

SMART

IRRIGATION SYSTEMS TO COMBAT WATER SCARCITY

AUTHOR

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Introduction:

Water is the foundation of agriculture, with farming accounting for approximately 70% of global freshwater withdrawals (United Nations Water, 2021). Yet, mounting pressures threaten the sustainability of this essential resource. Climate change is intensifying drought conditions, growing populations are driving demand, and much of today's irrigation infrastructure remains outdated and inefficient. Against this backdrop, agriculture faces a critical challenge: producing more food with less water. Meeting this challenge requires not discovering new water sources, but using existing supplies more efficiently. Smart irrigation technologies provide a promising, data-driven pathway toward enhanced water security.

do not respond to real-time soil or climate conditions. As a result, water is often applied when it is not needed, leading to substantial losses through evaporation, runoff, and deep percolation beyond the root zone. These inefficiencies deplete scarce water resources and exacerbate environmental concerns, including soil salinization and nutrient runoff into waterways (Food and Agriculture Organization, 2020).

Principles of Smart Irrigation

Smart irrigation systems address these inefficiencies by leveraging technology to deliver water precisely when and where it is required. The central principle is the replacement of rigid schedules with responsive, data-driven decisions. Key components include:

- 1. Soil Moisture Sensors:** Installed at multiple depths, these sensors provide real-time data on soil water content, preventing unnecessary irrigation when sufficient moisture is already available (Vellidis et al., 2017).
- 2. Weather Data Integration:** Advanced systems draw on local weather stations and online services, incorporating variables such

as rainfall, temperature, humidity, and evapotranspiration (ET) to calculate precise water requirements.

- 3. Automated Controllers:** These devices process sensor and weather data to dynamically adjust irrigation schedules. They can delay irrigation after rainfall, reduce application during cooler conditions, or increase it during periods of extreme heat.
- 4. Efficient Delivery Systems:** Smart controls achieve maximum impact when paired with technologies such as drip irrigation, which delivers water directly to the root zone, minimizing evaporation and runoff.



Tangible Benefits

The integration of smart irrigation technologies provides clear, measurable benefits for both water and food security:

- Significant Water Savings:** Research demonstrates reductions in outdoor water use ranging from 20% to 50% compared to conventional methods (Garcia et al., 2020).
- Improved Crop Performance:** Precise water management reduces plant stress, strengthens root systems, and can improve both yields and crop quality.
- Reduced Energy and Costs:** Lower water use decreases the energy required for pumping and distribution, resulting in cost savings and improved operational

sustainability.

- Climate Resilience:** By adapting in real-time to fluctuating weather conditions, smart systems enhance agricultural resilience to droughts, heatwaves, and other climate-related disruptions.

Tangible Benefits

Despite their advantages, smart irrigation systems face adoption barriers. High initial investment costs can deter smallholder farmers, while technical complexity requires training for effective use. Widespread implementation will therefore depend on targeted interventions, including:

- Financial Incentives:** Subsidies, low-interest loans, and cost-sharing programs to offset upfront expenses.
- Capacity Building:** Training programs to equip farmers and technicians with the skills required to install, operate, and maintain these systems.
- Research and Development:** Continued innovation to reduce costs and enhance usability.

Conclusion

Water security is one of the most pressing challenges of the 21st century. For agriculture — a sector both highly dependent on and vulnerable to water scarcity — the transition to efficient irrigation practices is essential. Smart irrigation systems represent a convergence of sensor technology, weather data, and automation that allows farmers to optimize water use while sustaining yields.

By enabling agriculture to “produce more with less,” smart irrigation technologies play a vital role in building a future that is both water-secure and food-secure.

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Limitations of Conventional Irrigation

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