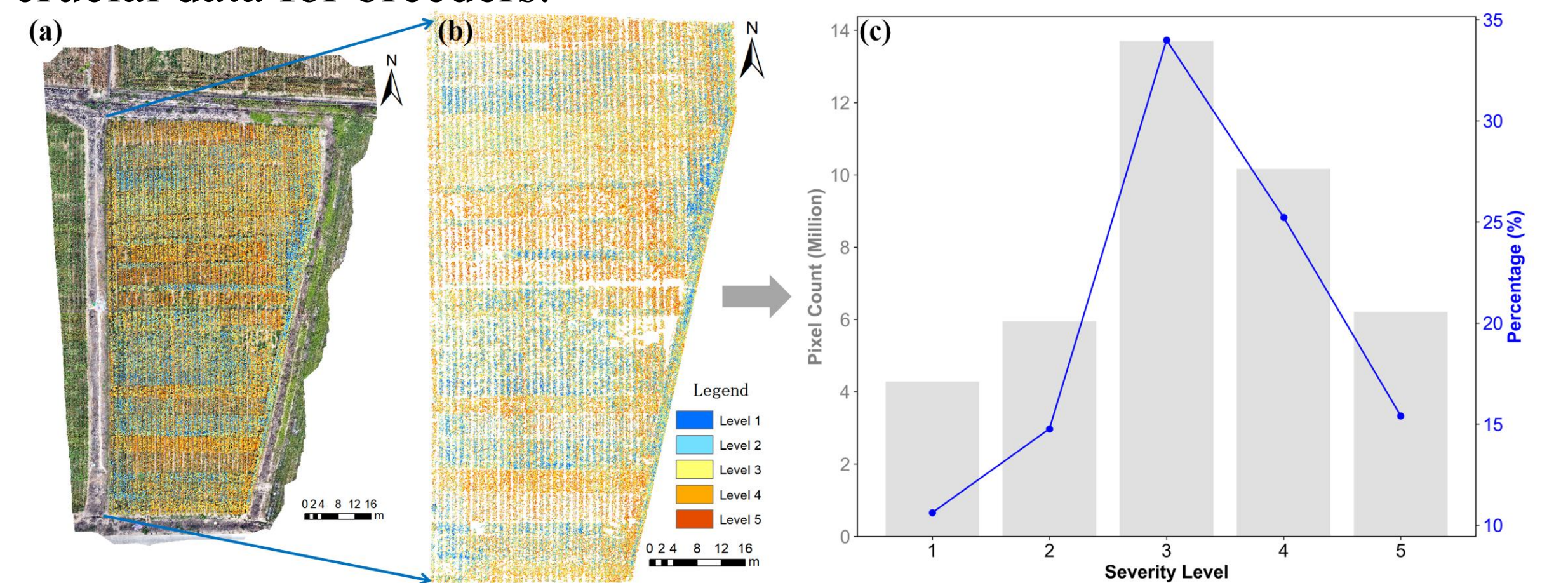


Figure 5 SCR severity mapping based on the optimal model. (a) The RGB image and Southern Corn Rust severity classification map of the study area. (b) Magnified Southern Corn Rust severity classification map. (c) The pixel count and percentage statistics of different severity levels.

4 Conclusion

- The proposed Enhanced Disease Detection Index (EDDI) is a highly sensitive and practical indicator for classifying SCR severity using UAV multispectral data.
- Fusing spectral information (EDDI) with spatial texture features improves the accuracy of machine learning models for disease assessment.
- The lightweight classification model developed in this study provides a rapid, scalable, and cost-effective tool for high-throughput phenotyping, supporting precision agriculture and the breeding of SCR-resistant corn varieties.

Acknowledgements

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