

Precision Agriculture Technologies

Precision Agriculture Technologies – Study Notes

1. Overview

- **Definition:** Use of advanced sensors, data analytics, and automation to manage crops and livestock at a fine spatial and temporal scale.
 - **Goal:** Increase productivity, reduce input costs, and minimize environmental impact.
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2. Core Components

Component	Function	Typical Technologies
Data Acquisition	Collect real-time information on soil, plants, weather, and equipment.	• GPS/RTK receivers • Satellite & drone imagery • Ground-based sensors (soil moisture, EC, temperature) • Weather stations
Data Management	Store, clean, and integrate heterogeneous datasets.	• Cloud platforms (AWS, Azure, Google Cloud) • Farm Management Information Systems (FMIS) • Data lakes & relational databases • GIS mapping
Analytics & Modeling	Transform raw data into actionable insights.	• Machine-learning models (yield prediction, disease detection) • Decision support tools (prescription maps)
Automation & Actuation	Apply inputs (seed, fertilizer, pesticide, water) precisely where needed.	• Variable-rate technology (VRT) • Autonomous tractors & sprayers • Robotic weeders & harvesters • IoT-controlled irrigation valves

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Component	Function	Typical Technologies
Feedback Loop	Monitor outcomes, refine models, and close the cycle.	• Yield monitors • Post-harvest sensor data • Continuous learning algorithms

3. Key Technologies

3.1 Global Navigation Satellite Systems (GNSS)

- **RTK/PPK:** centimeter-level positioning for row-accurate operations.
- **Differential GPS:** improves accuracy for mapping and machinery guidance.

3.2 Remote Sensing

Platform	Spatial Resolution	Typical Use
Satellite (e.g., Sentinel-2, PlanetScope)	3–10m	Large-area vegetation indices, drought monitoring
Manned Aircraft	<1m	Detailed canopy health, biomass estimation
Unmanned Aerial Vehicles (UAVs)	2–10cm	Spot scouting, disease detection, weed mapping
Ground-Based Sensors (LiDAR, multispectral cameras)	<5cm	Row-level plant height, canopy structure

3.3 Soil & Crop Sensors

- **Soil moisture probes** (capacitance, TDR) → irrigation scheduling.
- **Electrical Conductivity (EC) meters** → soil texture & salinity mapping.
- **Leaf wetness & temperature sensors** → disease risk models.
- **Plant canopy sensors** (NDVI, PRI) → real-time vigor assessment.

3.4 Variable-Rate Technology (VRT)

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- **Prescription maps** generated from sensor data.
- **Equipment:** VRT seeders, fertilizer spreaders, sprayers.
- **Benefits:** 10-30% input reduction, yield gains of 5-15% (crop-specific).

3.5 Autonomous Machinery

- **Self-driving tractors** with RTK guidance, obstacle detection.
- **Robotic weeders** (mechanical or laser) for pesticide-free control.
- **Harvest robots** equipped with AI vision for selective picking.

3.6 Internet of Things (IoT) & Edge Computing

- Low-power sensor nodes transmit data via LoRaWAN, NB-IoT, or