

COALINGA COLLEGE
DRONE SENSORS FOR WATER MANAGEMNT
AgSTEM Kit 2025



Instructor Guide: Drone Sensors for Water Management AgSTEM Kit

Introduction

The Drone Sensors for Water Management AgSTEM Kit introduces students to precision agriculture through the use of drones equipped with water management and soil moisture sensors. Designed for learners from elementary through community college, this kit provides a scaffolded exploration of how drones, sensors, and data integration are transforming modern farming. Students will learn how drones collect aerial data, how soil moisture is measured, and how farmers make irrigation decisions to conserve water, protect the environment, and improve crop yields.

This kit supports STEM learning, career exploration, and agricultural literacy, and is aligned with NGSS and CTE standards where appropriate. Students engage in inquiry-based learning, problem-solving, and real-world application through presentations, surveys, worksheets, video demonstrations, hands-on activities, and guided reflection.

Kit Components

Each AgSTEM experience includes:

- Age-appropriate presentation slides (2nd–Community College)
- Pre/post student surveys
- Student worksheets & logs
- Hands-on activity simulating or demonstrating drone-based water management
- Video demonstration of drone use in agriculture

Sequence of Use

The full experience is designed to be delivered in a **60–90 minute block**, but can be adapted to shorter segments or multi-day use.

Before the Session

1. Test drone equipment and ensure safe flight environment (or prepare drone footage if demonstration only).
2. Print:
 - o Age-specific pre-survey
 - o Student worksheet or log sheet
3. Load the video demonstration of drones and sensor data.
4. Prepare soil or field plots for hands-on activity (wet/dry zones or soil samples).

Delivery Outline

Segment	Description	Time
1. Welcome & Pre-Survey	Introduce drones in ag; collect baseline interest & knowledge	5–10 min
2. Presentation	Use age-appropriate slide deck to build background knowledge	10–15 min
3. Video Demo	Show drone aerial survey & sample moisture maps	5–10 min
4. Hands-On Activity	Students engage with drone survey simulation and logging	25–40 min
5. Reflection & Post-Survey	Discuss observations and evaluate learning	10–15 min

Hands-On Activities by Grade Level Overview

All activities center around **drone-based water management**, with added complexity in upper grades. Activities are outlined in detail in the Instructor Activity Guide and include:

- **Grades 2–3:** *Drone Water Spotters* – Students identify wet/dry spots with drone flyover or video.
- **Grades 4–5:** *Drone Crop Check* – Students survey mock plots with hidden wet/dry zones.
- **Grades 6–8:** *Drone Irrigation Detective* – Students compare drone maps with ground truth moisture readings.
- **Grades 9–10:** *Drone Flight Plan for Water Savings* – Students design efficient drone flight paths and identify irrigation zones.
- **Grades 11–12:** *Drone Sensor Data Analysis* – Students analyze drone + sensor datasets and recommend irrigation plans.
- **Community College:** *Operational Evaluation Lab – Drone Irrigation Sensors* – Students analyze real/simulated datasets and write mini-technical reports on optimizing irrigation.

Pre/Post Surveys Overview

Surveys are tailored to each grade level and measure:

- Student familiarity with soil moisture and irrigation technology
- Awareness of careers in precision agriculture and AgTech
- Understanding of drones and sensors as agricultural tools
- Interest in STEM and ag-related career pathways

Instructor Note: Surveys should be collected before and after the session for engagement assessment and grant reporting.

Student Worksheets & Logs Overview

Each activity includes a custom worksheet or log sheet with:

- Observation prompts
- Data collection tables (upper grades)
- Open-ended reflection questions

Instructor Use:

- Distribute before the hands-on segment
- Review responses for engagement and understanding
- Use responses to spark discussion or guide debrief

Video Demonstration Overview

A short video is included that showcases:

- A drone flying over a field to identify water stress zones
- Example drone moisture or NDVI maps
- Demonstration of drones assisting in precision irrigation decisions

Instructor Notes:

- Show before the hands-on activity
- Pause to discuss how drones gather data and how farmers interpret it
- Optional: replay after activity for deeper comparison

Instructor Tips

- Test drones or video equipment ahead of time, especially outdoors.
- Mark plots/zones clearly for student observation (flags, cones, or grids).
- Emphasize **safety protocols** if drones are flown in-class.
- Reinforce **career connections** (engineer, technician, data scientist, farmer).
- Encourage teamwork and accurate data recording.

Optional Extensions

- **Writing Prompt:** *“If I had a drone on my farm, it would help me by...”*
- **Career Research:** Assign students a job title from AgTech (Precision Agriculture Specialist, Data Analyst) to investigate.
- **Math/Science Integration:** Use data logs for basic calculations (percent water savings, irrigation efficiency, graphing NDVI vs. crop health).

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Meet the Drones

Farmers use different drones depending on the size of their fields, the type of crops, and the kind of data they need. Here are four common drones you may see in agriculture:

Inspire One

- A professional-grade drone often used in film and mapping.
- Large frame with a stable camera gimbal, making it excellent for **capturing detailed aerial maps of fields**.
- Can carry heavier cameras or sensors, useful for specialized agricultural imaging.

QX 350 Blade

- A smaller, entry-level quadcopter.
- Lightweight and easy to fly, often used in classrooms or training.
- Farmers and students use drones like this to **practice surveying fields** and learn flight controls before moving to advanced drones.

Phantom 3

- One of the most popular drones for both hobbyists and agriculture.
- Built-in camera that can take clear photos and video of crops.
- Affordable and reliable for farmers to **check crop health, spot dry areas, and monitor fields quickly**.

Mavic Air

- Compact and foldable, easy to carry into fields.
- High-quality camera and long flight time for its size.
- Farmers use it for **quick scouting trips** to check crop growth, irrigation patterns, or livestock.

Instructor Note: You don't need to have each of these drones for the kit. The goal is to help students recognize that drones come in many shapes and sizes, from small trainers like the QX 350 to powerful mapping tools like the Inspire One, and that **all can play a role in modern agriculture**.

Presentation 2nd-3rd Grade



How We Help Plants Get Water with Sensors

Welcome to our exciting journey exploring how technology helps us take care of plants! Today we'll learn about special tools called sensors that help plants get just the right amount of water they need.

What Plants Need to Grow



Sunlight

Plants use sunlight to make their own food through a process called photosynthesis. The sun's energy helps them grow tall and strong.



Water

Water moves nutrients from the soil into the plant. It helps plants stay firm and upright, and is used to make food.



Air

Plants breathe in carbon dioxide from the air and release oxygen that we breathe. They need fresh air just like we do!



Soil

Soil holds plants in place and contains important nutrients like nitrogen and phosphorus that plants need to grow healthy.

What is Soil Moisture?

Soil moisture is how wet or dry the soil is. Just like when you touch a sponge, soil can be:

- Very dry - crumbly and dusty
- Just right - feels damp but not soggy
- Too wet - water pools on top

Plants are picky about their soil moisture. Some plants like cacti prefer dry soil, while others like ferns love it wet!



Dry soil (left) makes it hard for plants to grow. Moist soil (right) helps plants thrive and

Why Water is Important for Plants



Water Helps Plants:

- Stand up tall and straight by filling their cells
- Move nutrients from roots to leaves
- Stay cool in hot weather through transpiration
- Make their own food with sunlight

Without enough water, plants get droopy, turn brown, and eventually die. Just like we get thirsty, plants need water to survive!

How Farmers Water Crops

Sprinklers

These spray water over many plants at once, like rain. They're good for large fields but can waste water.

Drip Irrigation

Small tubes with tiny holes deliver water right to the plant's roots. This saves water and keeps leaves dry.

Pivot Irrigation

Giant sprinklers on wheels move around in circles watering crops. These can water very large fields of corn or wheat.



What are Sensors?

Sensors are special tools that can "feel" things we can't always see. They're like extra senses for humans!

Soil moisture sensors measure how much water is in the soil. They send this information to farmers so they know exactly when plants need water.

Different types of sensors work in different ways:

- Some measure electricity that flows through the soil
- Others use heat to detect moisture
- Some even use light or sound waves!



A soil moisture sensor being placed in the soil. The display shows if the soil is dry or wet.



How Sensors Help Water Plants

Step 1: Sensing

Sensors in the soil constantly check if the soil is too dry or too wet.

Step 2: Sending Information

The sensors send this information to a computer or smartphone that the farmer can check.

Step 3: Decision Time

When the soil gets too dry, the sensor alerts the farmer that it's time to water.

Step 4: Watering

Some advanced systems can even turn on watering automatically when sensors detect dry soil!

Why Using Sensors is Helpful

Saves Water

Plants get water only when they need it, so we don't waste this precious resource.

Helps Environment

Using less water is good for our planet and leaves more water in lakes and rivers.

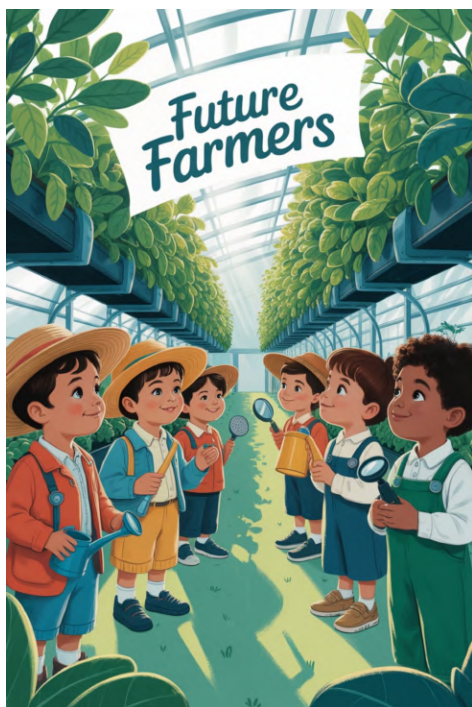


Saves Money

Farmers spend less on water bills and equipment when they water at the right times.

Healthier Plants

Plants that get the perfect amount of water grow bigger and produce more food.



Cool Jobs in Farming with Water Sensors

1

Farmer

Grows crops using technology to make decisions about water, planting, and harvesting.

2

Agricultural Engineer

Designs and builds the sensors and irrigation systems that help water plants effectively.

3

Soil Scientist

Studies soil to understand how water moves through it and how plants use water from soil.

4

Technology Specialist

Helps farmers use computers, phones, and other devices to monitor sensor data and control watering.

What's Coming Next: New Technology



The Future of Plant Watering

- Tiny robots that move through fields checking on plants
- Drones that fly over farms and take pictures to find dry spots
- Sensors that can talk to each other and make decisions without humans
- Phone apps that let you water your garden from anywhere in the world
- Sensors that can detect plant diseases before they spread

What questions do you have about plants and sensors? What was your favorite thing you learned today?

Presentation 4th-5th Grade

Sensors for Water Management: Helping Plants Grow

Welcome to our exploration of how technology helps plants get just the right amount of water! Today we'll learn how special tools called sensors help farmers and gardeners keep their plants healthy.



Understanding Soil and Water

Soil is more than just dirt! It's a special home for plants that holds important things they need to grow:

- Nutrients (plant food)
- Air for roots to breathe
- Water that plants drink

When we water plants, the water travels through tiny spaces between soil particles until it reaches the plant's roots. The roots act like straws, sucking up the water the plant needs.



What is Soil Moisture?

Definition

Soil moisture means how much water is held in the soil. It's like measuring how wet a sponge is!

Why It Matters

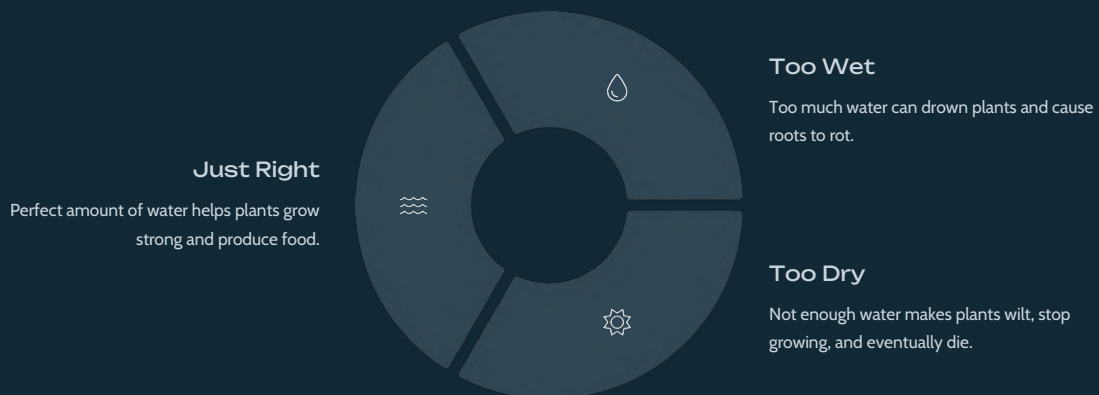
Knowing soil moisture helps us decide when to water plants and how much water to give them.

How We Measure It

We can feel the soil with our fingers or use special tools called sensors to measure exactly how wet the soil is.



Why Soil Moisture Matters to Plants



Plants are like Goldilocks - they need their soil moisture to be "just right" to be happy and healthy!

Planning Watering: Irrigation Schedules

Farmers need to be smart about when they water their crops. They create watering plans called "irrigation schedules" that tell them:

- What days to water
- How much water to use
- What time of day is best

For example, tomato plants need more water when they're making fruit and less water when they're still small.



Using Sensors to Measure Water



Soil Moisture Sensors

These amazing tools can be placed in the soil to measure exactly how much water is there. Sensors come in different shapes and sizes:

- Some look like probes that stick into the ground
- Others look like small stakes with digital displays
- Advanced ones connect to computers or phones

When placed in the soil, sensors can tell us if the ground is too dry, too wet, or just perfect for plants!

How Do Sensors Work?



Sense

Sensors in the soil detect how much water is present using electricity or light.



Send

The sensor sends this information to a computer, tablet, or smartphone.



Show

A special program shows the farmer exactly how wet or dry the soil is.



Solve

The farmer uses this information to decide when to water the plants.

It's like having a tiny robot helper that tells you exactly when your plants are thirsty!

Why Sensors Make Farming Better

Saves Water

Farmers use exactly the right amount of water - not too much, not too little. This helps save our planet's precious water!

Healthier Plants

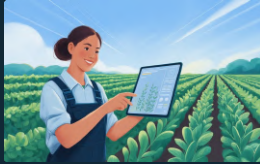
Plants get water when they need it, helping them grow stronger and produce more food for us to eat.

Less Pollution

When farmers use the right amount of water, fewer chemicals wash away into rivers and lakes.



Careers: Who Works with Sensors on Farms?



Precision Agriculture Specialist

Uses technology to help farmers make better decisions about growing crops.



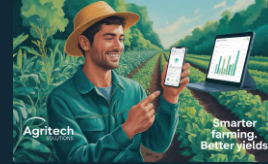
Agricultural Engineer

Designs and builds new tools and systems to help farmers grow more food.



Sensor Technician

Installs, fixes, and maintains sensors and other farm technology.



Farmer

Uses data from sensors to make smart decisions about caring for crops.

Future Tools for Smart Farming

Amazing technology is changing how we grow food!

- **Drones** fly over fields to take pictures that show which plants need water
- **Smart irrigation systems** automatically water plants when sensors say they're thirsty
- **Weather-connected sensors** know when rain is coming and adjust watering plans
- **Robot helpers** that can plant seeds, pull weeds, and harvest crops



These tools help farmers grow more food while using less water and keeping our

Summary: What We Learned



Soil & Water

Plants need the right amount of water in soil to grow healthy.



Soil Moisture

Measuring how wet soil is helps us know when to water plants.



Sensors

Special tools can measure soil moisture and send information to farmers.



Smart Farming

Technology helps farmers save water, grow better plants, and protect our planet.

Questions & Discussion

Let's Talk About It!

- What did you find most interesting about soil moisture sensors?
- How do you think sensors help the environment?
- If you could invent a new tool to help farmers, what would it do?
- How might you use sensors in your own garden at home or school?



The future of farming is in your hands! What will you create to help grow food and protect

Presentation 6th-8th Grade

Sensors for Water Management

Welcome to our exploration of how modern technology is revolutionizing the way we manage water in agriculture. Today, we'll discover how sensors are helping farmers use water more efficiently and grow healthier crops.



Water-Soil Relationship: What You Should Know

Soil is like a sponge that holds both water and nutrients that plants need to grow. When it rains or when we water plants, the soil captures this moisture.

Plants use their root systems to absorb water from the soil. These roots act like straws, pulling up water that contains dissolved nutrients essential for growth.

Different soil types hold different amounts of water:

- Sandy soil drains quickly and holds less water
- Clay soil holds more water but can become waterlogged
- Loam soil (a mix of sand, silt, and clay) is ideal for most plants



Soil Moisture: Key to Plant Health

1

What is Soil Moisture?

Soil moisture refers to the amount of water present in the spaces between soil particles. It's measured as a percentage of water volume in soil.

2

Too Little Water

Plants wilt and their growth slows. Leaves may turn yellow or brown and eventually die. Roots cannot absorb nutrients from dry soil.

3

Optimal Moisture

Plants grow vigorously with healthy green leaves. Roots develop properly and can absorb the right amount of nutrients from the soil.

4

Too Much Water

Roots can't get oxygen and may rot. Plants become susceptible to fungal diseases. Nutrients can be washed away from the root zone.

Finding the right balance is critical - plants need "just right" moisture levels, similar to Goldilocks!

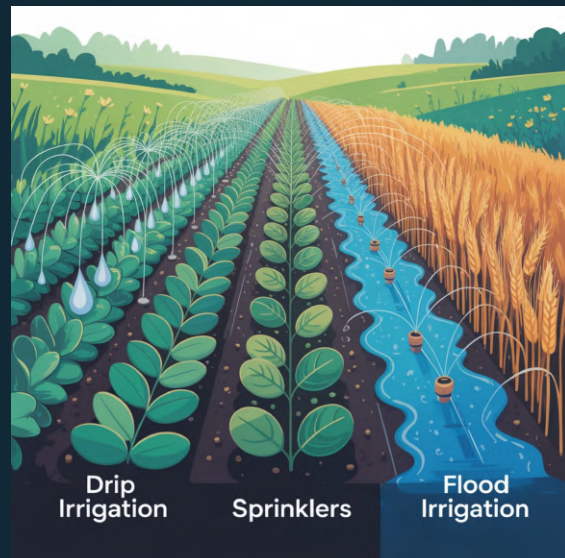
Managing Water with Irrigation

The Irrigation Challenge

Farmers face a constant challenge: providing exactly the right amount of water at the right time.

- **Too little water:** Plants won't grow properly and may die
- **Too much water:** Wastes resources and can damage plants

Efficient irrigation scheduling helps farmers conserve water while ensuring plants get what they need when they need it.



Common Irrigation Methods

Irrigation Scheduling Example: Tomatoes



Sensors in Agriculture

What Are Agricultural Sensors?

Agricultural sensors are devices that measure conditions in the soil, air, or plants themselves. For water management, soil moisture sensors are especially important.

These devices act like electronic "fingers" that can feel how wet or dry the soil is, much more accurately than human touch can detect.

Tensiometers

Measure how hard plant roots need to work to extract water from soil



How Do Sensors Measure Water?



Sensors in Soil

Sensors are placed at different depths in the soil near plant roots. They take measurements at regular intervals (often every 15-60 minutes).



Data Transmission

Measurements are sent wirelessly to a central hub or directly to the internet through cellular networks or WiFi connections.



Data Processing

Computers analyze the data and create charts and reports showing moisture trends over time. The system may also generate automatic alerts.



Farmer Access

Farmers view the information on smartphones, tablets, or computers. They can check moisture levels from anywhere at any time.



Benefits of Sensor-Based Water Management

Water Conservation

Sensors help farmers use 20-50% less water by applying it only when and where needed. This is especially important in drought-prone regions.

Cost Savings

Less water used means lower water bills and reduced energy costs for pumping. Sensors can pay for themselves within 1-2 growing seasons.

Healthier Plants

Consistent moisture levels help plants grow stronger and resist diseases. This can increase crop yields by 10-25%.

Environmental Protection

Preventing overwatering reduces runoff that can carry fertilizers and pesticides into streams, rivers, and lakes.

By using sensors, a single medium-sized farm can save millions of gallons of water each growing season - enough to fill several Olympic swimming pools!

Careers in AgTech: Jobs Using Water Sensors



Precision Agriculture Specialist

Uses sensors and maps to create custom irrigation plans for different parts of a field based on soil and plant needs.



Sensor Technician

Installs, calibrates, and maintains sensor networks to ensure they provide accurate data to farmers.



Agricultural Data Analyst

Studies sensor data to identify patterns and make recommendations for improving water use efficiency.

These careers combine technology, science, and agriculture. They typically require education in fields like agricultural science, engineering, computer science, or environmental studies.



Future of Irrigation Technology

Self-Adjusting Systems

Future irrigation systems will automatically adjust water delivery based on sensor readings, weather forecasts, and plant growth stages without human intervention.

Integrated Data Sources

Irrigation decisions will combine ground sensor data with satellite imagery, drone monitoring, and weather station information for complete environmental awareness.

Artificial Intelligence

AI systems will learn from past growing seasons to predict optimal watering patterns for specific crops, locations, and weather conditions, becoming smarter over time.

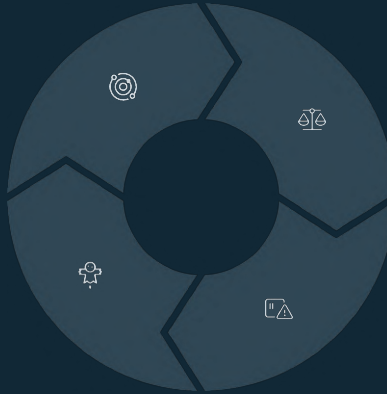
Summary of Key Points

Soil-Water Relationship

Soil type and texture determine how water is held and made available to plants. Understanding this relationship is fundamental to good irrigation.

Career Opportunities

The growing field of agricultural technology offers exciting career paths that combine technology with environmental stewardship.



Balance is Critical

Plants need just the right amount of water - not too much, not too little - and this "sweet spot" changes throughout their growth cycle.

Sensors Provide Precision

Modern sensors allow for precise measurement of soil moisture, helping farmers make data-driven decisions instead of guessing.

Questions & Discussion

Think About It:

- What type of sensor would you want to invent to help farmers?
- How could these agricultural technologies be used in your school garden or at home?
- Besides water, what other resources could sensors help farmers manage more efficiently?
- How might climate change affect the importance of water management in agriculture?



Let's discuss what you've learned today and explore how these technologies might shape the future of

Presentation 9th-10th Grade



Understanding Soil Moisture and Sensor Technology in Agriculture

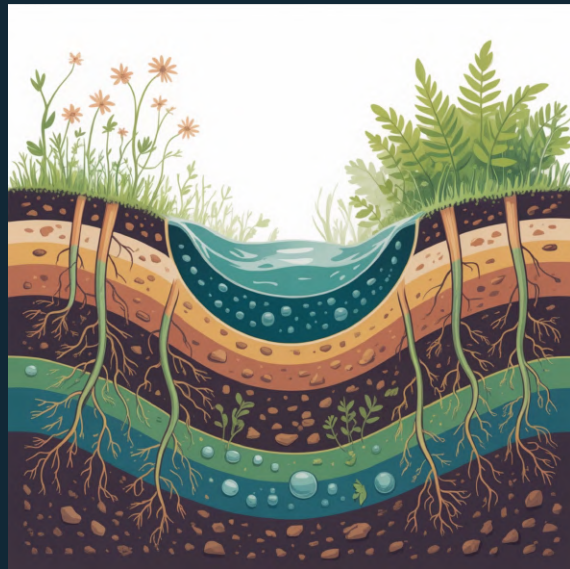
A journey into how technology is revolutionizing water management in modern farming for sustainable agriculture.

The Water-Soil Relationship

Soil Properties Affecting Water Retention

- Texture (sand, silt, clay proportions)
- Structure (arrangement of soil particles)
- Organic matter content
- Compaction level

Different soil types can hold vastly different amounts of water. Clay soils hold more water but release it slowly, while sandy soils drain quickly but hold less water overall.



Role in Plant Health & Crop Yield

Understanding Soil Moisture Levels

1	2	3
Field Capacity The maximum amount of water soil can hold after excess water has drained away. At this point, the soil contains water in micropores but not in macropores. Ideal moisture level for most plants, typically 2-3 days after heavy rainfall or irrigation.	Available Water Content The amount of water that plants can extract from the soil - the difference between field capacity and wilting point. Varies significantly between soil types: clay soils (1.5-2.5 inches/foot) vs. sandy soils (0.5-1.0 inches/foot).	Permanent Wilting Point The moisture level at which plants can no longer extract water from soil and begin to wilt permanently. At this point, water is held too tightly by soil particles for roots to access, causing crop damage or death.

Soil Moisture in Irrigation Planning

Why Strategic Irrigation Matters

Proper irrigation scheduling is vital for sustainable agriculture because:

- Water is a limited and increasingly scarce resource
- Agriculture accounts for approximately 70% of global freshwater use
- Climate change is creating more unpredictable rainfall patterns
- Energy costs for pumping water continue to rise

Consequences of Poor Management

⚠ Underwatering leads to:

- Stunted growth and reduced yields
- Increased susceptibility to disease
- Poor fruit quality and size

Overwatering causes:

- Nutrient leaching from soil
- Root diseases and oxygen deprivation
- Wasted water and increased runoff
- Environmental contamination

Data-driven irrigation decisions can reduce water usage by 30-60% while maintaining or improving crop yields.

Irrigation Scheduling: Tomato Crop Example



Sensor Technology for Water Management

Tensiometers

Physical sensors that measure soil water tension (how hard roots must work to extract water).

- Consist of a water-filled tube with a porous ceramic tip
- Most accurate in wet to moderately wet soils
- Require regular maintenance and refilling

Electrical Conductivity Sensors

Measure soil's ability to conduct electricity, which changes with water content.

- Relatively inexpensive and simple to use
- Affected by soil salinity and temperature
- Include gypsum blocks and granular matrix sensors

Capacitance & TDR Sensors

Measure soil's dielectric constant, which varies with water content.

- Highly accurate across wide moisture range
- More expensive but require less maintenance
- Can be installed at multiple depths to create soil moisture profiles



How Sensors Work: A Quick Look



Modern soil moisture sensors combine sophisticated measurement technology with wireless connectivity to provide real-time data for farmers.

Basic Sensor Mechanics

- Electrical conductivity sensors measure resistance between two electrodes that changes with water content
- Capacitance sensors create an electromagnetic field to measure how water affects the dielectric properties of soil
- Time Domain Reflectometry (TDR) measures the time for an electrical pulse to travel down a probe and back

IoT Integration

- Sensors connect to data loggers or transmitters via wired or wireless connections
- Data is sent to cloud servers through cellular, WiFi, or LoRaWAN networks
- Mobile apps and web dashboards display real-time and historical data
- Systems can automatically trigger irrigation based on predefined thresholds

Advantages of Using Sensors in Agriculture



Improved Water Efficiency

Sensors enable precise irrigation timing, reducing water usage by 20-60% compared to traditional scheduling methods. This conserves water resources and reduces pumping costs for farmers.



Increased Crop Yields

Studies show yield increases of 10-25% when irrigation is optimized using sensor data. Consistent moisture levels prevent stress periods that can permanently reduce crop potential.



Reduced Resource Waste

Beyond water savings, optimal irrigation reduces fertilizer leaching, fuel consumption, and labor costs. Automated systems can reduce the time spent managing irrigation by up to 75%.



Environmental Sustainability

Precision irrigation decreases runoff, minimizes groundwater contamination from fertilizers, and reduces the carbon footprint of farming operations through energy conservation.



Careers: Ag Technology & Water Management

Agricultural Engineer

Design irrigation systems, sensors, and farm equipment.

Education: Bachelor's degree in Agricultural Engineering

Salary Range: \$71,000 - \$114,000

Growth Outlook: 5% (2020-2030)

Precision Agriculture Specialist

Implement and manage technology systems on farms.

Education: Bachelor's in Agronomy or Agricultural Science

Salary Range: \$55,000 - \$95,000

Growth Outlook: 8% (faster than average)

Agricultural Data Scientist

Analyze farm data to optimize production and resource use.

Education: Bachelor's or Master's in Computer Science, Statistics, or related field

Salary Range: \$85,000 - \$135,000

Growth Outlook: 22% (much faster than average)

Future Trends in Irrigation Technology

AI-Driven Irrigation Systems

Artificial intelligence is revolutionizing irrigation by:

- Analyzing multiple data sources (soil moisture, weather forecasts, crop stage, evapotranspiration rates)
- Creating predictive models that anticipate water needs before stress occurs
- Learning from past seasons to continuously improve efficiency
- Autonomously adjusting irrigation schedules without human intervention



Remote Sensing Technologies

Beyond in-ground sensors



Summary: Technology Transforming Farming

1 Soil Moisture Fundamentals

Understanding field capacity, available water content, and wilting point is essential for proper irrigation management. These principles apply across all agricultural settings regardless of technology used.

2 Sensor Technology Benefits

Modern sensors provide real-time, accurate data that was previously unavailable to farmers. This precision allows for data-driven decisions that optimize water use, increase yields, and reduce environmental impact.

3 The Connected Farm

Irrigation is just one part of an increasingly connected agricultural ecosystem. Soil moisture sensors integrate with weather stations, crop monitoring systems, and farm management software to create comprehensive solutions for sustainable farming.

Discussion & Questions

Think About:

- How might technology like soil moisture sensors help farmers in your community?
- What role does water conservation in agriculture play in addressing climate change?
- Which careers in agricultural technology interest you most and why?
- How might these technologies evolve over the next decade?

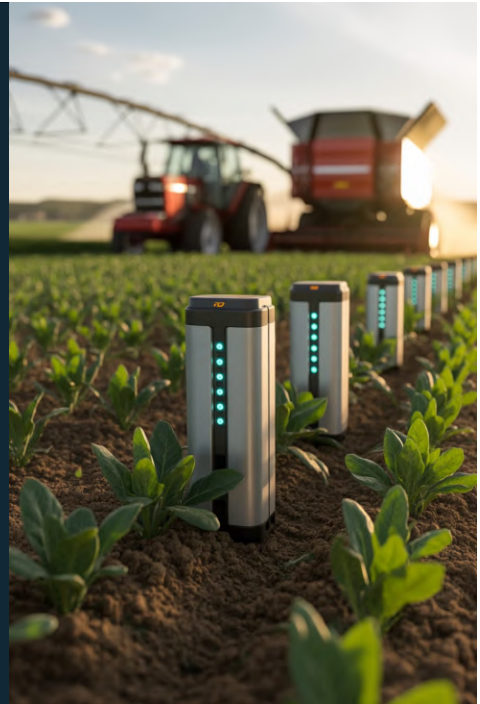


"The future of farming lies at the intersection of traditional agricultural knowledge and cutting-edge technology. Today's high school students will develop tomorrow's solutions for sustainable food production."

Presentation 11th-12th Grade

Precision Agriculture: Sensors and Soil Moisture Management

Transforming modern farming through technology and data-driven decision making



Water-Soil Dynamics & Plant Health

Understanding Water Retention

Different soil types have unique water retention capacities:

- Sandy soils drain quickly but hold less water
- Clay soils retain more water but may become waterlogged
- Loam soils offer balanced drainage and retention
- Organic matter improves water-holding capacity across all soil types



Proper soil moisture management directly impacts root development, nutrient availability, and

Soil Moisture: Defining Critical Levels

1

Field Capacity

The amount of water remaining in soil after excess has drained away. Represents optimal growing conditions with both water and oxygen available to roots.

2

Permanent Wilting Point

The moisture level at which plants can no longer extract water from soil. Plants will not recover without irrigation at this point.

3

Saturation

All soil pores are filled with water, displacing oxygen. Extended periods of saturation can cause root rot and nutrient leaching.

Maintaining soil moisture between field capacity and 50% of available water ensures optimal conditions for photosynthesis, nutrient transport, and cellular expansion in growing plants.



Integrating Soil Moisture into Irrigation Strategies



Data Collection

Sensors placed at various depths and locations throughout fields continuously monitor soil moisture levels



Analysis

Software interprets data against crop-specific thresholds and environmental factors



Decision

Farmers receive actionable irrigation recommendations tailored to specific field zones



Implementation

Precision irrigation systems apply water only where and when needed

This data-driven approach typically reduces water usage by 20-30% while maintaining or improving yields, representing significant cost savings and environmental benefits.

Irrigation Scheduling Case Study: Tomato Crop

Growth Stage	ET Rate (mm/day)	Soil Moisture Threshold
Seedling	2-3	75% of field capacity
Vegetative	4-5	70% of field capacity
Flowering	5-7	80% of field capacity
Fruit Set	6-8	85% of field capacity
Ripening	4-5	65% of field capacity



Using soil moisture data from a commercial tomato farm in California, irrigation was adjusted based on growth stage-specific thresholds. The results can show a 27% reduction in water use and a 12% increase in marketable yield compared to traditional scheduling methods.

Advanced Sensor Technology in Water Management



Dielectric Sensors

Measure soil's dielectric constant, which changes with moisture content. Cost-effective and require minimal maintenance. Accuracy: $\pm 3-5\%$.



Neutron Probes

Emit neutrons that slow down when they encounter hydrogen in water molecules. Highly accurate ($\pm 1\%$) but expensive and require special licensing.



TDR Sensors

Time Domain Reflectometry measures how electromagnetic pulses travel through soil. Provides excellent accuracy ($\pm 2\%$) across varying soil types.

Modern sensors connect to wireless networks, transmitting data in real-time to cloud platforms where it's processed and delivered to farmers via smartphone applications.

How Sensors Operate: Mechanisms & Data Use

Sensor Calibration Process

1. Install sensor in representative field location
2. Take physical soil samples near sensor
3. Measure actual moisture content in lab
4. Compare with sensor readings
5. Adjust calibration coefficients
6. Validate across different moisture levels

Proper calibration is essential—uncalibrated sensors can be off by as much as 20% in certain soil types.



Farm Management Integration

Modern sensors integrate with comprehensive farm management software that:

- Creates moisture maps showing field variability
- Tracks trends over time and across seasons
- Correlates moisture data with yield results
- Generates automated irrigation recommendations

Benefits: Efficiency, Sustainability, Precision

30%

Water Savings

Average reduction in irrigation water use compared to conventional methods

20%

Fertilizer Reduction

Decreased fertilizer application through reduced leaching and runoff

15% \$250/acre

Yield Increase

Typical yield improvement from optimized water and nutrient management

Cost Savings

Annual savings in water, energy, and input costs for row crops

Beyond the numbers, precision irrigation supports sustainable agriculture by reducing groundwater depletion, minimizing chemical runoff into waterways, and decreasing the carbon footprint of farming operations.

Career Pathways in Agricultural Technology



Agricultural Engineer

Education: BS in Agricultural or Mechanical Engineering

Skills: System design, mechanical aptitude, problem-solving

Role: Design irrigation systems, sensors, and equipment that optimize water use in agricultural settings



Agricultural Data Scientist

Education: BS/MS in Data Science, Computer Science, or Statistics

Skills: Programming, statistics, machine learning, GIS

Role: Analyze complex agricultural datasets to identify patterns and develop predictive models for irrigation



Precision Agriculture Specialist

Education: BS in Agronomy, Soil Science, or related field

Skills: Crop science, technology integration, communication

Role: Help farmers implement and optimize technology solutions on their operations

Median salaries range from \$65,000 to \$95,000 with strong job growth projected at 7-10% annually through 2030. These careers combine technology skills with agricultural knowledge to address global food security challenges.

Emerging Trends in Smart Irrigation

1

Present Day

Ground-based sensors communicate through wireless networks to provide point-specific moisture readings that guide manual irrigation decisions.

2

Near Future (1-3 years)

AI-powered irrigation controllers automatically adjust watering schedules based on sensor data, weather forecasts, and crop growth models.

3

Mid-Term (3-5 years)

Integration of satellite and drone imagery with ground sensors creates comprehensive field moisture maps with centimeter-level precision.

4

Long-Term (5-10 years)

Fully autonomous irrigation systems using robotics and predictive analytics optimize water use at the individual plant level across entire growing operations.



Summary: Precision Agriculture's Vital Role

Key Concepts Reviewed

- Soil-water dynamics determine plant health and productivity
- Critical moisture levels (field capacity, wilting point) guide irrigation decisions
- Modern sensors provide real-time, accurate moisture data
- Data-driven irrigation strategies significantly reduce water use
- Precision agriculture offers environmental and economic benefits



Global Impact

With agriculture consuming 70% of global freshwater, precision irrigation technology represents one of our most powerful tools for addressing food security challenges in a changing climate.

Open Discussion & Inquiry

Preparing for AgTech Careers

What skills should you develop now to prepare for careers in agricultural technology? Consider courses in programming, data analysis, agricultural science, and environmental studies.

Technology That Excites You

Which emerging precision agriculture technology interests you most? How might it change farming in your region?

Hands-On Experience

How might you gain practical experience with agricultural sensors and data analysis? Consider internships, research projects, or even small-scale experiments.





Understanding Water- Soil Relationships and Soil Moisture Management

Essential Concepts for Effective Irrigation and Plant Health

A comprehensive exploration of the critical relationship between water, soil, and plant systems for agricultural professionals seeking to optimize crop production through efficient water management practices.

Course Overview and Objectives

Learning Objectives

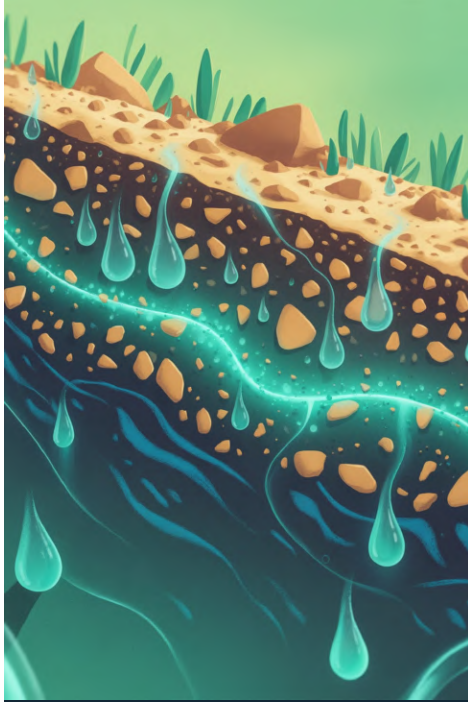
- Understand fundamental water-soil interactions and dynamics
- Interpret soil moisture measurements for irrigation decisions
- Apply sensor technology for precision water management
- Develop effective irrigation scheduling protocols

Why This Matters

Water scarcity and climate variability are increasing challenges for agriculture. Mastering soil moisture management can:

- Increase crop yields by up to 25%
- Reduce water usage by 30-60%
- Minimize nutrient leaching and environmental impact





Water-Soil Relationship: Fundamental Concepts

Soil Particle Interactions

Water molecules form strong hydrogen bonds with soil particles, creating thin films of moisture around each particle. The strength of these bonds varies by soil type and affects water availability to plants.

Soil Water Potential

The energy state of water in soil determines its movement and availability. Plants must overcome this potential energy to extract water through their roots.

Infiltration & Percolation

Water movement through soil profiles depends on texture, structure, and organic matter content. These factors determine water retention capacity and drainage rates.

Physical Properties of Soil-Water Systems

Key Soil-Water Concepts

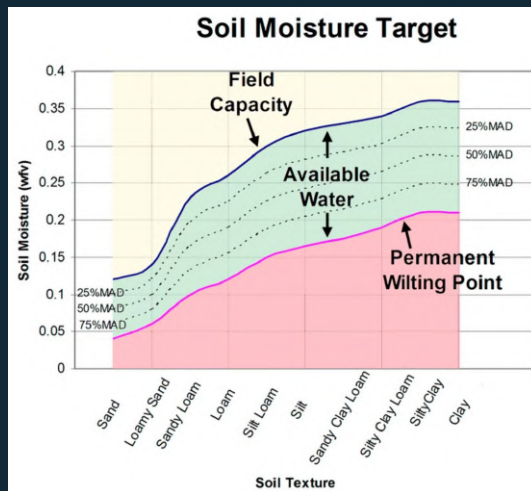
- **Field Capacity (FC):** Maximum water content after drainage of excess water (~ 0.33 bar)
- **Permanent Wilting Point (PWP):** Moisture level at which plants cannot extract water (~ 15 bar)
- **Available Water Capacity (AWC):** Water accessible to plants (FC minus PWP)
- **Saturation:** All soil pores filled with water
- **Gravitational Water:** Excess water that drains freely

Soil texture significantly impacts these properties, with clay soils having higher retention capacity but slower infiltration compared to sandy soils.



Diagram showing water distribution in soil profile and critical moisture thresholds

Plant-Available Water and Stress Thresholds



Understanding Plant Response to Moisture Levels

The diagram illustrates critical soil moisture thresholds and their impact on plant health. Note the Management Allowable Depletion (MAD) zone, which represents the optimal irrigation trigger point before plants experience stress.

Crop-Specific Sensitivity: Stress thresholds vary significantly between crop types. Vegetables like lettuce may show stress at 50% depletion, while drought-tolerant crops like sorghum can withstand up to 70% depletion.

Early signs of water stress include leaf rolling, stomatal closure, and reduced photosynthesis, often occurring before visible wilting.

Soil Moisture Measurement Methods



Gravimetric Method

The direct measurement of soil water content by weighing soil samples before and after oven drying. Considered the gold standard for accuracy but time-consuming and destructive.

Accuracy: $\pm 1\%$ • **Cost:** Low • **Complexity:** Moderate



Electronic Sensors

Includes Time Domain Reflectometry (TDR), capacitance sensors, and neutron probes that measure electrical properties affected by water content. Provides continuous monitoring capabilities.

Accuracy: $\pm 2-5\%$ • **Cost:** Moderate-High • **Complexity:** Low



Tensiometers

Measures soil water tension (the force plants must overcome to extract water). Directly relevant to plant water availability rather than total water content.

Accuracy: $\pm 5-10\%$ • **Cost:** Moderate • **Complexity:** Low

Critical Role of Soil Moisture in Plant Physiology



Nutrient Transport & Uptake

Water serves as the solvent that dissolves soil nutrients, making them available for root absorption. Without adequate soil moisture, even fertile soils can result in nutrient-deficient plants. Micro and macronutrients move to the root zone primarily through mass flow and diffusion processes that require water.

Temperature Regulation

Soil moisture buffers temperature fluctuations, protecting roots from extreme heat or cold. Evapotranspiration provides natural cooling that prevents heat stress during critical growth stages. Properly hydrated plants can withstand temperature extremes that would damage moisture-stressed crops.

Structural Support

Cellular turgor pressure, maintained through adequate water uptake, provides the structural support plants need to remain upright and maintain optimal leaf orientation for photosynthesis. Loss of turgor pressure is one of the first visible symptoms of water stress.

Developing Effective Irrigation Schedules

Key Components of Irrigation Scheduling

Irrigation scheduling requires balancing multiple factors to optimize water use efficiency while maintaining crop health and productivity.

- 1 Determine Crop Water Requirements**
Calculate crop-specific evapotranspiration (ET) rates based on climate data, growth stage, and crop coefficients (Kc).
- 2 Assess Soil Water Holding Capacity**
Evaluate your soil's texture, structure, and depth to determine available water capacity and infiltration rates.
- 3 Establish Depletion Thresholds**
Identify the Management Allowable Depletion (MAD) level specific to your crop's sensitivity to water stress.
- 4 Monitor & Adjust**
Implement regular soil moisture monitoring and adjust irrigation timing and amounts based on real-time conditions.



Irrigation Scheduling Methods

- **Water Balance Approach:** Tracking inputs and outputs
- **Soil Moisture Monitoring:** Direct measurement
- **Plant-Based Indicators:** Observing crop responses
- **Evapotranspiration Models:** Using weather data

Sample Irrigation Schedule: Tomato Production



This irrigation schedule for field tomatoes demonstrates how water requirements and irrigation frequency vary throughout the growing season. Note the critical flowering and fruit set stages require more frequent irrigation with higher volumes to prevent stress.

Practical Application: Adjust this baseline schedule according to local climate conditions, soil type, and irrigation system efficiency. Sandy soils may require more frequent irrigation with smaller amounts, while clay soils can handle less frequent irrigation with larger volumes.

Modern Soil Moisture Monitoring Technologies

Advanced Sensor Types and Applications

1

Capacitance Sensors

Measure dielectric permittivity of soil, which changes with water content. Provide continuous data and can be installed at multiple depths for soil profile monitoring.

Accuracy: ±3% **Cost:** \$200-600 per sensor

2

TDR Probes

Time Domain Reflectometry measures the time for an electromagnetic pulse to travel along a probe, correlating to moisture content. Highly accurate but more expensive.

Accuracy: ±1-2% **Cost:** \$1,000-3,000 per system

3

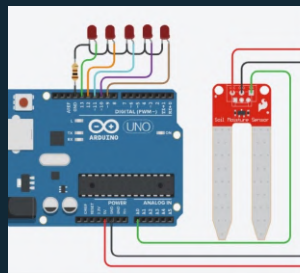
Wireless Sensor Networks

Distributed sensor arrays that communicate with central data collection systems, enabling comprehensive field monitoring with spatial resolution.

Coverage: 1 sensor per 5-10 acres **Cost:** \$3,000-10,000 per network



Capacitance soil moisture sensor



Wireless sensor network hub

Sensor Technology: Working Principles



Benefits of Sensor-Based Irrigation Management

30%

Water Savings

Precision irrigation guided by soil moisture sensors typically reduces water use by 20-40% compared to traditional scheduling methods, with the highest savings in arid regions.

15%

Yield Increase

Studies across multiple crop types show consistent yield improvements of 10-20% through optimized irrigation timing that prevents both water stress and overwatering.

50%

Fertilizer Efficiency

Controlling soil moisture levels reduces nutrient leaching beyond the root zone, improving nitrogen use efficiency by up to 50% and reducing groundwater contamination.

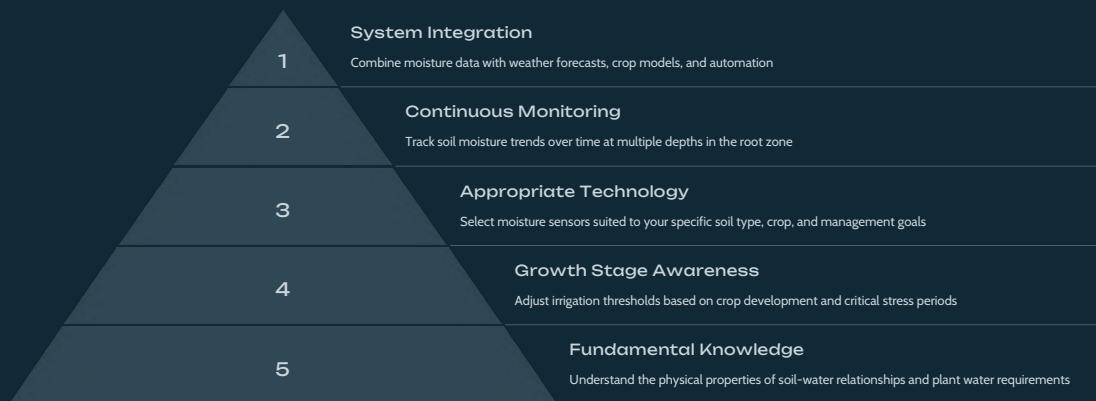
\$350

ROI Per Acre

The average return on investment for soil moisture monitoring systems ranges from \$200-500 per acre annually through combined water savings, yield improvements, and reduced input costs.

🕒 **Example Case Study:** California almond growers implementing sensor-based irrigation reduced water use by 20% while increasing nut yields by 12% and improving kernel quality, resulting in premium pricing. Complete system payback was achieved within 18 months.

Key Takeaways: Mastering Soil Moisture Management



Effective soil moisture management requires integrating scientific principles with practical field application. By building from fundamental knowledge to advanced technology implementation, agricultural professionals can optimize water use while maximizing crop productivity and sustainability.

Career Opportunities in Agricultural Water Management

Agricultural Engineer

Education: BS in Agricultural or Mechanical Engineering

Skills: System design, mechanical aptitude, problem-solving

Role: Design irrigation systems, sensors, and equipment that optimize water use in agricultural settings

Median Salary: \$80,000 - \$95,000

Agricultural Data Scientist

Education: BS/MS in Data Science, Computer Science, or Statistics

Skills: Programming, statistics, machine learning, GIS

Role: Analyze complex agricultural datasets to identify patterns and develop predictive models for irrigation

Median Salary: \$75,000 - \$90,000

Precision Agriculture Specialist

Education: BS in Agronomy, Soil Science, or related field

Skills: Crop science, technology integration, communication

Role: Help farmers implement and optimize technology solutions on their operations

Median Salary: \$65,000 - \$85,000

Job growth in agricultural technology sectors is projected at 7-10% annually through 2030, significantly outpacing traditional agricultural roles. These careers combine technical expertise with agricultural knowledge to address global food security challenges in a water-constrained world.

Emerging Trends in Irrigation Technology



Remote Sensing Integration

Satellite and drone-based thermal imaging can detect plant water stress across entire fields, allowing for targeted irrigation before visible symptoms appear. These technologies measure canopy temperature differentials that indicate transpiration rates and water status.

 **Water Resilience:** Future irrigation systems will increasingly focus on climate resilience, incorporating water harvesting, recycling, and deficit irrigation strategies to adapt to water scarcity challenges.

2023-2025: AI-Driven Irrigation

Machine learning algorithms that optimize irrigation schedules based on multiple data inputs including soil moisture, weather forecasts, and crop growth models.

2027-2030: Autonomous Systems

Fully automated irrigation management with robotics and IoT integration that requires minimal human intervention while maximizing water use efficiency.

1

2

3

2025-2027: Biological Sensors

Plant-based sensors that directly measure crop water status through stem water potential or sap flow, providing the most relevant indicator of irrigation needs.

Questions & Discussion



Additional Resources

- **Soil Moisture Management Guide:** Comprehensive handbook with crop-specific guidelines
- **Sensor Selection Tool:** Interactive online tool to determine the best sensor technology for your operation
- **Regional Irrigation Workshops:** Hands-on training sessions scheduled monthly at demonstration farms
- **Mobile App:** Free soil moisture calculator and irrigation scheduling assistant

All resources available through your local Extension office or agricultural department.

Pre-Presentation Survey: "How We Help Plants Get Water with Sensors" (2nd–3rd Grade)

Name: _____ Date: _____

1. Have you ever helped water a plant or garden?

☐ Yes ☐ No ☐ Not sure

2. What do you think a sensor does?

☐ Helps plants grow

☐ Tells when the soil is dry

☐ Makes the sun brighter

☐ I'm not sure

3. What do plants need to grow? (Check all that are true!)

☐ Sunlight

☐ Soil

☐ Water

4. What do you want to learn about sensors and watering plants?

Post-Presentation Survey: "How We Help Plants Get Water with Sensors" (2nd–3rd Grade)

Name: _____ Date: _____

1. What is one thing you learned about how sensors help farmers?

2. What do soil moisture sensors tell the farmer?

- ☐ If the soil is too dry or wet
- ☐ If the sun is shining
- ☐ If the wind is blowing
- ☐ If it's time to plant

3. What job did you think was the coolest?

- ☐ Farmer
- ☐ Agricultural Engineer
- ☐ Soil Scientist
- ☐ Technology Specialist

4. What is one new thing you want to explore or try after this presentation?

Pre-Presentation Survey: "Sensors for Smart Watering"

(4th–5th Grade)

Name: _____ Date: _____

1. Have you ever heard of soil moisture sensors before?

☐ Yes ☐ No ☐ Not sure

2. What do you think happens when plants get too much or too little water?

3. Why do you think it might be helpful to use sensors on farms?

4. Which of these jobs do you think would be the most fun?

- ☐ Precision Agriculture Specialist
- ☐ Agricultural Engineer
- ☐ Sensor Technician
- ☐ Farmer

Post-Presentation Survey: "Sensors for Smart Watering"

(4th–5th Grade)

Name: _____ Date: _____

1. What is one thing you learned about soil moisture sensors?

2. How do sensors help farmers make decisions?

- ☐ They water the crops automatically
- ☐ They tell how wet the soil is
- ☐ They plant seeds
- ☐ They pick fruit

3. What kind of technology or tool would you like to invent to help farmers?

4. Which job would you be most interested in and why?

Pre-Presentation Survey: "Sensors & Water Management in Agriculture" (6th–8th Grade)

Name: _____ Date: _____

1. Have you ever heard of soil moisture sensors before?

☐ Yes ☐ No ☐ Not sure

2. Why do you think it's important to manage water on a farm?

3. What do you think a sensor does in the soil?

☐ Measures how wet or dry the soil is

☐ Cools down the roots

☐ Makes fertilizer

☐ Scares away pests

4. Which AgTech career are you most curious about?

☐ Precision Agriculture Specialist

☐ Sensor Technician

☐ Agricultural Data Analyst

☐ Other: _____

Post-Presentation Survey: "Sensors & Water Management in Agriculture" (6th–8th Grade)

Name: _____ Date: _____

1. What is one new thing you learned about sensors and farming?

2. How do sensors help farmers save water?

3. What is one way sensor technology helps protect the environment?

4. Which AgTech job interests you the most and why?

Pre-Presentation Survey: "Sensors & Water Management in Agriculture" (9th–10th Grade)

Name: _____ Date: _____

1. How would you rate your understanding of how technology is used to manage water in agriculture?

- ☐ Strong understanding
- ☐ Some understanding
- ☐ Limited or no understanding

2. Which of the following technologies have you heard of before? (Check all that apply.)

- ☐ Soil moisture sensors
- ☐ Drones with cameras
- ☐ Capacitance probes
- ☐ None of the above

3. Why do you think water management is important in farming?

4. Which of these careers in AgTech and irrigation are you most interested in?

- ☐ Agricultural Engineer
- ☐ Precision Agriculture Specialist
- ☐ Agricultural Data Scientist
- ☐ Not sure

Post-Presentation Survey: "Sensors & Water Management in Agriculture" (9th–10th Grade)

Name: _____ Date: _____

1. What is one new thing you learned about soil moisture sensors?

2. How can sensors help reduce environmental impact in agriculture?

3. Which technology or tool mentioned today would you like to explore further?

4. How might precision irrigation help address global food and water challenges?

Pre-Presentation Survey: "Sensors & Water Management in Precision Agriculture" (11th–12th Grade)

Name: _____ Date: _____

1. How familiar are you with how soil moisture sensors work?

- ☐ Very familiar
- ☐ Somewhat familiar
- ☐ Not familiar

2. What role do you think technology plays in water conservation on farms?

3. Have you considered a career in agricultural technology? If so, which career interests you most?

- ☐ Agricultural Engineer
- ☐ Agricultural Data Scientist
- ☐ Precision Agriculture Specialist
- ☐ Not sure

4. What questions do you have about irrigation or sensor technology before we begin?

Post-Presentation Survey: "Sensors & Water Management in Precision Agriculture" (11th–12th Grade)

Name: _____ Date: _____

1. What is one key takeaway about how soil moisture sensors improve irrigation strategies?

2. Which sensor technology or irrigation method stood out to you and why?

3. How can agricultural data be used to reduce waste and improve crop yields?

4. Which career path in AgTech seems most aligned with your interests, and what steps might you take to explore it?

Pre-Presentation Survey: "Sensors & Water Management in Agriculture" (Community College)

Name: _____ Date: _____

1. Rate your current understanding of soil-water relationships and moisture management.

- ☐ Advanced
- ☐ Moderate
- ☐ Basic
- ☐ None

2. Which of the following sensor technologies are you familiar with? (Check all that apply)

- ☐ Capacitance sensors
- ☐ TDR probes
- ☐ Tensiometers
- ☐ Wireless sensor networks
- ☐ None

3. What are your current goals for learning about soil moisture monitoring and irrigation?

4. Are you considering a career in agricultural water management or related fields?

- ☐ Yes
- ☐ No
- ☐ Maybe

Post-Presentation Survey: "Sensors & Water Management in Agriculture" (Community College)

Name: _____ Date: _____

1. What is one significant concept you learned about soil moisture sensors?

2. How could soil moisture monitoring improve irrigation efficiency and environmental sustainability?

3. Which sensor system or technology would you consider implementing, and why?

4. Which career in agricultural water management are you most interested in exploring further?

☐ Agricultural Engineer

☐ Precision Agriculture Specialist

☐ Agricultural Data Scientist

☐ Other: _____

Hands-On Activity Grades 2–3: Drone Water Spotters

Objective: Introduce students to the idea that drones can “see” fields from above and help farmers decide where to water.

Materials:

- Sandbox, garden bed, or trays with soil (some dry, some moist)
- Blue/red flags or paper markers (wet vs. dry)
- Small drone (or video of drone flight)
- Printed log sheets (below)

Steps:

1. **Set the Scene (5 min):** Teacher explains that drones help farmers see big fields quickly. Show drone (or video).
2. **Mark the Soil (10 min):** Students place flags on areas they think are “wet” or “dry.”
3. **Drone Pass (5 min):** Fly drone overhead or play a short video showing aerial view.
4. **Compare & Discuss (10 min):** Students touch soil and check if their guesses matched. Discuss: “What did the drone help us see?”

Student Log:

Draw a picture of your field and circle where you thought the soil was wet or dry.

☐ The soil I thought was wet was really

☐ The soil I thought was dry was really

One thing I learned:

Hands-On Activity Grades 4–5: Drone Crop Check

Objective: Explore how drones help farmers make watering decisions by surveying fields.

Materials:

- Garden bed/trays with 3–4 soil plots (varying wet/dry)
- Simple drone or paper “aerial map” of plots
- Flags or markers for each plot
- Student log sheets

Steps:

1. **Introduction (5 min):** Review soil moisture (too much, too little, just right).
2. **Survey (10 min):** Students “fly” drone (or use aerial photos provided by teacher) to guess soil moisture.
3. **Ground Truth (10 min):** Students test soil with fingers to feel moisture.
4. **Compare (10 min):** Discuss how drones can show where to check but ground checks confirm accuracy.

Student Log:

Plot Drone Guess (Wet/Dry/Just Right) Touch Test Result Correct?

A
B
C

Reflection: *Drones help farmers know when:*

Hands-On Activity Grades 6–8: Drone Irrigation Detective

Objective: Compare drone-generated maps with ground sensor or field measurements.

Materials:

- Field grid (paper map, printed “drone moisture map”)
- Soil samples with moisture meters (or sponges/water cups at hidden levels)
- Flags/labels for zones
- Student log sheets

Steps:

1. **Setup (5 min):** Teacher shows drone moisture map (color-coded zones: green = moist, yellow = dry, red = very dry).
2. **Investigate (15 min):** Students take ground-truth readings with simple probes or soil feel.
3. **Compare (15 min):** Match drone map readings with actual results.
4. **Discussion (5 min):** Which readings matched? Why might they be different?

Student Log:

Zone Drone Map Reading Actual Reading Match? (Yes/No) Notes

1
2
3

Reflection: *One way drones + sensors help farmers save water is:*

Hands-On Activity Grades 9–10: Drone Flight Plan for Water Savings

Objective: Design efficient drone flight paths and analyze irrigation needs.

Materials:

- Blank field grid map (paper)
- Colored pencils/markers
- Sample drone data maps (NDVI or moisture)
- Student log sheets

Steps:

1. **Intro (5 min):** Teacher explains flight paths (zig-zag, grid, circle).
2. **Plan (15 min):** Students design a flight plan to cover whole field efficiently.
3. **Analyze (15 min):** Use sample drone maps to identify zones needing more/less water.
4. **Discuss (5 min):** How can better flight planning save time, energy, and water?

Student Log:

Sketch your flight plan on the grid:

- Color dry zones = red
- Moist zones = blue
- Healthy zones = green

Answer: *If I were a farmer, I would water _____ more and _____ less.*

Hands-On Activity Grades 11–12: Drone Sensor Data Analysis

Objective: Analyze and interpret drone sensor data to create irrigation plans.

Materials:

- Sample NDVI or soil moisture dataset (teacher-provided)
- Ground sensor comparison data
- Student log sheets

Steps:

1. **Intro (5 min):** Explain drones + ground sensors = more accurate decisions.
2. **Analyze (20 min):** Students compare drone data to ground readings.
3. **Plan (10 min):** Write an irrigation recommendation for different field zones.
4. **Discuss (5 min):** How does this data help farmers make sustainable choices?

Student Log:

Zone	Drone NDVI Reading	Ground Sensor Data	Irrigation Needed? (Y/N)	Notes
1				
2				
3				

Reflection: *Sensors + drones together help farms by:*

Hands-On Activity Community College: Operational Evaluation Lab- Drone Irrigation Sensors

Objective: Conduct a lab-style analysis integrating drone data, ground sensors, and weather information to optimize irrigation.

Materials:

- Simulated or real dataset (NDVI + soil moisture probes + weather data)
- Laptops or printed datasets
- Student lab report template (log)

Steps:

1. **Intro (5 min):** Explain lab goal: integrate multiple data sources.
2. **Data Review (15 min):** Students review drone imagery + moisture probes + weather station data.
3. **Analysis (15 min):** Compare data, note patterns, recommend changes to irrigation.
4. **Report (20 min):** Students complete a mini-lab report.
5. **Discussion (10 min):** Career connections, ROI, sustainability.

Student Log / Lab Report Template:

Introduction: What is the problem? Why are drones used?

Methods: What data sources were used (drone, sensor, weather)?

Results:

Zone	Drone Data	Sensor Data	Weather	Notes	Recommendation
1					
2					

Discussion: How did the drone + sensor data help decision-making?

Conclusion: One recommendation for improving irrigation efficiency.

Worksheet Grades 3-4: Sensors for Water Management

Name: _____ Date: _____

Part 1: Understanding Soil Moisture

1. Explain these terms in your own words:

- Soil moisture:

- Field capacity:

- Wilting point:

- Available water:

2. Why is soil moisture important for plants? How does it help them grow?

Answer:

3. What are the three types of dirt?

Answer:

4. List three signs that show a plant doesn't have enough water. How does not enough water affect how well plants grow and the food they make?

Answer:

5. How do farmers know when to water their plants? How do tools like dirt moisture sensors and weather reports help farmers use water better?

Answer:

Part 2: The Future of Watering Tools

1. What are the good things about using dirt moisture sensors? How do they help farmers use water better and take care of nature?

Answer:

2. Tell how dirt moisture sensors are getting better. What good things do better sensors do for farmers?

Answer:

3. How can farms use less water and energy but still grow good plants? How does this help farms?

Answer:

Conclusion: Think about what you've learned about dirt moisture and tools for watering. How can these ideas and tools help farms stay healthy and make sure people have good food in the future?

Answer:

Worksheet Grades 5-6: Sensors for Water Management

Name: _____ Date: _____

Part 1: Understanding Soil Moisture

6. Define the following terms:

- Soil moisture:

- Field capacity:

- Wilting point:

- Available water:

7. Why is soil moisture important for plants? How does it help them grow?

Answer:

8. How does the type of soil (sandy, loamy, clayey) affect how much water it can hold? Give examples of crops that grow well in each type of soil.

Answer:

9. List three signs that show a plant doesn't have enough water. How does lack of water affect how well plants grow and the quality of the food they produce?

Answer:

10. How do farmers know when to water their crops? How can tools like soil moisture sensors and weather forecasts help farmers use water more wisely?

Answer:

Part 2: Future Trends in Irrigation Technology

1. What are the benefits of using soil moisture sensors? How do they help farmers use water better and protect the environment?

Answer:

2. Describe how soil moisture sensors are getting better. What good things do improved sensors do for farming?

Answer:

3. Why is it important for farms to be able to deal with changes in the weather and climate? How does new technology help with this?

Answer:

4. How can farms use less water and energy but still grow good food? How does this help farms be more sustainable?

Answer:

Conclusion: Think about what you've learned about soil moisture and technology for watering. How can these ideas and tools help farms stay healthy and make sure people have good food in the future?

Answer:

Worksheet Grades 7-8: Sensors for Water Management

Name: _____ Date: _____

Part 1: Understanding Soil Moisture

11. Define the following terms:

- Soil moisture:

- Field capacity:

- Wilting point:

- Available water:

12. Why is soil moisture important for plants? How does it help them grow?

Answer:

13. How does the type of soil (sandy, loamy, clayey) affect how much water it can hold?
Give examples of crops that grow well in each type of soil.

Answer:

14. List three signs that show a plant doesn't have enough water. How does lack of water affect how well plants grow and the quality of the food they produce?

Answer:

15. How do farmers know when to water their crops? How can tools like soil moisture sensors and weather forecasts help farmers use water more wisely?

Answer:

Part 2: Future Trends in Irrigation Technology

1. What are the benefits of using soil moisture sensors? How do they help farmers use water better and protect the environment?

Answer:

2. Describe how soil moisture sensors are getting better. What good things do improved sensors do for farming?

Answer:

3. Why is it important for farms to be able to deal with changes in the weather and climate? How does new technology help with this?

Answer:

4. How can farms use less water and energy but still grow good food? How does this help farms be more sustainable?

Answer:

Part 3: Case Study Analysis

Read about this case study and answer the questions below:

Case Study: Precision Agriculture in California Vineyards

- **Where:** Central California, where there are lots of vineyards.
- **Problem:** Vineyards have different kinds of soil and don't always have enough water for growing grapes.
- **Solution:** Farmers put sensors in the ground to check how much water is in the soil at different levels.
- **Result:**
 - o **Water Saved:** Used 20% less water than before.
 - o **More Grapes:** Got 15% more grapes because they used water better and kept the vines healthy.
 - o **Better Grapes:** Made grapes better, so they were worth more money and got more respect from wineries.

Questions:

1. How did sensors help save water in California's vineyards?

Answer:

2. Why were sensors good for deciding when to water the vines?

Answer:

3. How did using sensors help make more and better grapes?

Answer:

4. Why is this case study important for making sure farms last a long time and use water well?

Answer:

Conclusion: Think about what you've learned about soil moisture and technology for watering. How can these ideas and tools help farms stay healthy and make sure people have good food in the future?

Answer:

Worksheet Grades 9-10: Sensors for Water Management

Name: _____ Date: _____

Part 1: Understanding Soil Moisture

16. Define the following terms:

- Soil moisture:

- Field capacity:

- Wilting point:

- Available water:

17. Why is soil moisture important for plants? How does it help them grow?

Answer:

18. How does the type of soil (sandy, loamy, clayey) affect how much water it can hold?
Give examples of crops that grow well in each type of soil.

Answer:

19. List three signs that show a plant doesn't have enough water. How does lack of water affect how well plants grow and the quality of the food they produce?

Answer:

20. How can farmers tell when to water their crops? How do soil moisture sensors and weather information help farmers use water more effectively?

Answer:

Part 2: Future Trends in Irrigation Technology

1. What are the benefits of using soil moisture sensors? How do they help farmers use water better and protect the environment?

Answer:

2. Describe how soil moisture sensors are getting better. What good things do improved sensors do for farming?

Answer:

3. Why is it important for farms to be able to deal with changes in the climate? How does new technology help with this?

Answer:

4. How can farms use less water, less energy, and still make good food? How does this help make farming more sustainable?

Answer:

Part 3: Case Study Analysis

Read about this case study and answer the questions below:

Case Study: Precision Agriculture in California Vineyards

- **Where:** Central California, with many vineyards.
- **Problem:** Vineyards have different kinds of soil and not always enough water for growing grapes.
- **Solution:** Farmers put sensors in the ground to check how much water is in the soil at different levels.
- **Result:**
 - o **Water Saved:** Used 20% less water than normal.
 - o **More Grapes:** Got 15% more grapes because they used water better and kept the vines healthy.
 - o **Better Grapes:** Made grapes better, so they were worth more money and got more respect from wineries.

Questions:

1. How did sensors help save water in California's vineyards?

Answer:

2. Why were sensors good for deciding when to water the vines?

Answer:

3. How did using sensors help make more and better grapes?

Answer:

4. Why is this case study important for making sure farms last a long time and use water well?

Answer:

Conclusion: Think about what you've learned about soil moisture and technology for watering. How can these ideas and tools help farms stay healthy and make sure people have good food in the future?

Answer:

Worksheet Grades 11-Community College: Sensors for Water Management

Name: _____ Date: _____

Part 1: Understanding Soil Moisture

1. Define the following terms:

- Soil moisture:

- Field capacity:

- Wilting point:

- Available water:

2. **Explain the importance of soil moisture in agriculture. Why is it crucial for plant growth?**

Answer:

3. **Discuss how soil texture (sandy, loamy, clayey) influences water retention. Provide examples of crops suited to each type of soil.**

Answer:

4. **List and describe three symptoms of water stress in plants. How does water stress affect crop yield and quality?**

Answer:

5. **Describe two methods for determining irrigation needs. How do soil moisture sensors and weather data contribute to efficient irrigation management?**

Answer:

Part 2: Future Trends in Irrigation Technology

1. **Discuss the advantages of using soil moisture sensors. How do these sensors optimize water use and reduce environmental impact?**

Answer:

2. **Describe advancements in soil moisture sensor technology. What are the benefits of using advanced sensors in agriculture?**

Answer:

3. **Examine the concept of climate-resilient irrigation practices. Why are these practices important in the context of climate change?**

Answer:

4. **Explore the integration of the water-energy-food connection in agriculture. How can this integration lead to more sustainable farming practices?**

Answer:

Part 3: Case Study Analysis

Read the following case study and answer the questions below:

Case Study: Precision Agriculture in California Vineyards

- **Location:** Central California, known for its extensive vineyard operations.
- **Challenge:** Vineyards face varying soil conditions and water availability, affecting grape quality and yield.
- **Solution:** Farmers implemented capacitance soil moisture sensors across their vineyards to monitor soil moisture levels at different depths.
- **Implementation:** Sensors were installed in critical areas to ensure precise irrigation scheduling based on real-time data.
- **Results:**
 - o **Water Savings:** Reduced water use by 20% compared to traditional irrigation methods.
 - o **Yield Increase:** Increased grape yield by 15% due to optimized water management and improved vine health.
 - o **Quality Improvement:** Enhanced grape quality, leading to higher market prices and improved reputation among wineries.

Questions:

1. How did soil moisture sensors contribute to water savings in the California vineyards?

Answer:

2. What were the benefits of using sensors for optimizing irrigation scheduling?

Answer:

3. How did the implementation of sensor technology improve grape yield and quality?

Answer:

4. Discuss the broader implications of this case study for sustainable agriculture and water management.

Answer:

Conclusion:

Reflect on what you have learned about soil moisture and irrigation technology. How can these concepts and technologies contribute to sustainable farming practices and food security in the future?

Answer:

Video Demonstration

The video introduces students to the role of drones in modern agriculture. It begins by highlighting four different drones: **Inspire One**, **QX 350 Blade**, **Phantom 3**, and **Mavic Air**, showing how each can be used by farmers depending on the task. Viewers then follow a farmer as he prepares and flies a drone across a field of **melons and squash**. The drone is equipped with soil moisture sensors that collect data as it surveys the crops. Onscreen graphics demonstrate how sensor readings are converted into color-coded maps, revealing which areas of the field are too dry and which have enough water.

The farmer reviews the data, explaining how drones make it possible to water only where it's needed, saving both **water and energy** while ensuring healthier crops. The video closes by connecting drone technology to **sustainability and AgTech careers**, reinforcing how tools like drones and sensors are shaping the future of farming.



<https://www.youtube.com/watch?v=cspn6k4eqgo>