New Approaches to Water Management in Agricultural Operations

The Business Case for Investing in "Internet of Things" Water Conservation Technologies

FREEWAVE

State of the Industry Report

Most growers and producers agree that water conservation is a worthy goal. But as water conservation technology advances and farmers consider its associated costs, many are rightfully concerned about return on investment. With water scarcity worsening in certain areas of the United States, climate-smart agriculture (CSA) technologies—namely, internet-connected assets, or the "internet of things" (IoT)—is poised to support grower's goals. This white paper applies to water management, specifically, recommending ahead-of-the-curve, proactive adoption of IoT-driven water management as a sound business decision as well as a pressing environmental and humanitarian responsibility. With an increasing number of IoT companies entering the market, farmers can take advantage of cost-conscious options with calculable and compelling returns by partnering with the right AgTech provider.

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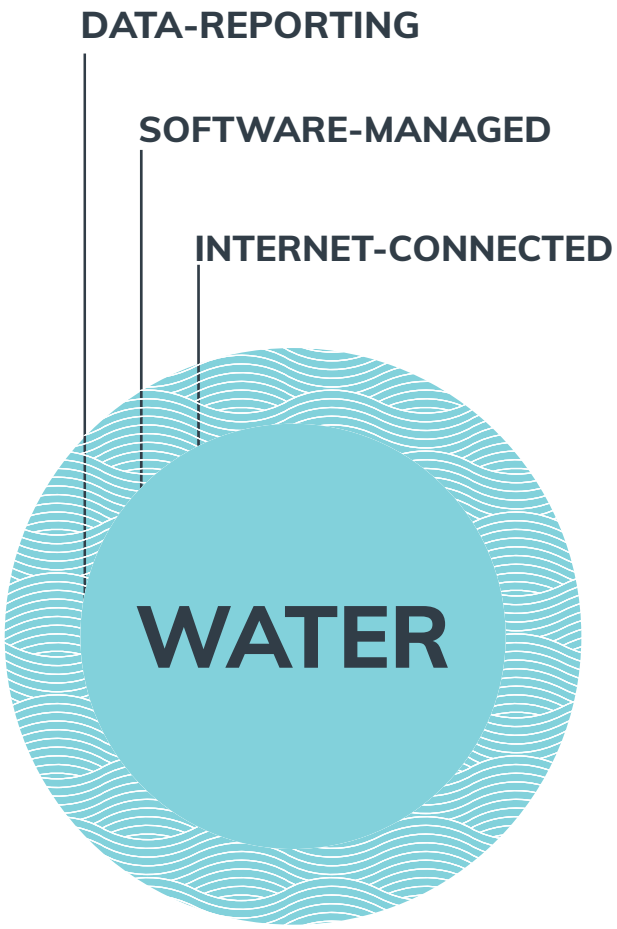
Water Management Innovations for Agriculture—A Primer

Water management plays a critical role in agricultural operations. Climate change and regional crises like drought conditions, groundwater depletion, and water-rights disputes—as well as global population growth—underscore the need to conserve water in irrigated agriculture, the world's largest water user by a long shot. In response to these pressures and in anticipation of challenges to come, new technologies have evolved in support of agriculture as a whole. Alongside other CSA innovations, IoT in irrigation practices has become a hot topic of late.

Producers, with an ever-growing concern for increasing margins while decreasing their environmental impact, have found they can improve operational efficiencies, lower labor and energy costs, and increase yields by adding connected data-monitoring devices to their existing "things," including water tanks, pumps, and troughs. The long-term potential of incremental IoT adoption is an ever-expanding volume of data for developing higher-level, "Big Data"-driven best practices for managing and conserving water, benefitting the ag sector overall. In that sense, IoT plays a mission-critical role in agriculture's future.

IoT is the concept of connecting physical objects—or "things"—to the internet and other devices for the purpose of capturing, exchanging, and visualizing data. It enables a non-computerized or "dumb" object (such as a stock tank or water trough) to digitally transfer and visualize measurements and other data at the actual time an event occurs (as an example, a leak in a stock tank, the moisture level in soil, or the water level in a trough). These events would otherwise require on-site monitoring.

An IoT device is an internet-connected, sensor-monitored, data-reporting, software-managed, and remotely controlled piece of hardware.



As the CSA revolution enters its next phase, data will emerge as a driving force in water management. Indeed, where IoT implementation has taken place, the continual collecting and processing of data guides day-to-day water management decisions, resulting in demonstrable water conservation while maintaining the health and worth of livestock and crops.

If data is the driving force, connectivity is the octane, and where it's lacking, a technology called edge computing processes data at the source, enabling producers and farmers to respond quickly to changing conditions or problems detected by smart sensors.

CSA's next phase comes with an array of challenges and solutions, with water conservation gaining in priority as pressures such as scarcity, international sustainability pacts and regulatory proposals continue to mount.

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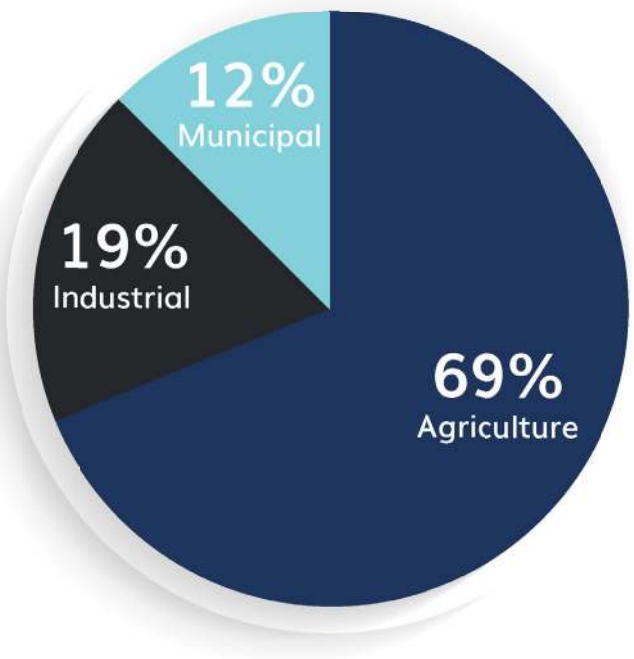
The Far-Reaching Impact of Water Conservation

Agricultural operations annually account for about 70% of the world's water use, according to the World Bank. That amounts to a whopping 2 quadrillion gallons of water. That number is incomprehensible, so let's break it down to size. Cattle raised for beef each drink up to 35 gallons of water per day, while dairy cattle each quaff up to 50 gallons. These volumes don't represent the livestock's total water footprint. In the case of ranching operations in drought-prone areas, the livestock's drinking water is but a fractional amount of the total used; the overall footprint also includes irrigation for grazing. The popular Paramount Network series "Yellowstone" fails to show that a significant part of a producer's job is strategically placing water stock tanks and adjusting irrigation to produce the best grass for grazing livestock, while conserving water to the extent possible.

Global water use by sector [1]



Because agriculture utilizes water more than any other sector, implementing data-driven technologies to assist in the sustainable use of water can have a positive impact industry-wide. More and more growers and farmers are looking for solutions to help them be better stewards of the environment.

Tech giant IBM estimates that the average farm can generate half a million data points per day, assisting farms of the future with on-the-spot and long-term business decisions to optimize every aspect of operations. In the here and now, forward-thinking growers can make incremental changes and parlay much smaller data sets to significantly improve water management for financial as well as environmental and humanitarian reasons.

IoT tech applications and benefits extend beyond water conservation, driving other efficiencies including decreased labor and fuel costs. Rural producers know better than anyone the time and cost associated with making countless treks into the remotest parts of their grazing lands just to check on water levels. With the support of simple drop-in wirelessly connected solutions, producers can immediately receive notifications on their mobile device and know the status of their water levels—giving them time to focus on priority tasks while saving them money as well.

Technology also helps people and the planet and enriches the future of the ag industry by attracting younger, tech-savvy workers to farming and rural areas. Many new homesteaders are embracing innovations and bringing environmental awareness to the agriculture space, leveraging technology to not only measure water quality and availability, but the impact of water on soil.

[1] The Food and Agriculture Organization (FAO) of the United Nations (UN)

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Key Concerns of Modern Agricultural Operators

Producers are great stewards of their land and the earth and have already taken steps to improve water conservation practices by installing hardware, such as automatic irrigation systems. Automating elements of the water infrastructure has indeed helped with production efficiency, but many conventional systems that aren't Wi-Fi-connected and software-managed—otherwise now known as "smart"—don't conserve water in the long run. Research published in 2020 in the journal Review of Environmental Economics and Policy suggests that "water conservation" practices put in place over the past few decades have helped individual enterprises with efficiencies and earnings, but these practices may result in greater water use overall as farmers use these gains to expand operations. Conventional drip irrigation systems that don't allow for variable coverage or generate actionable data and predictive analytics for quick adjustments and long-term planning are but one example of a "water conservation" measure due for an IoT makeover. With the availability of connected monitoring, sensors, and device-related solutions, its easier now than ever to evolve agriculture and water management systems to recalibrate business goals and performance metrics in preparation for changes to come.

Interrelated changes and challenges driving the digital transformation of water management include but aren't limited to:

- Climate change and extreme weather events, including worsening droughts in areas already experiencing water scarcity
- Groundwater depletion and increased competition for water resources
- Global population growth profoundly impacting food insecurity, water scarcity, and land use
- International environmental sustainability goals that specifically call on the agricultural sector to increase production while simultaneously decreasing water consumption—a paradigm often referred to as "sustainable intensification" or "more crop per drop"
- Pressure to bring policy approaches and regulatory actions to bear on agricultural water use

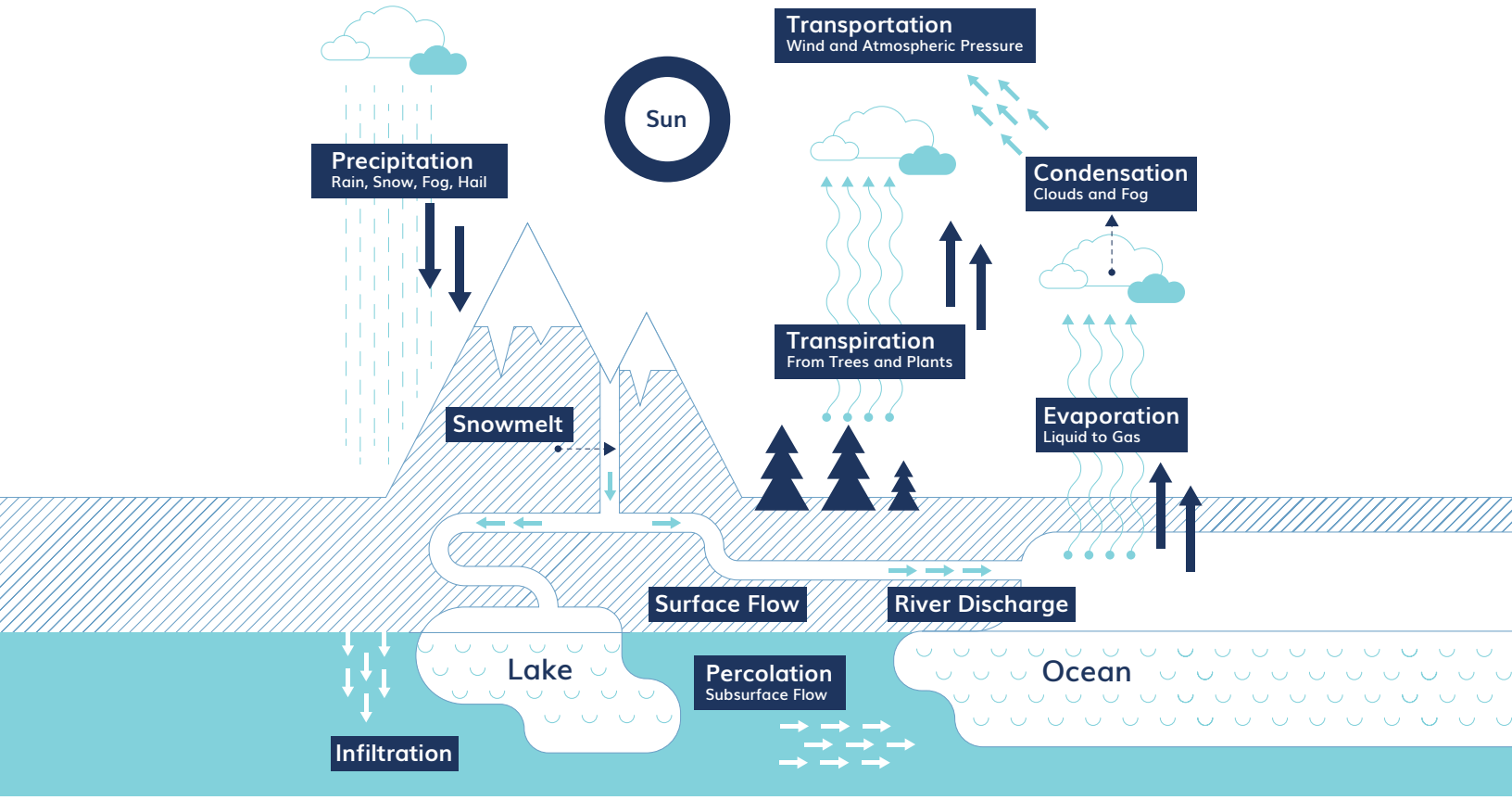
Since 2012, the U.S. Department of Agriculture (USDA) has made protecting water resources a federal priority. The USDA has since been a prime driver of water conservation, deeming it "one of the most critical issues of our time" and calling on the agriculture industry to "accelerate" efforts to improve water quality and water use efficiency. IoT technology literally gives producers a control panel and insights empowering them to practice precision irrigation—water application at the right time and place and in Goldilocks "just right" amounts.

Agriculture's Impact on the Water Cycle

To say that the world is running out of freshwater is a gross oversimplification. Water is, in fact, a finite resource, but it's continuously recycled through processes including evaporation and precipitation. While the amount of water in the world remains fairly constant, the number of freshwater sources readily available for food production and human consumption is increasingly scarce throughout the world.

Agricultural practices can interrupt the water cycle in a number of ways. Irrigation can deplete surface and groundwater supplies, for example, and adding amendments like pesticides and fertilizers to crops can potentially pollute water via surface runoff, soil erosion, and groundwater infiltration.

Simplified Diagram of the Water Cycle



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Internet-Connected, Data-Generating Equipment

With their hand tools and subsistence production, the farmers of Colonial America couldn't have imagined how the first two Industrial Revolutions would transform farming, let alone how far today's agricultural operations have advanced. Now, agriculture is undergoing a digital transformation, and, unlike their forebears, today's farmers not only can envision what next-generation agriculture operations might look like, but the technology already exists to usher the Farm of the Future into being, albeit in a strategic, phased process best carried out with AgTech partners that offer tailored solutions and ongoing training. Given the USDA's emphasis on water conservation, equipping water management architecture with IoT devices is a great place to start.

Many companies offer smart, IoT-connected water management technologies, which minimally consist of sensors or gauges that transfer data over the internet, enabling farmers to receive alerts and react quickly to emergent issues or changes in ambient conditions. With cloud computing and the right software, farmers can also crunch the steady stream of incoming data to trend-spot and strategize for the future.

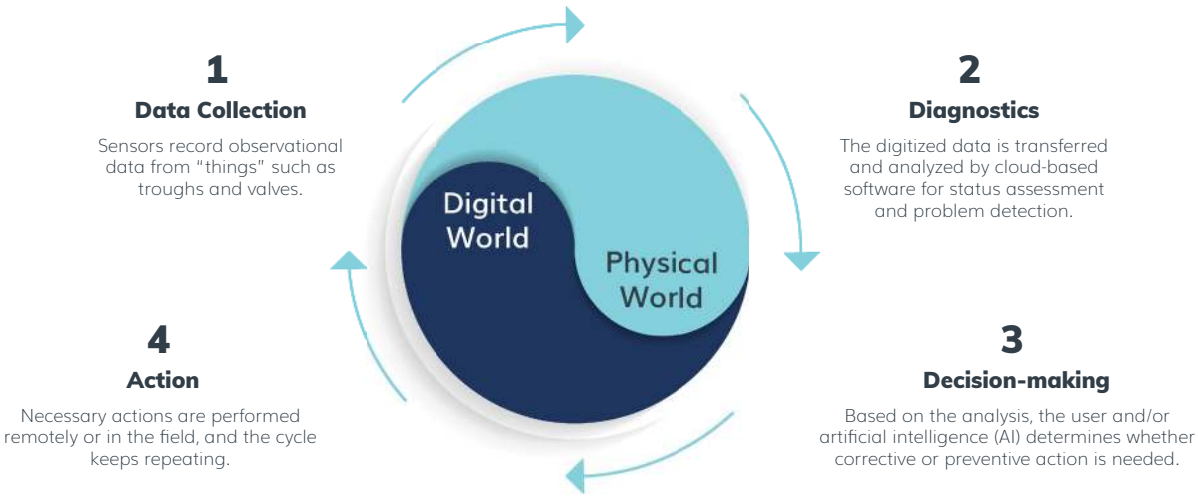
A vital part of CSA, cloud computing takes data from on-farm IoT devices like water level monitors and soil sensors and aggregates it with weather station updates and to help farmers optimize water applications. Enabling cloud computing often requires a wireless data radio access network and a network backbone to transmit the data. Where connectivity is problematic—on a sprawling remote ranch, for example—combining connectivity types with edge computing enables quick, decisive action on the farmer's part.

With connectivity and/or an edge computing platform as a baseline, an ideal water management solution is created – a holistic technology ecosystem made up of many interconnected IoT devices feeding data into a single communications hub and displaying it in a "single pane of glass," such as a smartphone or computer screen.

From this interface, farmers can monitor and adjust water use, including irrigation timing and other factors, to minimize waste while maintaining the health and worth of livestock or crops.

In order to respond quickly to changing conditions or problems that IoT devices detect, consistent connectivity is key. On some large ranches and farms, internet connectivity and cellular coverage are spotty at best. Given today's technology, establishing a reliable communications network and on-farm connectivity is usually doable. The challenging—and rewarding—part is finding an AgTech partner that can supply the necessary connectivity infrastructure (as well as onboarding and ongoing training and support).

Integrating IoT devices into a one-hub water management platform creates a single source of truth that guides farmers' day-to-day decisions and long-term planning in an ongoing cycle.



Responsible water management must take a lot of factors into consideration, including climate data, soil characteristics, and crop attributes. The principles for irrigation efficiency must also work in harmony with other best practices involving plant nutrition and pest management. Today's market offers IoT technologies and devices for just about every aspect of water management; however, this solutions roundup applies to two principal concerns—how much water is available and how fast it's being used.

IoT technology enables remote visibility of water usage and loss, thereby reducing on-site inspections. Holistic water level monitoring across a farm's entire water infrastructure is a key component.

The following chart offers an overview of IoT device-driven water management applications in agriculture.

Water flow meters	These measure and supply data on the volume of water moving per unit of time throughout a water distribution system. Water flow meters usually attach directly to existing pipes. Conventional "water conservation" practices like drip irrigation can achieve greater precision and efficiency with flow meters
Pump monitoring and managing	A pump monitoring and management solution also monitors water levels while enabling users to remotely control scheduling and pressure-switching to increase efficiency and pump life.
Water delivery monitors	Among other benefits, a water delivery monitoring solution provides for wetting-front detection in the soil, especially where flood irrigation is used.
Water pressure monitors	A water pressure monitoring solution ascertains that irrigation water is distributed within the system manufacturer's recommended performance range—a prerequisite for adequate and uniform watering of the intended crop. It is especially important not to over-pressure drip irrigation systems, as doing so can burst the low-pressure pipes or damage the sprayers.
Water level monitors	A water level monitoring solution measures the depth of water at critical points in the water management ecosystem, including tanks, troughs, rivers, dams, and pumping stations. Depth measurement is based on sensor placement—at the bottom of a tank, for example, or mounted on a pole in a river. Where irrigation systems take water from a natural resource such as an on-farm stream, a water level monitoring solution supplies the data required for water-use regulatory compliance. On ranches, tank and trough level sensors can be critical to worker and animal safety. The USDA requires ranchers to check on livestock every day. Manual daily checks limit operational efficiencies, reduce profitability due to rising labor and fuel costs, and potentially put worker safety at stake.
Water quality monitors	Water quality monitoring solutions test for salinity, pH balance, electroconductivity, and the presence of harmful pollutants and microorganisms. Water quality intertwines with water conservation because it affects the amount of water available for reuse in the water cycle and how much is available and useful for livestock and crop watering. A contaminated water supply is a threat to human, animal, and plant health unless the water undergoes an expensive and energy-intensive purification process.

The net result of proper water management on ranches and farms not only prevents excessive use of water, but it also helps to:

- Increase crop quality and yield
- Maintain the welfare and worth of livestock
- Reduce labor and transportation costs
- Minimize pumping costs
- Prevent excessive soil erosion
- Protect the quality of groundwater and downstream surface water

Center-Pivot Irrigation is Ripe for an IoT Upgrade—A Use Study

Along with drip irrigation systems, center-pivot irrigation is another example of a conventional practice that's being digitally transformed using IoT technology. The invention of center-pivot irrigation in 1940 turned the High Plains—previously decimated by drought cycles and crop failures culminating in the catastrophic Dust Bowl of the 1930s—into one of the most agriculturally productive regions in the world.

Center-pivot irrigation systems are widely used to improve operational efficiencies and increase yields. Pivot irrigation uses less water than many other surface irrigation methods, including furrow flood irrigation. Tests by researchers at the University of California-Davis comparing center-pivot irrigation sprinklers to furrow irrigation showed that 30 percent less water was applied by the sprinkling method, while still achieving comparable yields.

When it comes to water conservation, center-pivot irrigation also outperforms ground irrigation methods that require soil tillage, which can cause soil erosion and water runoff.

But conventional pivot irrigation is one of those "water conserving" methods that end up increasing water use over the long run. As the method's water use efficiency improved over the years, farmers tended to plant more intensively. As a result, in parts of the U.S., center-pivot irrigators have contributed to aquifer depletion.

A global population explosion expected over the next 30 years means that farmers will have to produce more food without using more land, and while substantially decreasing water use. Reconfigured to achieve precision irrigation (or the application of water to crops at the right time and place and in optimal doses), IoT-enabled center-pivot irrigation systems not only produce gains at the enterprise level but also truly address the long-term challenge of water conservation.

Working with precision irrigation equipment manufacturer Reinke Manufacturing, FreeWave Technologies—a leader in industrial wireless connectivity—offers technology that connects pivot sprinklers and other irrigation systems to the cloud in order to transfer actionable data in real time. FreeWave's Fusion Bridge Technology—a rugged radio network—establishes reliable connectivity and delivers the data to Reinke's ReinCloud ag-data service. Multiple irrigation systems can be connected through one gateway, giving farmers remote water management control through a "single pane of glass," such as a smartphone or a computer screen. ReinCloud's customizable dashboard allows farmers to organize data in a way that works for their operation. Notifications keep farmers apprised of ambient conditions and system performance and alerts them should problems occur or conditions arise that affect water application needs. Amassed data can be used for trend analysis and forecasting.

Technologies like FreeWave's that enhance CSA-aligned water management practices while improving production represent the future of irrigated agriculture. And that's just the first step. The Farm of the Future will be holistically, sustainably, and profitably managed through a single pane of glass, based on data and insights from IoT sensors all across the farm.

The digital transformation of farming is on the horizon, and water management is only a part of it. Full deployment of IoT devices across all operations creates a technology ecosystem that generates data, which then undergoes big-picture or fine-detail analysis. The process detects and even predicts inefficiencies and problems, such as equipment breakdown. A dashboard presents the analytics in various formats to the farmer, who manages and optimizes all aspects of operations through this interface—without stepping foot in the field.

The Sun is Out

Farmland makes up 63% of Missouri, famous for their prudence and the phrase, "You'll have to show me." When it comes to implementing new practices, farmers by and large are Missourians at heart: If you can show them the business case for water conservation, they'll get on board.

Where water scarcity is a reality or threat, water conservation is more readily accepted as beneficial from a business standpoint, but the cost-benefit analysis isn't as clear cut where water usage isn't a drain financially. High-level research on IoT-driven water management is nascent but auspicious, and the growing body of enterprise-level data and case studies, not to mention the potential consequences of continued inaction, make a strong case for proactive as opposed to reactive adoption.

Make no mistake—various forces are pressing farmers to increase yields with less water, and if push comes to shove, regulators will seek to curb usage by raising water prices; reallocating water among regions and sectors according to need; and enforcing caps on its use. Just as scores of farmers and producers have done since the dawn of agriculture, they are well-positioned to face the future by doing what they do best: plan, nurture and grow using the most advanced tools and technologies available.

Next Steps to Creating a Sustainable Ag Business

Step 1:

Producers who want to improve water management on the land they own or lease can contact the USDA's Natural Resources Conservation Service (NRCS), which offers technical and financial assistance to develop an irrigation plan that will conserve water while promoting desired crop response.

Step 2:

Schedule a free demo with FreeWave's water management experts to learn how our solutions will help you conserve water while advancing your business objectives.
To find out more on how you can gain water efficiencies by partnering with FreeWave, schedule a free demo.

Step 3:

Partner with FreeWave at the forefront of the digital transformation in agriculture. We're not just a vendor but a partner with a vested interest in your success. We form relationships based not on transactions but on transformations. To continue the conversation, contact us at 1-866-923-6168 or send a note at insidesales@freewave.com.

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