SUNSHINE AGRICULTURE e-Newsletter

ISSN (E): 2583 – 0821

Sun. Agri.:e- Newsletter, (2025) *5*(9), 71-73

Article ID: 441

The Role of Satellite Imagery in Precision Agriculture

Rita Fredericks

CEO, Precision Grow (A Unit of Tech Visit IT Pvt Ltd)

Open Access

*Corresponding Author
Rita Fredericks*

Available online at
www.sunshineagriculture.vitalbiotech.org

Article History
Received: 2. 09.2025
Revised: 6. 09.2025
Accepted: 11. 09.2025

INTRODUCTION

Agriculture is confronted by serious global issues such as population expansion, climate change, soil fertility decline, and calling for sustainable use of resources. Conventional farming involves a lot of intuition and application of generalized practices, which causes inefficiencies. Precision agriculture uses sophisticated technologies like satellite imagery, drones, sensors, GIS (Geographic Information Systems), and AI-based analytics to make decisions based on specific conditions of the field.

Satellite images are especially useful because they can scan wide areas, offer high-resolution information, and monitor changes over time. From soil survey to crop monitoring, farmers can identify variability, distribute inputs accurately, and optimize yields with minimal environmental impacts.

Uses of Satellite Imagery in Precision Agriculture

1. Crop Monitoring and Growth Assessment

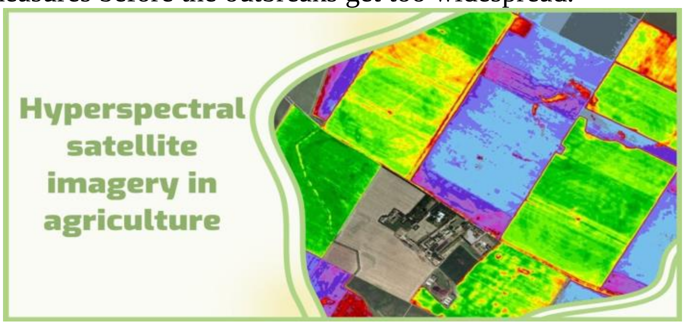
Satellite imagery gives fine details of vegetation health through indices like the Normalized Difference Vegetation Index (NDVI). It assists farmers in identifying stressed plants, monitoring growth stages, and measuring biomass accumulation.

2. Mapping Soil and Moisture

Soil heterogeneity in fields influences productivity. Satellite information aids in the mapping of soil categories, organic matter, and water levels. Farmers can utilize such data in applying fertilizers and irrigation only to the targeted areas, saving resources.

3. Pest and Disease Detection

Diseases and pests tend to affect the color of plants, canopy cover, or reflectance. Satellites are able to detect these changes early, enabling farmers to take early prevention measures before the outbreaks get too widespread.



Source: https://geopard.tech/blog/how-does-satellite-imagery-help-precision-agriculture

ISSN (E): 2583 – 0821

4. Irrigation Management

Through evapotranspiration and soil moisture content assessments, satellites optimize irrigation schedules. This is particularly beneficial in water-scarce areas, where it ensures water-use efficiency.

5. Yield Prediction and Forecasting

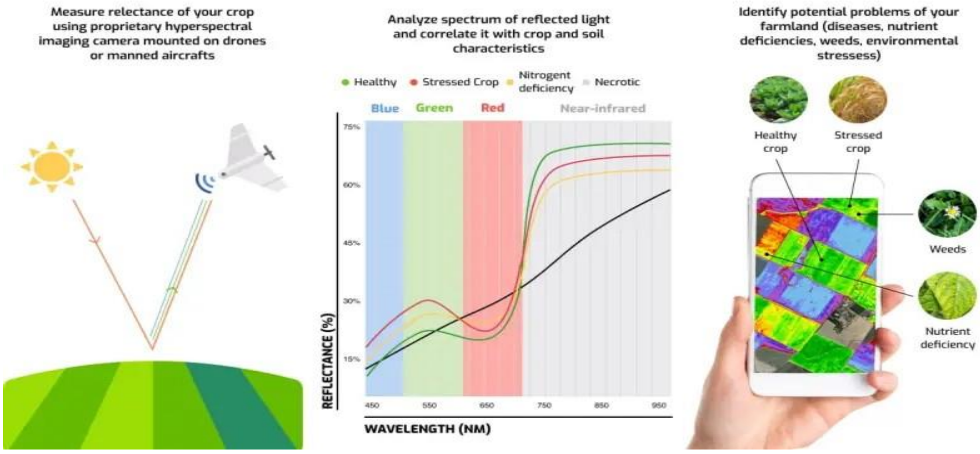
Satellite images, coupled with weather information and crop models, estimate yields with fair accuracy. This is advantageous to farmers, agribusiness, and policymakers in pre-planning harvests, storage, and market logistics.

6. Land Use and Crop Mapping

Satellite images are utilized by governments and research institutions to map patterns of cropping, land use transitions, and agricultural encroachment. It aids in food security planning and policy formulation.

7. Climate and Environmental Monitoring

Satellites monitor temperature, rainfall, drought, and soil erosion hazard. This assists climate-smart agriculture and reduces the effects of extreme weather events.



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Benefits of Satellite Imagery in Precision Agriculture

1. Large-Scale Monitoring – Satellites can monitor large agricultural areas simultaneously, as opposed to drones or ground sensors.

2. High Temporal Resolution – Regular updates enable real-time monitoring of crop dynamics.

3.Low-Cost Data – With free software like Sentinel (European Space Agency) and Landsat (NASA/USGS), farmers and scientists are able to obtain valuable data at low or no cost.

4.Enhanced Efficiency of Resources – Allows for accurate application of fertilizers, pesticides, and irrigation water, cutting waste.

5.Decision-Support – Offers evidence-based information for farm operation and agricultural policy-making.

6.Environmental Advantage – Decreases overuse of inputs, offsets greenhouse gas emissions, and encourages sustainable use of land.

Problem Areas in Utilizing Satellite Imagery

1. Resolution Limitations – Certain satellites have low-resolution data, which can fail to reveal small field variations.

2. Cloud Cover Interference – Cloud cover can impede satellite images, particularly in the tropics.

3. High Charges from Commercial Data – Although free satellite data is available, commercial providers' high-resolution images can be costly.

4. Technical Expertise Requirement – Farmers might not have the skills in GIS and remote sensing, and there is a requirement for training and extension support.

5. Data Integration – Satellite data needs to be combined with drones, sensors, and on-the-ground information, which demands sophisticated analytics.

6. Digital Divide – Developing-country smallholder farmers might not possess access to digital infrastructure to be able to use satellite-based tools.

Case Studies

Case 1: India – Satellite-Based Crop Insurance

India's Pradhan Mantri Fasal Bima Yojana (PMFBY) combines satellite imagery with crop

ISSN (E): 2583 – 0821

insurance programs to ensure correct damage evaluation and prompt compensation for farmers.

Case 2: Europe – Copernicus Sentinel Program

Free multispectral imagery from the Sentinel-2 satellites is utilized for crop identification, monitoring soil health, and planning agricultural policies in Europe.

Case 3: Africa – Drought Monitoring

Satellite-based drought monitoring systems in Africa give early warnings, allowing governments and NGOs to respond in a timely manner to avert food crises.

Future Outlook

- Integration with Machine Learning and AI – Automated systems will scrutinize satellite data to give predictive advice and real-time suggestions.
- Nano and Micro Satellites – Cheap, diminutive satellites will give high-resolution data at shorter intervals.
- Customized Advisory Services – Farmers will get mobile-based, farm-specific advisories from satellite imagery.
- Blockchain Integration – Connecting satellite information with blockchain can enhance supply chain transparency and traceability.
- Climate-Smart Applications – Satellites will have a significant contribution to carbon tracking, sustainable land use, and global climate action.

CONCLUSION

Satellite imagery has transformed precision farming by making possible accurate, timely, and extensive monitoring of crops, soil, and the environment. Satellite imagery facilitates farmers' adoption of site-specific management approaches, resource conservation, and climate variability adaptation. Although challenges like cost, resolution, and technical skills persist, technological advances in remote sensing, AI, and digital infrastructure are increasingly making satellite-based instruments available. In the future, satellite imagery will be at the heart of developing productive, resilient, and sustainable agricultural systems. Through empowering smallholder farmers as well as large-scale farmers, it will ensure that agriculture is able to deliver global food security demands while preserving natural resources.

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