Leveraging Precision Agricultural Tools

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Outline of the talk

- Introduction
- Understanding variability and the 4R Principle
- Brief history of Precision Agriculture
- Application in Farming
- Different tools and components
- Case studies and real-world application
- Challenges and Consideration
- Future of Precision Agriculture
- Conclusion / Q&A

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Question

1. **What comes to your mind when you hear the term Precision Agriculture?**

a) GPS-guided tractors
b) Drones and remote sensing
c) Variable Rate Technology
d) Yield Mapping
e) AI & data analytics
f) Other

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Precision Agriculture: A Smarter Way to Farm

- Precision agriculture integrates advanced technologies to optimize farm management, increase productivity, and improve sustainability.

- **Goal**: To optimize returns on inputs while preserving resources.

Observing inter and intra-field variability in crops, soil, weeds, water, disease, insects etc.

↓

Measuring and quantify the variabilities

↓

Responding by making prescriptions for the best management

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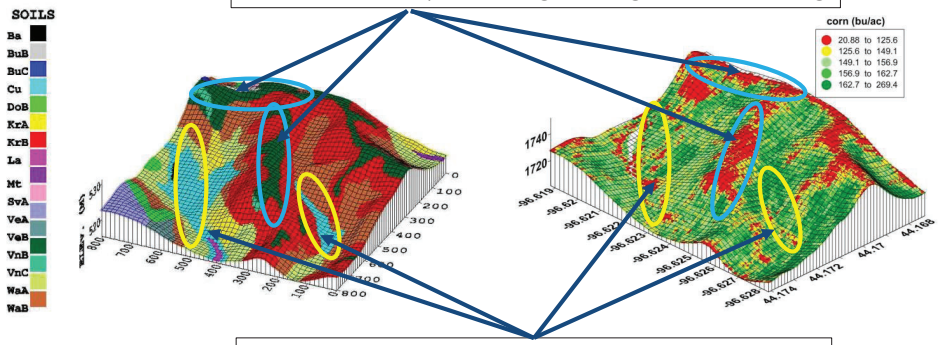
Understanding Variability in Precision Agriculture

Summit:
- Same soil type but low soil moisture and nutrient availability.
- Results in low corn yield due to higher drainage and nutrient leaching.

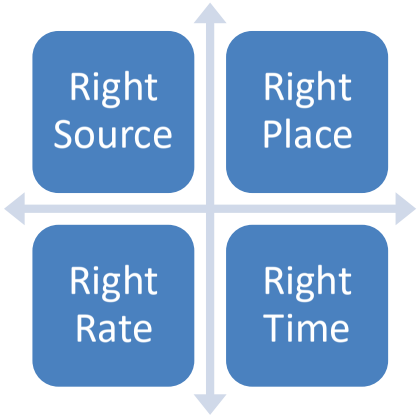


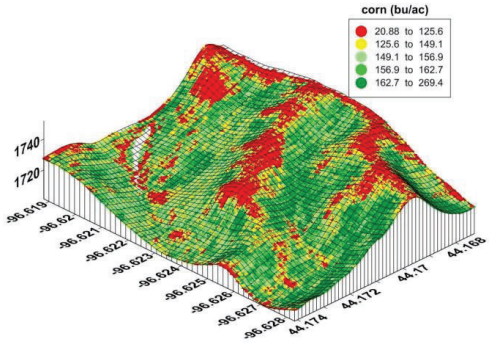
Foot-slope:
- Same soil type but higher soil moisture and nutrient retention.
- Results in greater yield due to better water and nutrient availability.

- **Spatial variability in**
  - Soil type, topography, slope, soil moisture, soil nutrient etc.
- **Spatial variability in**
  - Yield

Image Credit: Dr. Jiyul Chang, South Dakota State University (SDSU)

4R Principle of Precision Agriculture





- **Right Source**: What is right source for N fertilizer?
- **Right Rate**: Can we apply fertilizer at same rate to all different zones within a field?
- **Right Time**: What are the critical growth stages of crops that require nutrients?
- **Right Place**: Should it be applied around the crops or closer to the roots?

Question

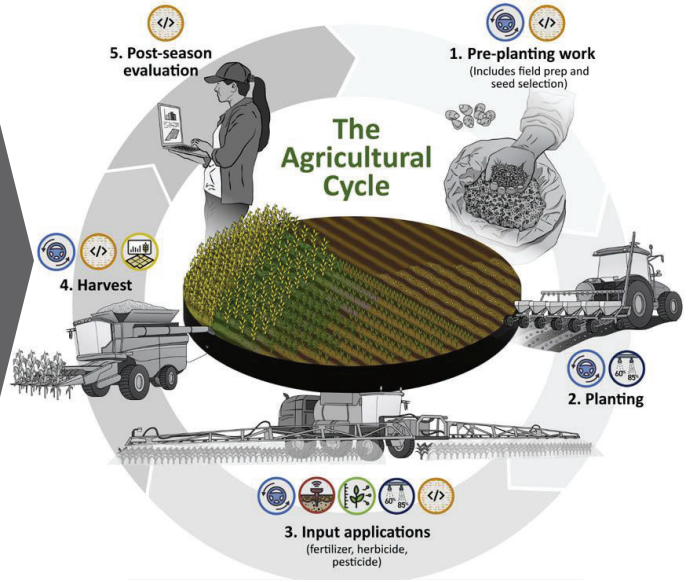
2. Which of the following is an example of the "Right Source" in the 4R Principle?

a) Applying nitrogen fertilizer at a fixed rate across the entire field.
b) Using a nitrogen stabilizer to reduce volatilization losses.
c) Applying fertilizer only at the beginning of the season.
d) Spraying pesticides before planting.

Evolution of Precision Agriculture

- **1980s:** Introduction of GPS technology.
- **1990s:** Development of yield monitors and variable rate technology (VRT).
- **2000s:** Adoption of Remote Sensing and GIS.
- **2010s:** Integration of IoT and big data analytics.
- **2020s:** Emergence of AI and machine learning in agriculture.

Precision Agriculture: Important Role in Agriculture Cycle



Source: GAO, 2024

Precision Agriculture: Livestock

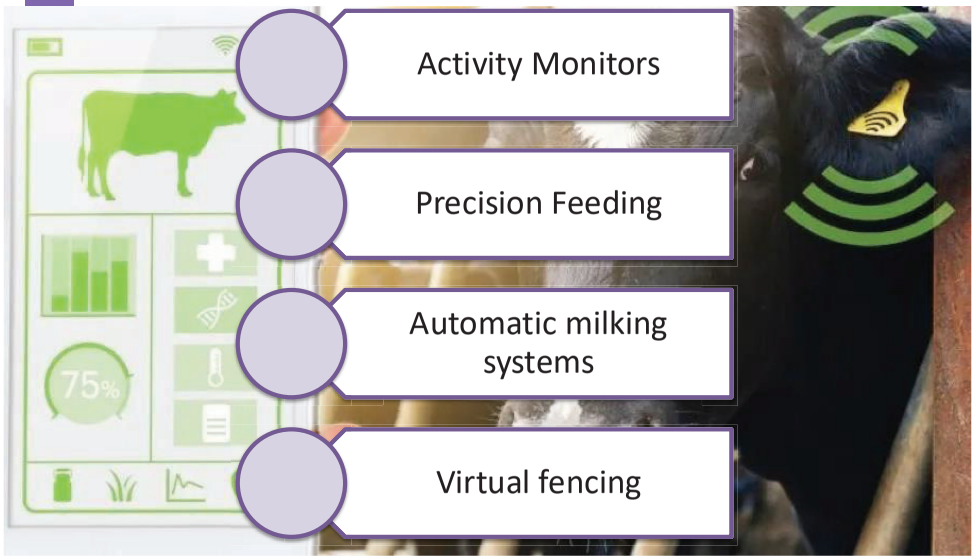
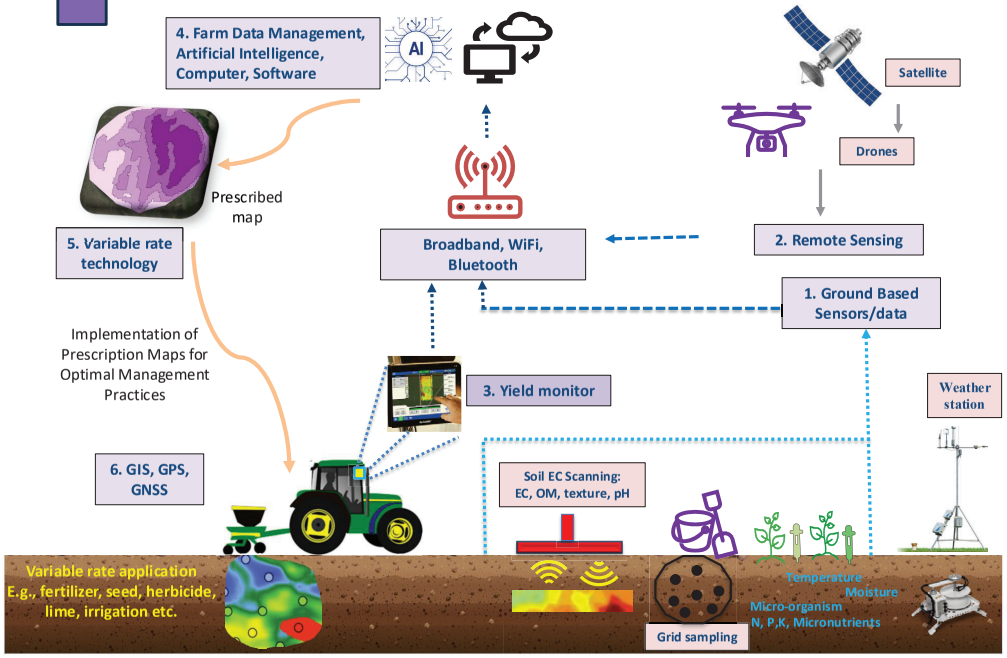


Image Credit: https://fmb.co.bw/2023/04/17/future-of-precision-livestock-farming-in-botswana/

Precision Ag Tools & Components



Question

3. Which of the following Precision Agriculture Tools have you used before? (Select all that apply)

a) GPS-guided tractors
b) Variable Rate Technology (VRT)
c) Drone-based remote sensing
d) Soil sensors for moisture and nutrients
e) Yield monitors
f) GIS Mapping Software
g) None of the above

Key Components of Precision Agriculture

Remote Sensing:

- Satellite and drone imagery for crop health monitoring.
- Satellite: Provide large-scale field monitoring
- Drones: High-resolution imagery for small scale field monitoring

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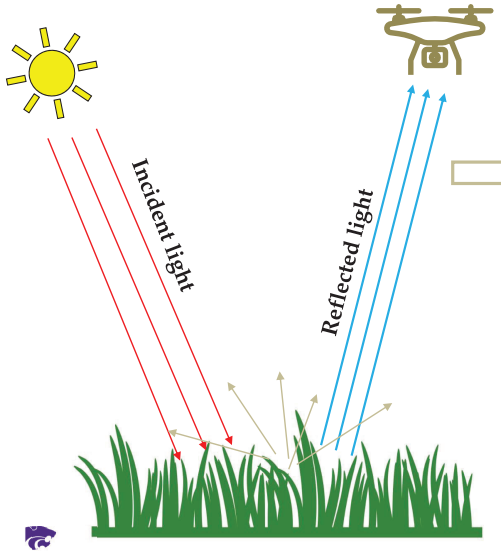
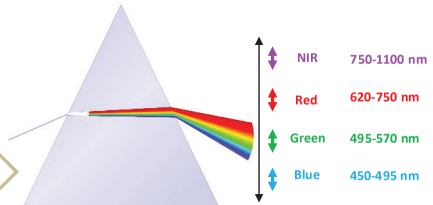
Key Component of Precision Agriculture: Remote Sensing





- Remote sensing is a critical component of Precision Agriculture, enabling farmers and researchers to monitor crops, assess soil conditions, and make informed management decisions
- Reflected light passes through prism in sensor and splits into different colors (bands).
- After split, detector in sensor detect or measure number of different colors or bands reflected.

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Remote Sensing: Satellite & Drone

- Crop Health Monitoring,
- Soil Properties & Moisture,
- Yield Prediction & Mapping,
- Field Variability & Management Zone
- Disease & Pest Detection,
- Weed Mapping & Control,
- Drought & Water Stress Assessment

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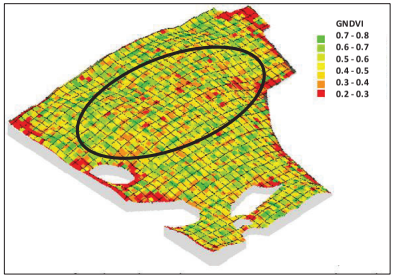
Drone based Remote Sensing

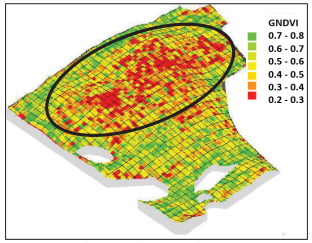
Why drone?
Drones can see things that human eyes cannot.

Green: Healthy plants
Red: Less healthy

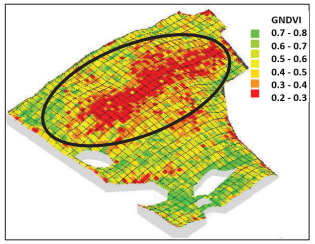


Drone image taken at early July
[Early symptoms of disease]

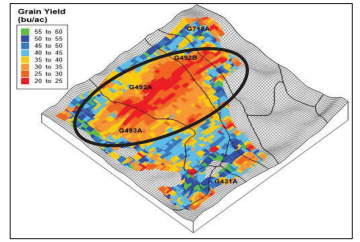
Periodic drone images for field scouting, growth monitoring, detection of biotic & abiotic stress



Drone image taken at early August
[White mold identified]



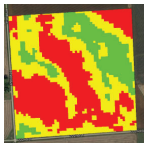
Drone image taken at late August
[Plant growth and development affected by white mold]



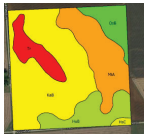
Yield reduction due to white mold

Ground based & handhold sensors

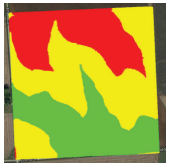
- Real time monitoring of soil and plant health conditions.
- Electrical conductivity, moisture, temperature, nutrients and elevation etc.
- Weather stations measure temperature, rainfall, humidity and wind speed.



EC Map



Soil type



Soil elevation

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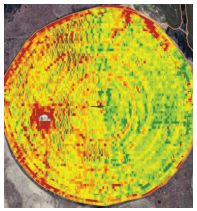
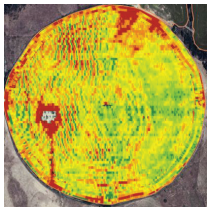
Yield Monitor Data and Yield Map

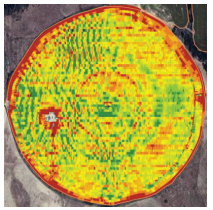
- Crop Harvest data with geospatial information.
- Yield maps identify high and low yield areas within a field.
- Growers can adjust fertilizer, irrigation and seeding rates based on yield variability.
- Optimization of inputs for improved efficiency and sustainability.



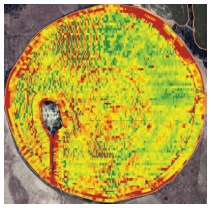
2024



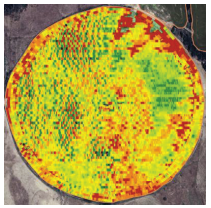
2023



2022



2021



2020

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Data Management, Cloud Computing and AI

- Effectively managing agricultural data such as high-resolution satellite imagery, drone data, soil health records, and IoT sensor readings is very critical in Precision Agriculture.
- Cloud computing enables real-time access, storage, and processing of agricultural data on remote servers.
- AI helps in analyzing large datasets, automating decision-making, and optimizing farming processes.

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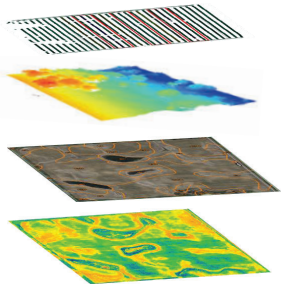
AI In Precision Agriculture

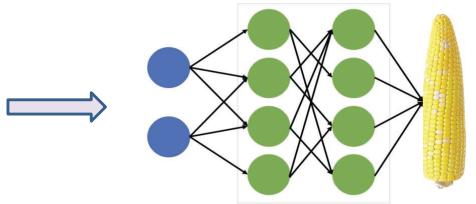


Yield monitor data

DEM : Elevation, slope, aspect

Soil Indices

Satellite Data



Different Scenarios:

1. Topographic variables only
2. Topographic + Soil Indices Only
3. Topographic + Soil Indices + Vegetation Indices

Four Machine learning models

- Partial Least Squares Regression (PLSR)
- Support Vector Machine (SVM)
- Random forest (RF)
- Extreme Gradient Boosting (XGBOOST)

Corn Yield Prediction

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Question

4. How much do you trust AI in decision-making?

a) I completely trust AI and rely on it for decision-making.

b) I trust AI, but I always verify its recommendations.

c) I am somewhat skeptical and use AI cautiously.

d) I do not trust AI and prefer traditional decision-making methods.

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Variable Rate Technology (VRT)

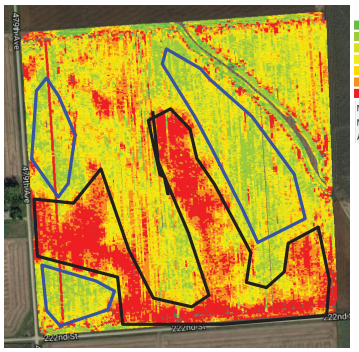

Figure. Understanding corn yield variability

- Yield: 215 bu/ac
- Based on Yield Goal: 258 lbs N/ac
- (Under-fertilized)

- Yield: 100 bu/ac
- Based on Yield Goal: 120 lbs N/ac
- (Over-fertilized)

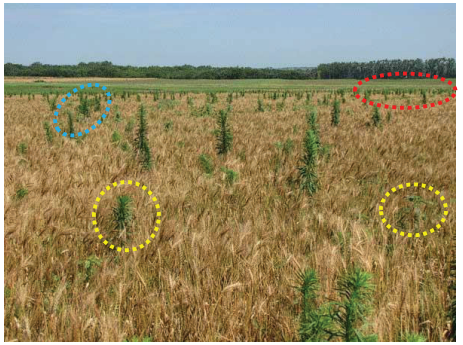

Figure. Understanding weed distribution in wheat field

Image credit: Dallas Peterson, Agronomy eUpdates

Sites having single weed & Scattered.

Some places have moderate weeds presence and clustered

Some places have high weed infestation and clustered

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A uniform input application rate may lead to under-application or over-application by failing to account for field variability.

Management zone/ Site specific based VRT

- Input application based on specific zones within field.
- Fertilizers, seeds, herbicides and irrigation.
- Solve the issue of over-application and under-application.
- Optimization of Resource use: Input applied where needed.
- Cost Savings: reduced input costs, lower fuel and labor costs.
- Improved Crop Yield and Quality: Optimized growth conditions.
- Environmental Benefits: Minimizes excess fertilizer, pesticide application preventing contamination with water bodies.

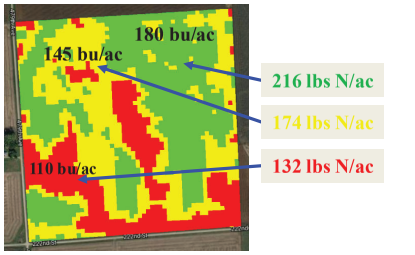

Figure. Variable rate fertilizer application

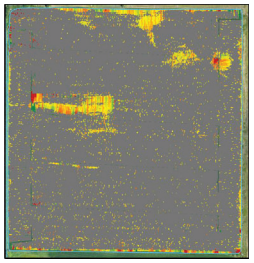

Figure. Herbicide coverage map generated based on weed pressure variability

Image credit: https://www.precisionfarmingdealer.com/articles/6098-isu-precision-spraying-study-157-herbicide-savings-per-acre

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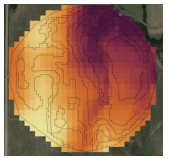
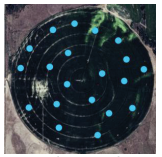
Variable Rate Technology

Prescription maps: Created from collected data to apply inputs at variable rates based on field conditions.

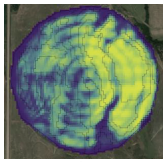
- **Yield Monitor data**: Multi-year yield monitor data gives idea about different productivity areas within field.
- **Imagery (Satellite & Drone)**: Provides real-time crop health information. Detects weeds, plant stress, disease, and nutrient deficiencies.
- **Slope & Elevation**: Identifies areas with steep slopes that may affect water, nutrient retention and erosion.
- **Electrical Conductivity (EC)**: Measures soil texture, moisture, and nutrient availability.



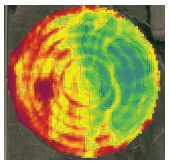
Soil EC Scan



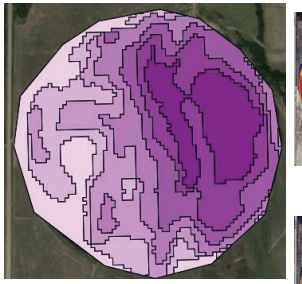
Grid Sampling



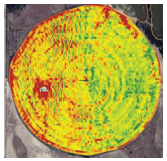
Slope



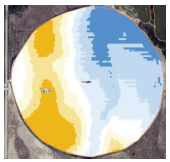
Satellite Imagery



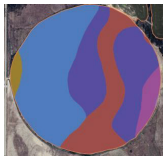
Variable Rate Prescription Map



Yield data



Elevation



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GIS, GNSS & GPS

- **Geographic Information System (GIS)**: Computer based tools used in analysis, visualization and management of spatial data.

- **Application in Precision Agriculture:**

1. Field Mapping and Zoning
2. Soil and Crop Analysis
3. Yield Mapping and Analysis
4. Irrigation and water management
5. Climate and weather analysis

- **Global Navigation Satellite Systems (GNSS):** Provide real-time positioning and navigation for agriculture machinery, drones and field monitoring.

- **Application in Precision Agriculture:**

1. Automated and GPS-Guided Machinery
2. Variable Rate Technology
3. Drone and UAV Navigation
4. Livestock and Asset Tracking

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Benefits of Precision Agricultural Tools

- Increased Efficiency: Optimized input usage.
- Enhanced Crop Productivity: Yield forecasting & disease detection.
- Sustainability & Environmental Benefits: Better soil management.
- Cost Savings: Reduction in resource wastage.
- Data-Driven Decision Making: Improved farm strategies.

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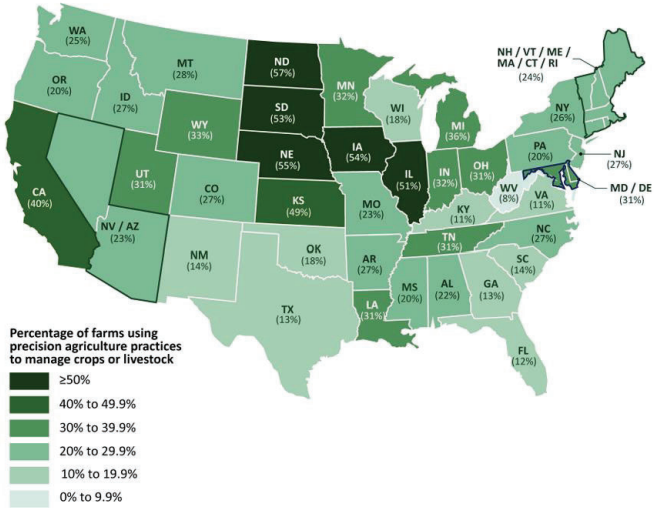
Adaptation of Precision Agriculture Tools in Kansas

- Top five states using precision agriculture technologies: North Dakota, Nebraska, Iowa, South Dakota and Illinois.
- Kansas is in top ten sates with 49% of farms using precision agriculture tools to manage crop or livestock.



Source: GOA summary of U.S. Department of Agriculture 2023 Technology Use.

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Question

5. What is one of the biggest challenges in adopting Precision Agriculture in Kansas? (select only one).

a) Lack of interest from farmers

b) High initial investment costs for technology

c) Incompatibility of precision tools with Kansas soil

d) Limited access to high-speed rural broadband

e) Resistance to change from traditional farming practices

f) Other

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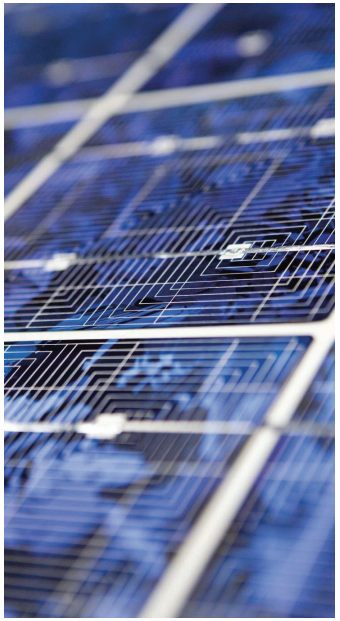
Challenges & Considerations

High Initial Investment: Cost barrier for small farmers.

Data Management & Interpretation: Expertise needed.

Infrastructure & Connectivity: Rural internet and GPS access.

Regulatory and Privacy Concerns: Data security challenges.



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Future of Precision Agriculture

- **IoT & Edge Computing**: Real-time analytics
- **Digital Twins**
- **5G Connectivity**
- **Blockchain for Food Traceability**
- **Robotics & Autonomous Farming Systems**: AI-powered robotic solutions

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Thank you for your Attention

Any Questions?

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