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Use of Remote Sensing in Crop Yield Forecasting

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Introduction

Accurately forecasting crop yields well before harvest is crucial, especially in India, where weather patterns are unpredictable and agriculture produce frequently losses or destroyed by extreme weather events like cyclone, unseasonal rainfall and droughts. Assessing crop yields early on at both the regional and national levels is critical for various stakeholders, including agricultural planners, policymakers, crop insurance companies, agro-processing companies, and the research community.

Traditional crop yield forecasting methods, which rely on ground-based observations, are laborious, costly, and prone to human error. Technological advancements have led to the adoption of weather data and regression models for crop yield forecasting. However, this method is solely dependent on weather data, making them susceptible to errors caused by incorrect or missing weather observations leads to generate incorrect forecast. Remote sensing, with its ability to capture detailed and real-time information about crops health at various crop growth stages, has emerged as a game-changer in the quest for yield forecast. In recent times, with the successful deployment of a range of remote sensing satellites series, such as Landsat, Sentinel, SPOT-VGT and MODIS, remote sensing has emerged as a valuable resource for offering precise, free cost, efficient, and rapid data about crops for yield forecast. This article delves into the pivotal role of remote sensing data in advancing crop yield forecasting methodologies.

Selection of Satellites Data

The selection of appropriate remote sensing satellites data is crucial for accurate crop yield forecasting. Various factors influence the choice of data, including crop type, study area, and the specific research objectives. Key considerations include:

- **Spatial Resolution:** Size of the smallest area that can be distinguished in a remote sensing image. Higher spatial resolution images provide more detailed information about crops.

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- **Spectral Resolution:** Range of wavelengths of electromagnetic radiation that a sensor can detect. Different wavelengths provide information about different aspects of crop health, such as chlorophyll content and water stress.
- **Temporal Resolution:** Temporal resolution refers to the frequency with which remote sensing images are acquired (revisit time). Higher temporal resolution data allows for more frequent monitoring of crop growth and development.
- **Data Availability:** The availability of a substantial amount of historical data allows for the development of more precise forecasting models and we can validate models by least three to four years holdout data.

Vegetation Indices (VIs)

Vegetation indices (VIs) derived from remote sensing data are crucial tools for monitoring and assessing the health of vegetation. These indices are mathematical combinations of different spectral bands, primarily in the visible and near-infrared parts of the electromagnetic spectrum. Here are some commonly used vegetation indices for yield forecasting:

- Normalized Difference Vegetation Index (NDVI)
- Enhanced Vegetation Index (EVI)
- Soil Adjusted Vegetation Index (SAVI)
- Normalized Difference Water Index (NDWI)
- Vegetation Index based on Red Edge (VIRE)
- Leaf Area Index (LAI)
- Vegetation Condition Index (VCI)
- Green Normalized Difference Vegetation Index (GNDVI)
- Simple Ratio (SR)

The MODIS (Moderate Resolution Imaging Spectroradiometer) instrument on NASA's Terra and Aqua satellites provides several Vegetation Indices (VIs) that are widely used for monitoring vegetation health and yield forecasting.

Table: 1 MODIS Vegetation Indices Products for Yield Forecasting

VIs Name	Product Name	VIs Name	Product Name

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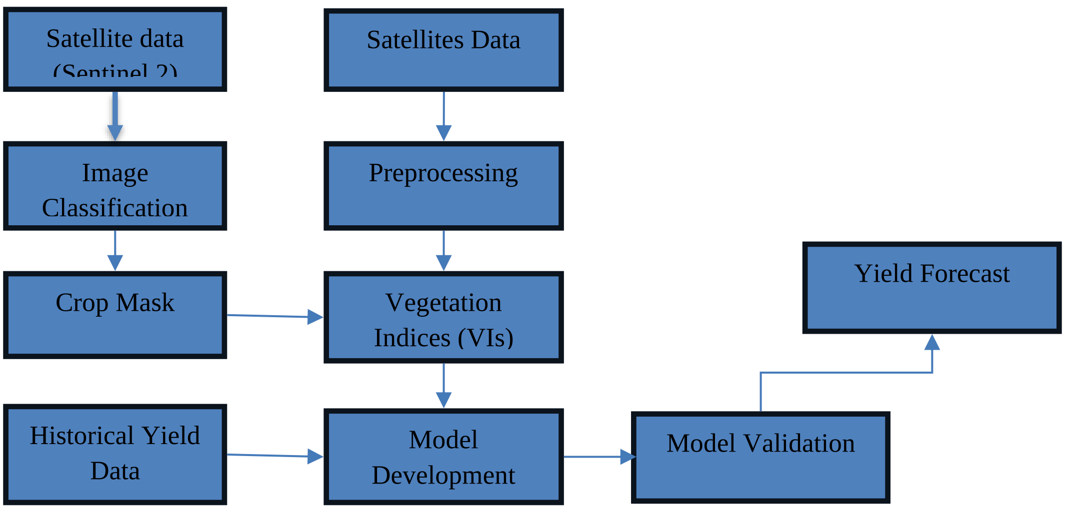
Normalized Difference Vegetation Index (NDVI)	MOD13Q1	Enhanced Vegetation Index (EVI)	MOD13Q1
Normalized Difference Water Index (NDWI)	MOD44W	Leaf Area Index (LAI)	MOD15A2H
Fraction of Photosynthetically Active Radiation (FPAR)	MOD15A2H	Gross Primary Productivity (GPP)	MOD17A2H
Net Photosynthesis (PSNnet)	MOD17A2H	Leaf Chlorophyll Content (LCC)	MOD15A2H

Procedure Flow Chart



Advantages

- **Large-scale coverage:** Monitors vast agricultural landscapes efficiently.
- **Timeliness:** Frequent data acquisition enables real-time tracking of crop development.
- **Objectivity:** Reduces reliance on subjective ground-based assessments.
- **Cost-effectiveness:** Can be cheaper than traditional yield estimation methods.

Challenges and Limitations

- **Cloud cover:** Can obscure optical sensors and necessitate alternative data sources like radar.
- **Data volume and processing:** Requires advanced computational resources and expertise.
- **Model complexity:** Balancing accuracy with interpretability can be challenging.

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Future Outlook

- Integration of AI and machine learning for more sophisticated models.
- Fusion of remote sensing data with other sources like weather and soil data.
- Hyper-spectral and LiDAR sensors offering even finer details about crop health.

Conclusion

In conclusion, the integration of remote sensing data into crop yield forecasting has emerged as a transformative approach, revolutionizing traditional agricultural monitoring methods. Leveraging the capabilities of satellites data of MODIS, Landsat, and Sentinel-2, coupled with advanced machine learning techniques, this methodology provides a comprehensive and dynamic understanding of crop health and potential yield forecasting.