SAI Pakistan

WEBINAR

Precision Agriculture

Presented by:

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Objectives of the Webinar (Nov. 19, 2025)

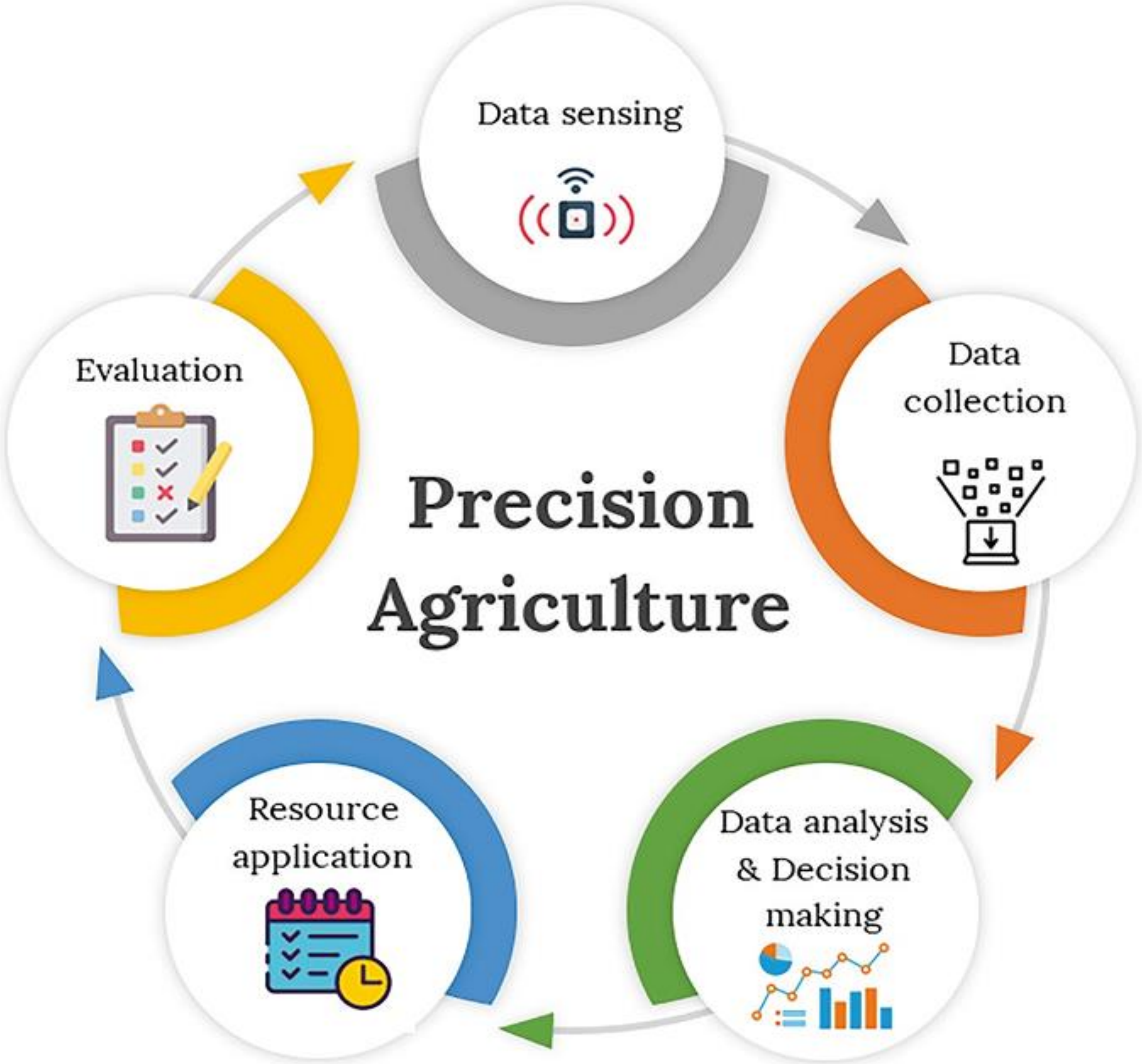
- Webinar will serve as a platform to:
  - Explore advancements in Precision Agriculture
  - Challenges (faced in implementation of Precision Agriculture)
  - Collaborative opportunities (between SAIs)
- Examples: Remote Sensing, In-ground sensors, Targeted spray systems, Automated mechanical weeders and others.
- Perspective of an SAI, if any.

Sequence of Presentation

- Precision Agriculture, its core components
- Global Relevance – a Case of Pakistan
- Tools and Techniques of Precision Agriculture
- Case Study: Irrigation System of Coconuts Plants in Sri Lanka
- An Overview of the Precision Agriculture Technologies
- Challenges in the Adoption of Precision Agriculture
- Enhancing Accountability in Precision Agriculture: The Role of an SAI

Precision Agriculture – Urgent Need

- Precision Agriculture (PA), a modern farming approach that uses data and technology to improve efficiency.
- **Why it matters:**
- By 2050, global population is **10 B** (current 8.2 B).
- Food production must increase by **70%**.
- Resources (land, water, fertilizers) are limited.
- **PA helps:**
  - Increase yields; Reduce waste.
  - Protect the environment.
- Farming has evolved: manual → mechanized → digital → smart farming (Agriculture 4.0).



Source: A. J. Atapattu et al. (2024) Challenges in Achieving Artificial Intelligence in Agriculture, Coconut Research Institute, Lunuwila, Sri Lanka

Core Components of Precision Agriculture

1. Observation:
   – Collecting data about soil, crops, weather, and livestock.
   – Tools: sensors, drones, satellites, yield monitors.
2. Decision-making (Planning):
   – Analyzing data to decide how much water, fertilizer, or pesticide is needed.
   – Tools: AI, big data analytics, decision support systems.
3. Execution (Action):
   – Applying inputs precisely where and when needed; Smart irrigation systems; Precision seeding
   – Tools: automated tractors, drones, variable rate technologies (VRTs)
4. Monitoring:
   – show nutrient levels, soil quality, and productivity (Soil and yield mapping).
   – Tools: Remote sensing (drones and satellites images to detect crop health, pests, and diseases)

Result: Higher efficiency, lower costs, and reduced environmental damage.

Global Relevance – a Case of Pakistan

- Pakistan: 21% of GDP from agriculture.
- Facing water scarcity, low productivity & climate risks.
- 93% farmers are small land holders.
- Employs around 40% of labor force.
- Major crops: Wheat, rice, sugarcane, cotton.
- Export challenges: low quality, inefficiency, & high input costs.
- Precision Agriculture can bridge yield gaps.
- Huge potential for resource-efficient technologies.
- PA is in rudimentary phase in Pakistan

Tools & Techniques of Precision Agriculture

1. GPS Technology

- Enhances precision in farming operations by providing exact field coordinates, allowing for **precise mapping**, planting, fertilizing, and harvesting.
- A GPS-guided tractor plants seeds in straight, even rows; avoids overlapping or missing spots, saves fuel, and ensures every part of the field is used efficiently. Later, the same GPS helps apply fertilizer only where it's needed — saving money and boosting crop growth.

2. Variable Rate Technology (VRT)

Farmers apply inputs like water, fertilizer, seeds, and pesticides in the **right amount, at the right place, and at the right time** — instead of using the same amount across the whole field.

For example: a farmer has a large field. Some parts of the field are dry, some are rich in nutrients, and some have pests. Instead of treating the entire field the same way, VRT allows the farmer to treat each part differently — based on what it actually needs.

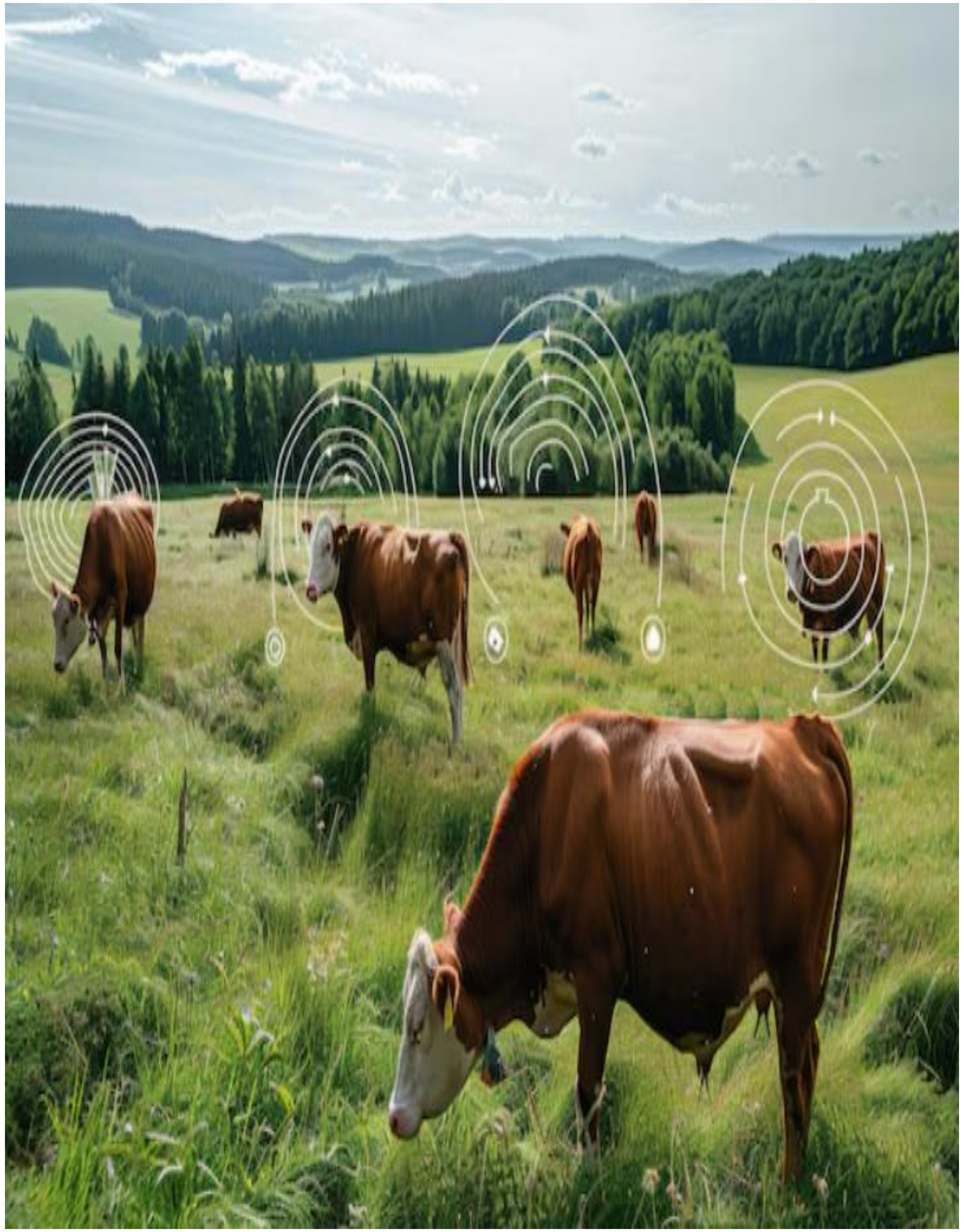
3. Sensor Technology

- Various sensors measure temperature, soil moisture, nutrients, and other factors to provide real-time data for precision agriculture practices.

Example: A dairy farmer places wearable sensors on cows to track their body temperature, movement, and eating habits.

If a cow shows less movement or a drop in temperature, the sensor sends an alert to the farmer's phone. This helps the farmer detect illness early, even before visible symptoms appear.

The farmer can treat the cow quickly, preventing bigger health issues and protecting milk production.



4. Remote Sensing

- Utilizes drones or satellites to gather data (images, temperature, moisture, crop health, weather conditions) supporting efficient farm management.
- A farmer uses a drone to scan the field. The drone spots a dry patch where crops are stressed. Instead of checking the whole field, the farmer goes straight to the problem area and fixes a broken irrigation pipe — saving water and protecting the crop.

Ref: R.K. Goel, C.S. Yadav, S. Vishnoi, R. Rastogi, 'Smart agriculture – Urgent need of the day in developing countries'Sustain. Comput.: Inform. Syst., 30 (2021)

5. Targeted Spray Systems

- A targeted spray system uses smart sensors and AI to detect exactly where weeds or pests are in a field — and sprays only those spots, not the entire area. This saves chemicals, protects crops, and reduces environmental harm.
- A farmer uses an AI-powered sprayer mounted on a tractor. As the tractor moves, cameras scan the ground. When a weed is spotted, the system instantly activates the nozzle above that weed.
- No spray is wasted on bare soil or healthy crops.
- The system reduces herbicide use by up to 90% compared to traditional blanket spraying.

6. Yield Monitoring

- Systems installed on harvesters measure and record crop yield and moisture levels in real-time, providing data for yield mapping.
- A farmer uses a GPS-equipped combine harvester during wheat harvest. As the machine moves across the field, sensors measure how much grain is collected at each spot, creating a yield map; low yield areas are investigated and cured precisely.

- On-the-Go Yield Monitors
- Yield Mapping
- Data Integration and Analysis

7. Precision Planting

Technology-driven approach based on GPS and sensors, optimizes seed spacing, depth, and placement, enhancing germination rates and crop growth efficiency.

Ref: R. Shamshiri, Redmond, Sanaz Shafian, and Ibrahim A. Hameed, eds. 2024. ‘Precision Agriculture - Emerging Technologies’. Agricultural Sciences

8. Soil Sampling

Automated tools collect soil samples at precise locations to analyze nutrient levels and soil properties, guiding fertilization and conditioning.

Grid Sampling

Collects soil samples in uniform, grid-based patterns.

Zone Sampling

Samples based on variations in soil properties, topography.

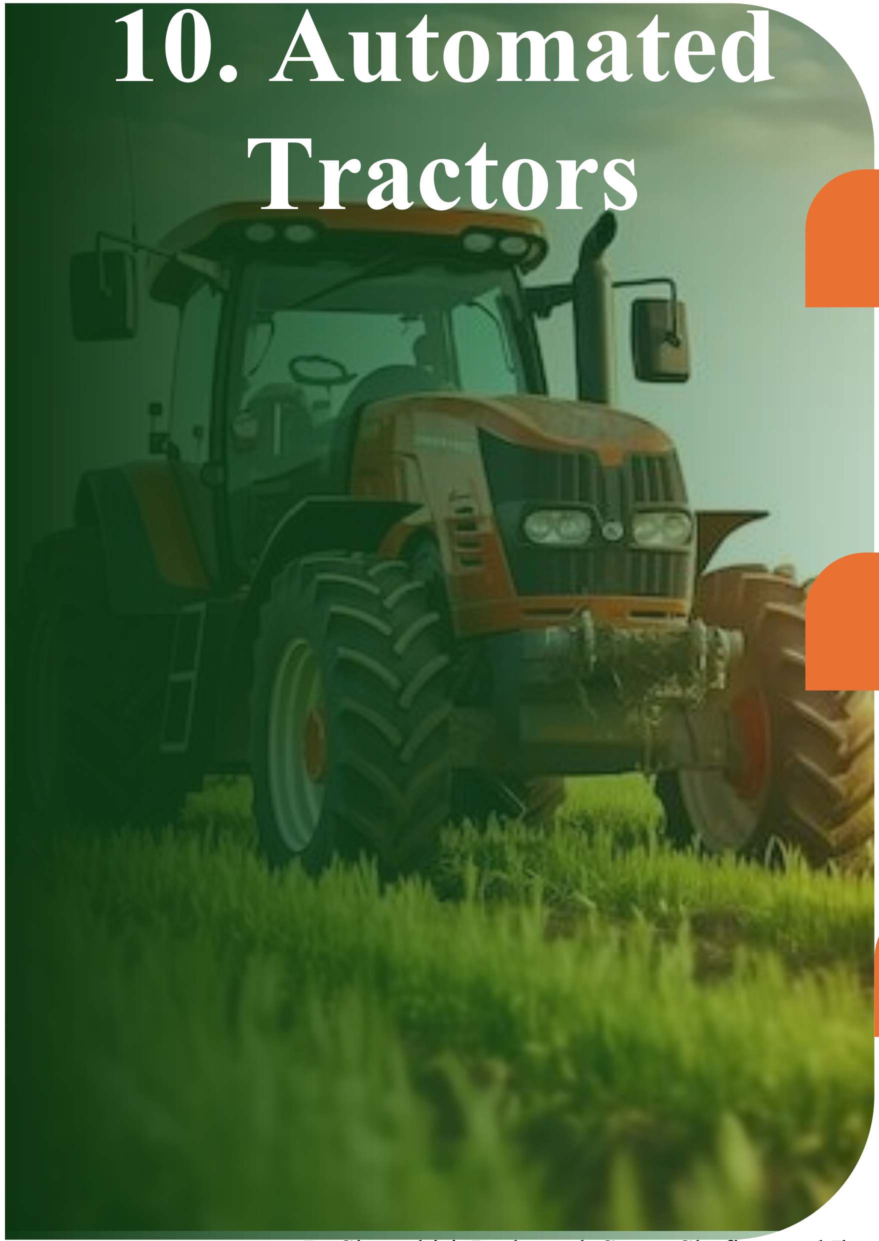
Ref: R. Shamshiri, Redmond, Sanaz Shafian, and Ibrahim A. Hameed, eds. 2024. ‘Precision Agriculture - Emerging Technologies’. Agricultural Sciences

9. Drones in Agriculture

Used for crop monitoring, spraying, and detailed field analysis, drones optimize and reduce the costs of farm management practices.

Ref: R.K. Goel, C.S. Yadav, S. Vishnoi, R. Rastogi, ‘Smart agriculture – Urgent need of the day in developing countries’Sustain. Comput.: Inform. Syst., 30 (2021),

10. Automated Tractors



Self-driving Technology

- Automated tractors use GPS, sensors, cameras, and AI to perform tasks like plowing, planting, and harvesting — with little or no human control.
- They make farming faster, more precise, and less labor-intensive.

Increased Efficiency

Increases productivity by using emerging technologies and reduces labor costs.

Ref: R. Shamshiri, Redmond, Sanaz Shafian, and Ibrahim A. Hameed, eds. 2024. ‘Precision Agriculture - Emerging Technologies’. Agricultural Sciences

11. Weather Tracking

Advanced **weather stations** and **forecasting models** help farmers make informed decisions about planting, pest control, and harvesting.

Example: A farmer installs a weather station in the field; it tracks rainfall and humidity every hour; the system alerts the farmer that rain is expected tomorrow.

- So, the farmer delays irrigation and reschedules pesticide spraying to avoid it being washed away.
- This saves water, chemicals, and money — while protecting the crop.

12. Smart Irrigation System

Sensor-Based Systems

Monitor soil moisture, optimize water usage efficiently.

Drip Irrigation

Delivers water directly to roots, reduces evaporation.

Automated Sprinklers

Programmable, adjusted based on weather and soil conditions.

Smart Controllers

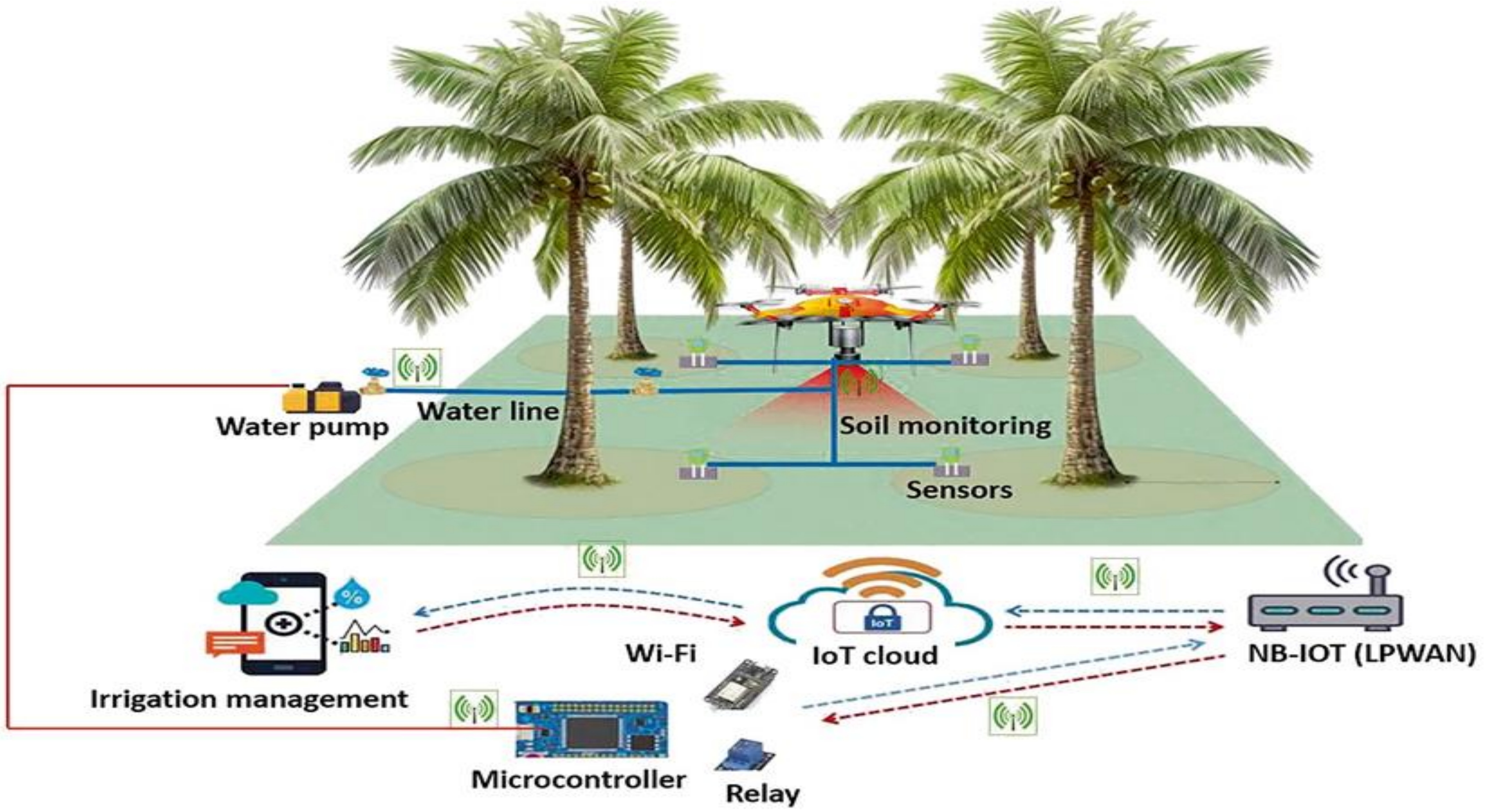
Use weather data to plan and adjust irrigation.

Source: R.K. Goel, C.S. Yadav, S. Vishnoi, R. Rastogi, ‘Smart agriculture – Urgent need of the day in developing countries’Sustain. Comput.: Inform. Syst., 30 (2021),

Economic Analysis of Precision Farming

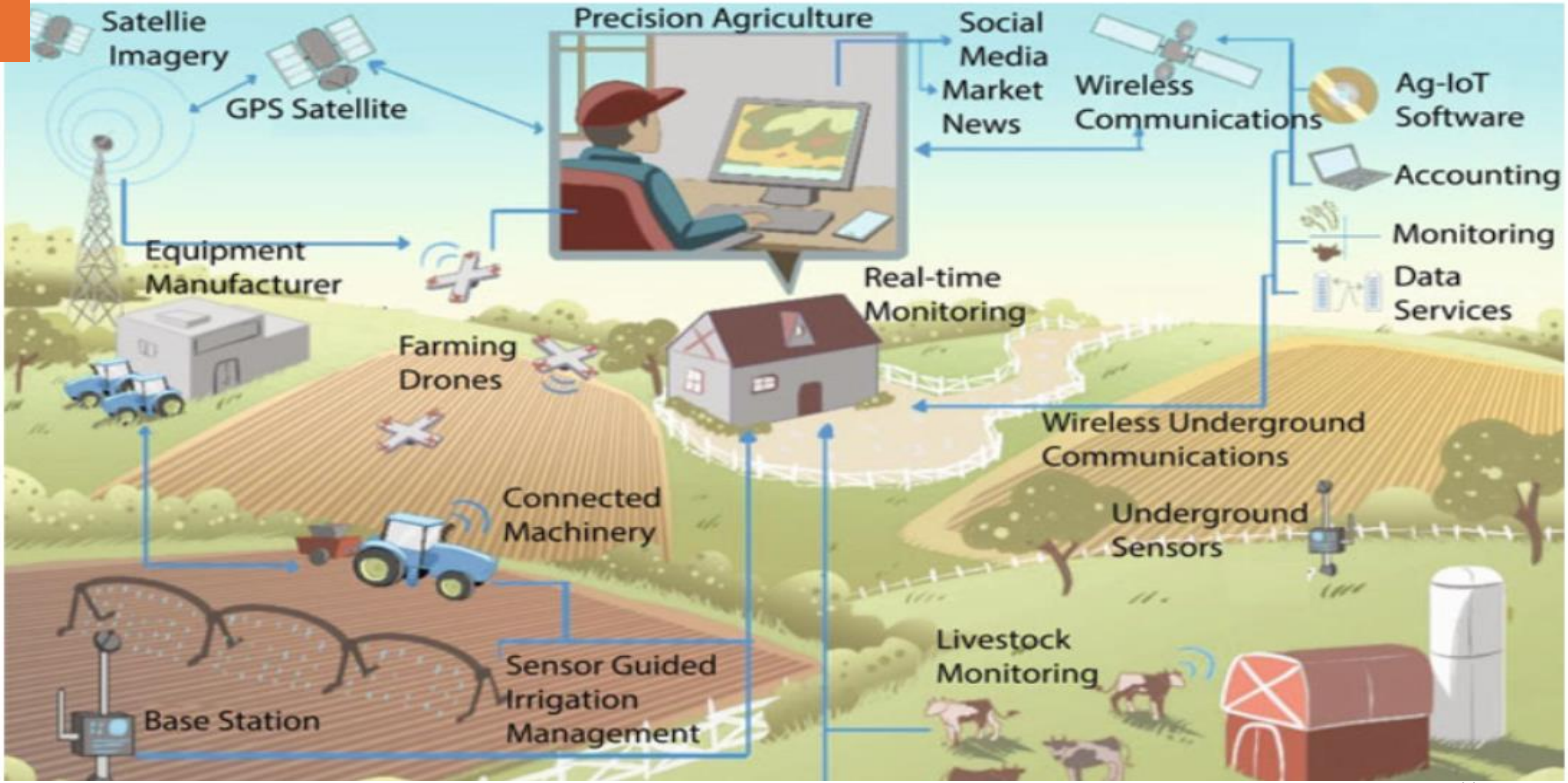
Category	Costs	Benefits	Net Impact
Technology Purchase	High initial expense	Long-term efficiency gain	Positive over 5+ years
Maintenance	Regular upkeep costs	Decreased machine downtime	Cost-effective long term
Labor	Reduced labor needs	Lower long-term labor cost	Significantly positive
Yield	Minor variability cost	Increased yield	Highly positive
Resource Use	Lower input costs	Savings on water & chemicals	Environmentally positive

Case Study: Irrigation Management System in Coconut Cultivation in Sri Lanka



Source: A. J. Atapattu et al. (2024) Challenges in Achieving Artificial Intelligence in Agriculture, Coconut Research Institute, Lunuwila, Sri Lanka

Precision Agriculture Technologies – an Overview



Source: Abdul Salam (2022) Internet of Things in Agricultural Innovation and Security, Available at: https://doi.org/10.1007/978-3-030-35291-2_3

Precision Agriculture Practices around the Globe

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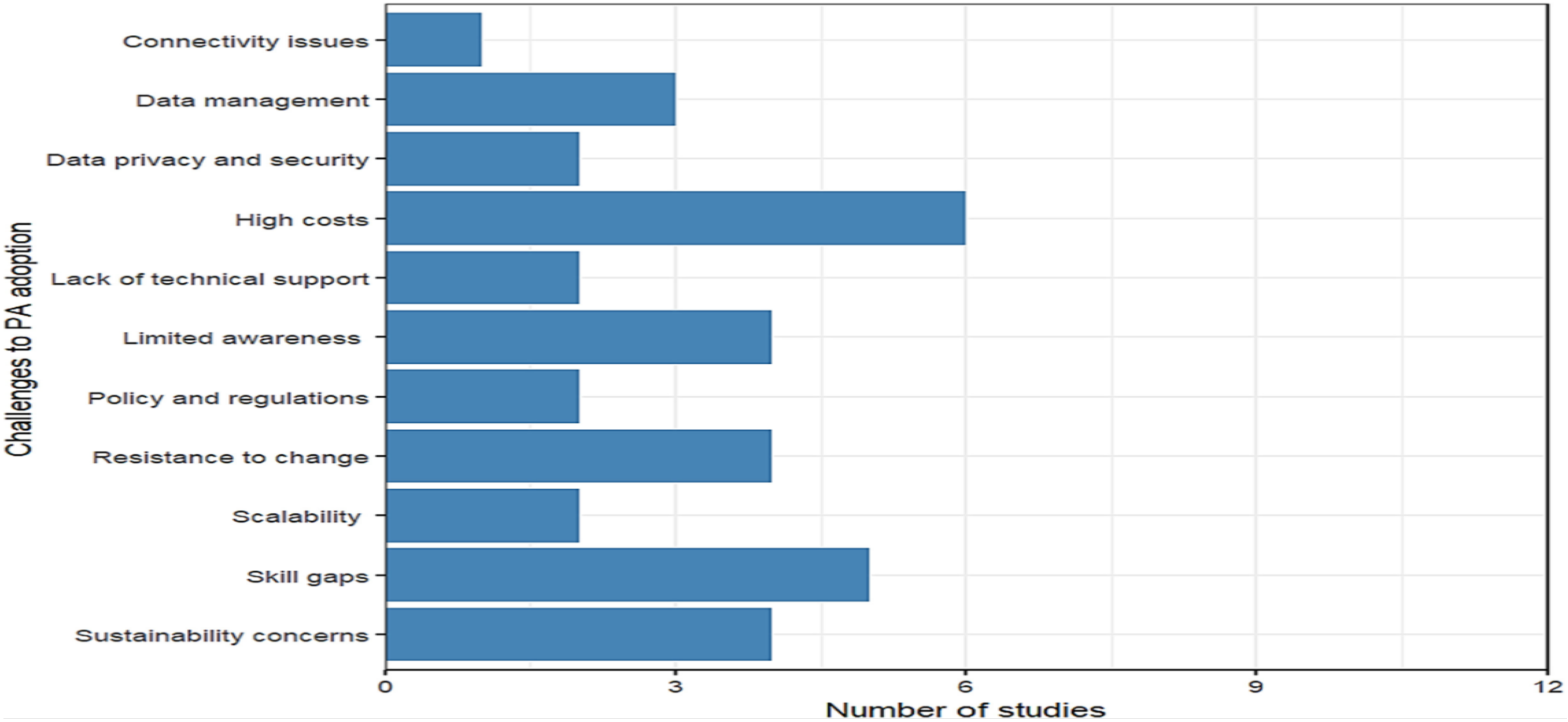
Challenges in the Adoption of Precision Agriculture



Source: Karunathilake EMBM, Le AT, Heo S, Chung YS, Mansoor S. The Path to Smart Farming: Innovations and Opportunities in Precision Agriculture. *Agriculture*. 2023; 13(8):1593

Enhancing Accountability in Precision Agriculture: The Role of an SAI

Mandate of an SAI

- Independent constitutional authority.
- Expected to bring improvements in financial discipline to minimize the possibility of waste and fraud.
- Expands into strategic foresight and risk assessment in emerging sectors.

Why Oversight Matters

- Precision agriculture involves public funds, subsidies, and infrastructure.
- Risks: misuse of funds, data privacy breaches and inequitable access.
- SAIs ensure transparency, value for money, and ethical use of technology.

Financial Audits in AgTech Projects

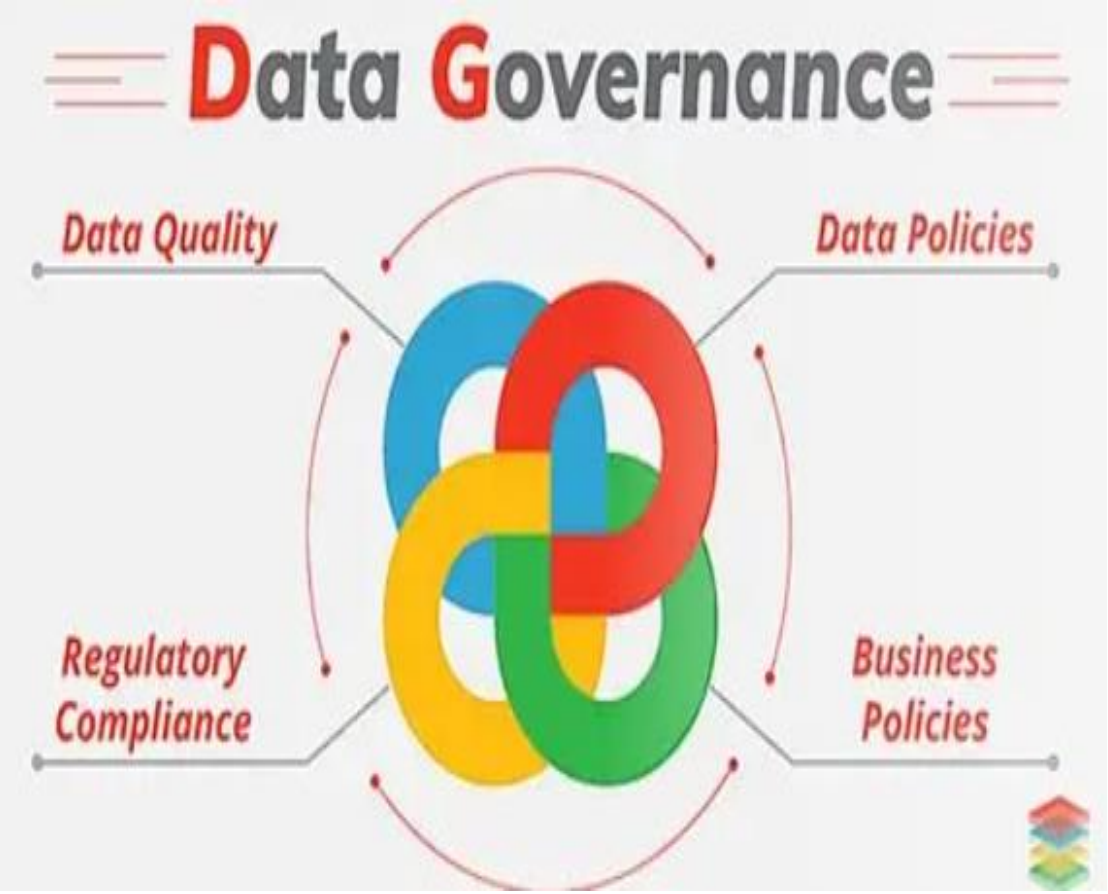
- Review of public spending on smart farming initiatives.
- Verification of procurement, contracts, and subsidies.
- Detection of fraud, inefficiencies, and misreporting.

Performance Audits for Impact Analysis

- Assessing whether AgTech programs meet intended outcomes.
- Evaluating cost-effectiveness, environmental impact, and farmers' satisfaction.
- Recommending improvements for future programs.

Data Governance and Cybersecurity

- **Auditing data collection, storage, and usage in precision agriculture.**
- **Ensuring compliance with privacy laws and ethical standards.**
- **Identifying vulnerabilities in digital infrastructure.**



Ref: A. Al-Badi et al .Exploring big data governance frameworks, Procedia Computer Science, (2018)

Strategic Advisory Role

- Providing **insights to policymakers on risks and opportunities**.
- Encouraging inclusive access to technology for smallholders.
- Promoting long-term sustainability and climate resilience.

Conclusion and Way Forward

- SAIs as key players in responsible innovation.
- Need for capacity building in tech audit skills.
- Call for collaboration between audit offices, academia, tech experts, and agriculture ministries.

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