ISBN: 978-81-972400-8-9

18. IoT and Agriculture: Transforming Farming Practices with Smart Irrigation

Karan Verma

Assistant Professor, Agronomy,
Faculty of Agriculture, Guru Kashi University Talwandi Sabo,
Bathinda, Punjab, India.

Praveen Kumar

Assistant Professor, Genetics and Plant Breeding,
Maharaja Agarsen Agriculture College Suratgadh,
Rajasthan, India.

Anu Alphonsa Augustine

Ph. D Agronomy Scholar,
Faculty of Agriculture, Guru Kashi University Talwandi Sabo,
Bathinda, Punjab, India.

Rajju Priya Soni

Senior Dietitian,
M.Sc Food Science and Nutrition, CSK HPKV,
Palampur, H.P., India.

Raghveer Singh

M. Sc Agronomy, Scholar,
Faculty of Agriculture, Guru Kashi University,
Talwandi Sabo, Bathinda, Punjab, India.

Abstract:

Agriculture plays an imperative role in the country's development. In our country, more than 72% of people depend upon farming which is one third of the population invests in farming. Thus, the challenges and issues concerning agriculture need to be focused to hinder the country development. As agriculture remains a cornerstone of global food security and economic development, the adoption of innovative technologies becomes imperative to address challenges such as water scarcity, climate change, and increasing demand for agricultural products. Smart irrigation systems leverage IoT principles to revolutionize traditional farming practices by integrating real-time data collection, analysis, and automation into water management processes. Smart irrigation technology uses weather data or soil moisture data to determine the irrigation need of the landscape. Smart irrigation technology includes: These products maximize irrigation efficiency by reducing water waste, while maintaining plant health and quality. An intelligent irrigation system is a way to deal with all of the issues in a conventional approach.

This method regulates the water by sensing the soil quality and moisture and providing adequate moisture needed using motor pumps. The IoT technique here transfers the data to a network with little human communication. Smart irrigation technology uses weather data or soil moisture data to determine the irrigation need of the landscape. Smart irrigation technology includes: These products maximize irrigation efficiency by reducing water waste, while maintaining plant health and quality. Soil moisture sensors used with smart irrigation controllers when buried in the root zone of turf, trees or shrubs, the sensors accurately determine the moisture level in the soil and transmit this reading to the controller. Smart irrigation eliminates overwatering and the associated water waste, by delivering only the exact amount of water needed to landscapes at the exact right time. But conserving water isn't the only way that smart irrigation has a positive impact on the environment. It will be focused on systems using artificial intelligence techniques in urban and rural agriculture for soil crops to identify those that are currently being used or can be adapted to urban agriculture. A Sensor-based automated irrigation system provides a promising solution to manage agricultural activity. Now a days very handful of commercial vertical farms are under operation but the interest in this new farming technique is growing rapidly which is silver lining for agriculture sector. In metro cities, people are interested in growing rooftop gardens, home gardens, for producing healthy and organic supplies for home. As these gardens are broader concept of urban agriculture. Vertical farming is best way to them for raising medicinal and vegetable crops.

Keywords:

Smart Agriculture, Smart Irrigation, Soil Monitoring, Agriculture, Urban Agriculture System, Internet of Things (IoT), Sensors, Water Management and Crop Monitoring.

18.1 Introduction:

Agriculture is the main source of food production in our country. In India, agriculture contributes 18% of the country’s Gross Domestic Product (GDP) which employs more than half of the total population. The Indian government has stressed and highlighted the need of innovations to be in above mentioned criteria’s in agriculture, thus seeks an indication of technology exposure and innovative implementation practices to enhance the productivity.

The productivity in agricultural, food security, erratic conditions in climates, soil conditions requires new ideas and innovations. While this is largely depends on irrigation system, and current techniques in irrigation which helps to achieve more productivity per drop of water. Automation in irrigation system helps to farmers to manage their work much easier and helps to take decisions even in the absence of farmers. IoT, sensors, smart phone tools are the technologies which helps farmers to know the status of their land, amount of water needed, temperature of soil, humidity, weather conditions, pH level.

Water is an important element for plant growth and agriculture in general. It is used first for the planting process of some plants and also for the watering for other plants to ensure normal growth and acceptable production. In the past, irrigation was done by traditional methods, by creating waterways above the ground. However, using this type of method requires considerable effort and time to set up, it also requires a large amount of water.

These irrigation methods are feasible in the case of small or medium crops, but they become unnecessary in the case of the use of large agricultural areas. With a sharp increase in the world population, it becomes necessary to increase productivity through large-scale cultivation, so the use of traditional methods of irrigation has become inefficient.

Therefore, it is helpful to find or develop more efficient and effective watering methods and means. In this context, this research paper presents a study on the use of automatic and intelligent methods in the management of irrigation of agricultural land.

Among these technologies, the artificial intelligence and Internet of Things (IoT), which are used to optimize the manage irrigation water in agricultural lands. The elements of the agricultural system and its environment are presented by things that are in direct contact by relying on information and communication technology (ICT).

Communication between things goal is to exchange information and cooperate with each other to realizing the main goal, it is a well-managed watering operation of the farms. On the basis of this technology, it is possible to obtain more production with less effort and less financial investment. Finally, this work can be considered as a reference and a knowledge base for students, professor-researchers and farmers.

Smart agriculture, in general, refers to the incorporation of new technologies in crop management to make remote monitoring, resource optimization, and the automation of the systems involved easier. Smart irrigation technology uses weather data or soil moisture data to determine the irrigation need of the landscape. Smart irrigation technology includes: These products maximize irrigation efficiency by reducing water waste, while maintaining plant health and quality.

Incorporating smart irrigation technology in the landscape can potentially reduce outdoor water consumption. This technology is appropriate for small, residential landscapes as well as large, managed landscapes. The following sections describe how each product functions and the advantages and disadvantages of each product. Irrigation managers and homeowners should be aware that smart irrigation technology will need to be periodically adjusted and maintained for maximum water savings.

How Smart Irrigation Systems Work?

In traditional irrigation systems, a grower will manually open and close valves as needed. On the contrary, in smart water technology, the smart water valves embedded into your drip irrigation system intelligently track your water consumption while allowing you to remotely control your usage.

A smart water valve contains a valve controller, a flow meter, wireless connectivity, and a power source. The smart valve captures data from flow meters, which measures water flow through each of your irrigation lines. It then sends that information to a cloud managed software platform via a wireless connection. From there, you can access your water usage data on your phone or computer at any time, from anywhere and make adjustments accordingly.

Working components for Smart Irrigation Systems in Agriculture:

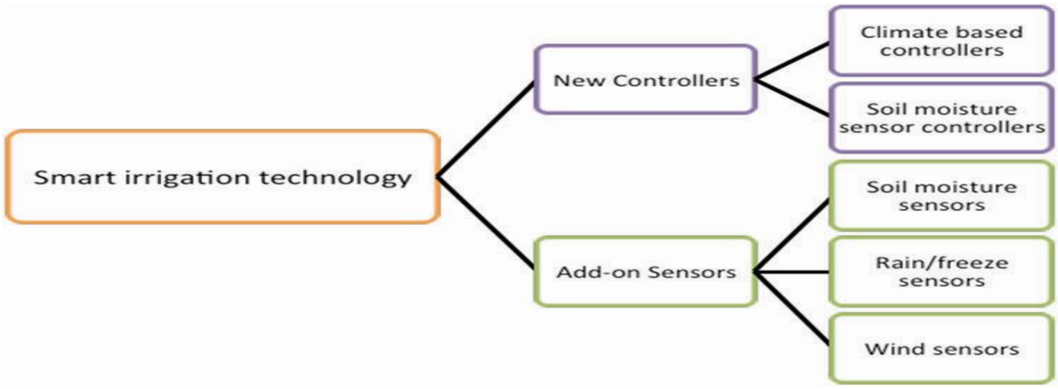

Figure 18.1: Smart Irrigation Technology

18.2 Smart Irrigation Technology:

Smart irrigation technology uses weather data or soil moisture data to determine the irrigation need of the landscape. Smart irrigation technology includes: These products maximize irrigation efficiency by reducing water waste, while maintaining plant health and quality.

New Controllers:

There is a broad spectrum of smart irrigation technology that consumers can benefit from utilizing. Choosing the correct technology for the situation is essential to achieve potential water savings. Watering restrictions exist in some areas of Oklahoma, so the irrigation timer may be adjusted for allowed watering days. Irrigation controllers can be separated into two main categories: Climate based controllers and soil MBControllers.

Climate-Based Controllers:

Climate-based controllers also referred to as evapotranspiration (ET) controllers use local weather data to adjust irrigation schedules. Evapotranspiration is the combination of evaporation from the soil surface and transpiration by plant materials.

These climate-based controllers gather local weather information and make irrigation run-time adjustments so the landscape only receives the appropriate amount of water.

18.2.1 There are three Basic Types of ET Controllers:

Signal-based controllers use meteorological data from a publicly available source and the ET value is calculated for a grass surface at the site. The ET data is then sent to the controller by a wireless connection.

Historic ET controllers use a pre-programmed water use curve, based on historic water use in different regions. The curve can be adjusted for temperature and solar radiation.

On-site weather measurement controllers use weather data collected on-site to calculate continuous ET measurements and water accordingly.

Evapotranspiration controllers have been shown to reduce outdoor water use. In Las Vegas, Nev., homes with ET based controllers saw an average of 20 percent irrigation reduction compared to homes with homeowner-scheduled irrigation (Devitt et al., 2008). Additionally, a study conducted on St. Augustine turfgrass showed an average irrigation savings of 43 percent in the summer compared to homeowner-scheduled irrigation, with no reduction in turfgrass quality (Davis et al., 2009). The accuracy of ET controllers depends on the equation parameters. Most ET controllers cost between INR Rs 25000 and INR Rs 50000.

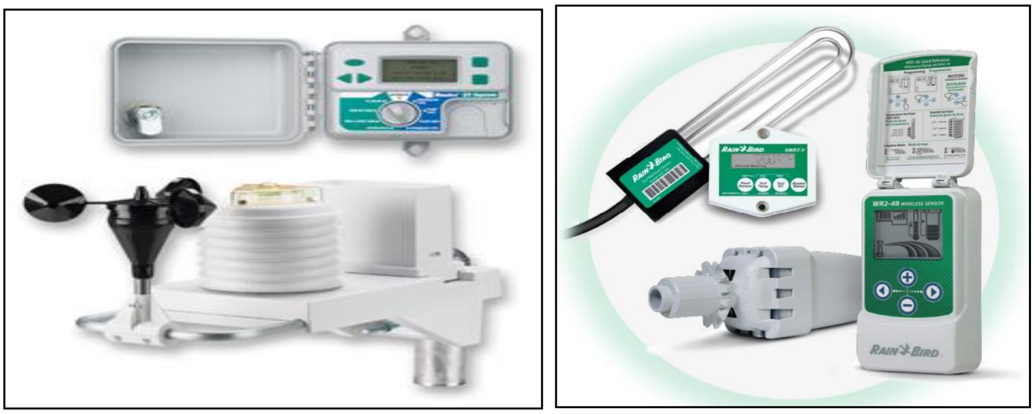

Figure 18.2: Evapotranspiration based controller and Photo courtesy of Rainbird

A. Soil Moisture Sensor Controllers:

The second type of smart irrigation controllers includes soil moisture sensor controllers. Instead of using weather data, soil moisture sensor controllers utilize a soil moisture sensor placed belowground in the root zone of lawns to determine water need. The soil moisture sensor estimates the soil volumetric water content. Volumetric water content represents the portion of the total volume of soil occupied by water. The controllers can be adjusted to open the valves and start irrigation once the volumetric water content reaches a user-defined threshold. The appropriate threshold value depends on soil and vegetation type and usually ranges from about 10 percent to 40 percent. Soil moisture sensors must be installed in a representative area of the turf; far enough from sprinkler heads, tree roots, sidewalks and walls.

Similar to ET controllers, soil moisture controllers have been shown to reduce irrigation, while maintaining turfgrass quality. Compared to homeowner irrigation schedules, soil moisture controllers had an average 72 percent irrigation savings and a 34 percent water savings during drought conditions (Cardenas-Laihacer et al., 2010; Cardenas-Laihacer et al., 2008). In some cases, studies have shown smart controllers will increase water use at sites that typically use less than the theoretical irrigation requirement (Mayer and Deoreo, 2010). Typically, soil moisture sensor controllers range from INR Rs 22000 to 35000. Difference in pricing depends on product manufacturer and end user, either residential or commercial customers.

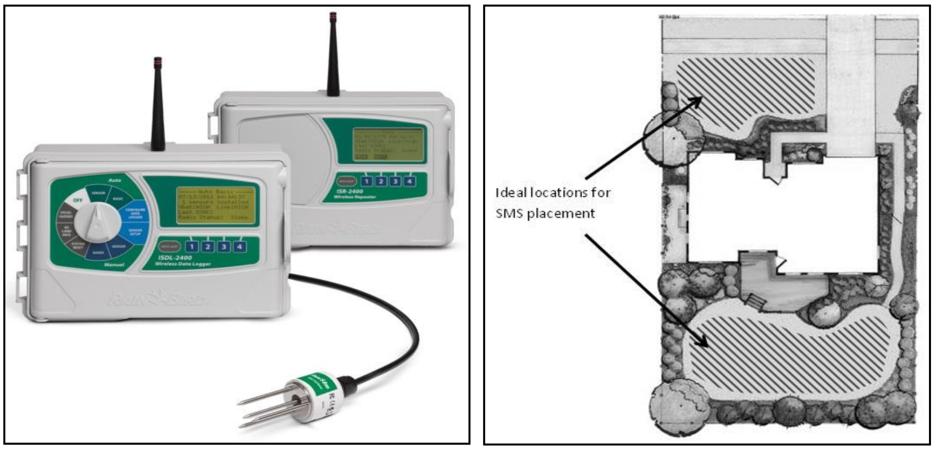

Figure 18.3: Example of a soil moisture controller and Ideal locations for soil moisture sensor placement.

Smart Irrigation Technology: Add-on Sensors:

In many cases, a scheduling irrigation controller is already in use on a property and upgrading to a smart controller is impractical. To increase efficiency of automatic irrigation systems a soil moisture, rain, wind or freeze sensor can be added to upgrade the existing system. Some manufacturers produce devices capable of measuring multiple environmental elements using one apparatus.

Many sensors are compatible with existing systems, easy to install and produce similar results to smart irrigation controllers. The add-on sensors are generally more affordable than smart irrigation controllers, assuming a compatible irrigation timer is already installed on site.

Soil Moisture Sensors:

Soil moisture sensors can be connected to an existing irrigation system controller. The sensor measures the soil moisture content in the root zone before a scheduled irrigation event and bypasses the cycle if the soil moisture is above a specific threshold.

Different types of soil moisture sensors are available and the consumer should ensure system compatibility before purchasing a sensor. Some soil moisture sensors include a soil freeze sensor that will interrupt the irrigation cycle if temperatures fall below 32 F. Soil moisture sensors are available as wired or wireless systems. Typical cost for a soil moisture sensor can range from INR Rs 7899 to 9165.

B. Rain and Freeze Sensors:

Although these sensors are not considered smart technology, rain and freeze sensors interrupt the irrigation cycle during a rain or freeze event when irrigation is unnecessary.

Watering during the rain wastes water, money and causes unnecessary runoff. Three different types of rain sensors are available and each function is based on separate concepts.

The original type of rain sensor still in use today works with a small cup or basin that collects water, once a pre-determined amount is collected, the weight of the cup interrupts the irrigation cycle. Debris in the cup can also interrupt the irrigation cycle and should be checked and cleared of litter periodically.

The second type of rain sensor uses a dish with two electrodes that are a specific distance from the bottom of the cup.

The distance can be adjusted to allow for small rain events and similar to the first type of rain sensor, debris can reduce accuracy by displacing water in the cup. When the water reaches the electrodes, the irrigation cycle is interrupted.

The third type of rain sensor does not have a rain catch cup, which makes it low maintenance and reliable. Instead, the sensor uses several disks that expand as they get wet. The expanded disks trigger the switch and interrupt the cycle. The system will resume the scheduled cycles once the disks dry out. The disks should be checked at least once a year to determine if they need to be replaced. All of the devices should be mounted in an open area where they will receive rainfall.

Potential water savings depends on the amount of rainfall in any given year. During years with average to above average rainfall, water savings are more significant than during dry years. Rain sensors have shown payback periods of less than a year, but should be monitored for optimum performance (Cardenas-Laihacar and Dukes, 2008).

As an example, if a homeowner's irrigation system waters a ¼-acre yard and applies 1 inch of water each irrigation cycle, then each cycle applies 6,789 gallons of water. If water costs INR Rs. 400 per 1,000 gallons, the monetary savings will be INR Rs. 4500 each time the irrigation cycle is interrupted during a rainfall event.

Considering each rainfall event, the homeowner could expect substantial water and money savings. Most wireless rain sensors are more expensive and range from INR Rs. 9800 to 17200, while wired rain sensors cost approximately INR Rs. 2400 to 4000.

Freeze sensors interrupt an irrigation cycle when air temperatures fall below 32 F. Eliminating irrigation during freezing temperatures can potentially extend irrigation system life and prevent sidewalks and streets from icing over, causing dangerous situations.

Many rain sensors include a freeze sensor and homeowners should account for sensor capability when considering price.

Figure 18.4: Rain sensor with a small basin to collect rainfall, Rain sensor attached to a gutter (top) and the inside of an expanding disc rain sensor (bottom). Photo's courtesy of Hunter Industries.

C. Wind Sensors:

Oklahoma has an average wind speed of 16 miles per hour (mph) with wind gusts from 20 mph to 30 mph. Watering during windy conditions reduces irrigation distribution uniformity across the landscape and decreases the amount of water infiltrating into the soil profile. Wind sensors interrupt the irrigation cycle if wind speed exceeds a specific threshold.

Smart irrigation technology may help reduce water waste, while also providing a healthy, attractive landscape. Irrigation system owners should provide regular maintenance and ensure the irrigation system is only watering the landscape when needed. Many wind sensors are around 5000 to 8000 dollars or are packaged with other sensors.

The Environmental Protection Agency (EPA) has created performance criteria for irrigation technology manufacturers under the Water Sense program. For more information go to: www.epa.gov/watersense/. Often, it depends on consumer preference when deciding which irrigation controller or add-on sensor is appropriate for the end user. Many local irrigation distributors have smart irrigation technology available for customers.

Figure 18.5: Example wind sensor for use in the landscape. Photo courtesy of Hunter Industries.

Table 18.1: Temperature, Humidity and Moisture Requirements of Major crops are listed:

Sr. No.	Crop Name	Temperature	Moisture (%)	Humidity (%)
1	Rice	21-37	20-25	60-80
2	Wheat	10-15	14-20	60-70
3	Bajra	20-38	20-25	55-70

Advantages of a Smart Irrigation System?

When you’re conserving water use in drought times but want to continue to irrigate landscapes with optimal efficiency- a smart irrigation system leaves traditional methods of irrigation behind in the dust. As technology evolves with each passing year, it’s only getting smarter. Traditional irrigation systems are pre-set manually to turn on and off using a timer. It doesn’t matter if an unexpected downpour occurs on a scheduled day or the soil deep beneath the ground surface where the eye can’t see has become oversaturated. That timer is pre-set to water on each scheduled day; rain, or shine. Clearly, this isn’t the most efficient or cost-effective way to manage landscape irrigation in times of drought.

Studies show that 70 percent of water consumption around the world is used for irrigation, and half of that is wasted due to inefficient, traditional irrigation practices. The optimal way to manage irrigation and nurture your landscape would be to know how much hydration plant roots deep need on any given day or if they’re getting too much scheduled watering.

The good news is today’s cloud-based smart irrigation does the work for you. It takes control of watering your plants and landscape, adjusting day by day, hour by hour, as it continuously collects and ingests weather data in real-time at your specific site. Taking that Smart technology below ground, embedded deep in the root zone of plants, ultra-sensitive Soil Moisture Sensors electronically transmits soil moisture content readings to the Smart Controller and automatically delivers the perfect amount of water needed to plant roots-no more, no less– to keep plants above ground healthy and thriving.

Smart Irrigation systems save water, time, and money. Studies show that up to 50% of water usage for landscape irrigation can be saved with cloud-based Smart Irrigation systems. As a result, Smart systems typically pay for themselves in water savings within two years. Smart Irrigation is not only cost-effective, but also the responsible thing to do. Not only in these times of drought, but as we strive to conserve our finite and dwindling water sources, and protect our environment and leave our world a better place for future generations to come.

18.3 Conclusion:

The incorporation of Internet of Things (IoT) technology into agriculture, specifically through the implementation of smart irrigation systems, marks a pivotal advancement in modern farming practices. Smart irrigation technology, driven by IoT principles, offers a tailored approach to water management by utilizing real-time data from weather forecasts, soil moisture sensors, and crop water requirements.

By accurately determining irrigation needs and delivering precise amounts of water at the right time and place, these systems optimize resource utilization while minimizing water waste and environmental impact. Moreover, the automation and remote monitoring capabilities inherent in IoT-based irrigation systems streamline agricultural operations, freeing up valuable time and labour for farmers. While dry areas have less rainfall and irrigation is challenging. The smart agricultural system guarantees higher productivity with efficient use of water. Automation of the irrigation control process by using the detected environmental parameters to be needed. The smart agricultural system guarantees higher productivity with efficient use of water. Automation of the irrigation control process by using the detected environmental parameters to be needed. Smart irrigation can be automated with the help of current technologies presented above and its main advantages are increase in productivity, reduce water consumption and reduce soil erosion.

18.4 References:

1. David Vallejo-Gómez and Marisol Osorio. 2023. Smart Irrigation Systems in Agriculture: A Systematic Review. Agronomy. 13(2) 342 https://doi.org/10.3390/agronomy13020342.
2. Abdelkader Hadidi, Djamel Saba, Youcef Sahli. 2022. Smart Irrigation System for Smart Agricultural Using IoT: Concepts, Architecture, and Applications https://doi.org/10.1002/9781119823469.ch7.https://onlinelibrary.wiley.com/doi/chapter-epub/10.1002/9781119823469.ch7#accessDenialLayout
3. Wolfert S, GeL, Verdouw C and BogaardtMJ. 2017. Big Data in Smart Farming - A Review. Agricultural Systems. 153 69-80
4. Cardenas-Lailhacar B, MD Dukes and GL Miller. 2008. Sensor-based automation of irrigation on bermudagrass, during wet weather conditions. *Journal of Irrigation andDrainage Engineering*. 134(2): 120-128.
5. Cardenas-Lailhacar B and MD Dukes. 2008. Expanding disk rain sensor performance and potential savings. Journal of Irrigation and Drainage Engineering. 134(1):67-73.
6. Cardenas-Lailhacar, BMD Dukes and GL Miller. 2010. Sensor-based automation of irrigation on bermudagrass, during dry weather conditions. *Journal of Irrigation and Drainage Engineering.* 136(3): 184-193.
7. Davis SL, Dukes MD and Miller GL. 2009. Landscape irrigation by evapotranspiration-based controllers under dry conditions in southwest Florida. Agriculture Water Management. 96(12): 1828-1836.
8. Devitt DA, K Carstensen and RL Morris. 2008. Residential water savings associated with satellite-based ET irrigation controllers. *Journal of Irrigation and Drainage Engineering*. 134(1): 74-82.
9. Mayer PW and Deoreo WB. 2010. Improving urban irrigation efficiency by using weather-based “smart” controllers. *American Water Works Association*. 102(2):86.
10. Y Kim, R Evans and W Iversen. 2018.Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network, IEEE Transactions on Instrumentation and Measurement, Pages: 1379-1387
11. Indian Economic Survey‖, http://mofapp.nic.in:8080/economicsurvey, Govt. of India, 2018.
12. J Jegathesh Amalraj, S Banumathi and J Jereena John. 2019. A Study on Smart Irrigation Systems for Agriculture Using. *International Journal of Scientific & Technology Research* 8(12): 1935-1938