

Smart Irrigation System - Paving the Future of Indian Agricultural Sector

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Abstract

Irrigation systems have been resolute as an appreciative contributor toward streamlined irrigation systems that augment continual research and development, emphasizing cost reduction and sustainable operations. In an epoch wherein sustainability is of foremost significance and water resources are increasingly stressed, solutions for minimizing ecological impact, growing crop yields, and optimizing water usage are gaining traction. Conventional irrigation methods, often dependent on manual oversight and fixed schedules, add to limited adaptability and inefficient water usage to robust environmental conditions. Amalgamating the power of precision, automation, and data analytics is projected to completely transform the way water is used and managed in farming. This article delves into the trends and challenges of the smart irrigation technologies across the different regions of India. It discusses key market players in different Indian States, embracing strategic initiatives and offering the latest innovative solutions. Substantial rise in government backing and funding, coupled with a sequence of agricultural reforms enforced in the country, are expected to bolster the growth of smart irrigation in India.

Keywords: Smart Irrigation, Sustainable, Automation, Conventional Irrigation

Introduction

The Indian agricultural sector devours a significant amount of water, with varying irrigation requirements and precipitation being concerted during monsoons. The sector contributes nearly 18.2 percent to the country's GDP, yet a considerable number of farmers count on traditional techniques such as rotational water supply and flood irrigation systems, which consume

an immoderate amount of water, often resulting in depletion, underproduction, and inconsistent results. Incorporating such techniques also minimizes crop yields and increases the dependency on manual labour.

Over the past decades, the intensification efforts have substantially impacted India's agricultural output. However, the groundwater levels have been hit extremely, with the sector accounting for nearly 90 percent of the water used for irrigation. The efficient usage of water is deterred by immoderate groundwater extraction and obsolete irrigation methods, resulting in substantial wastage of water. With approximately 4 percent of the freshwater resources, India is witnessing mounting demands from an increasing population and escalating industrial activities. Changing climatic patterns and growing water scarcity have heightened the need for effective actions to optimize the irrigation process.

The integration of state-of-the-art technologies, such as Machine learning (ML) and the Internet of Things (IoT), offers efficient water management across the agricultural sector. Despite the exorbitant prices of sensors, innovations are projected to offer affordable solutions. Smart irrigation engaging IoT technology augments farming by minimizing water wastage and bolstering crop quality, which poses a necessity for economic growth.

Unlike these conventional methods, which also largely depend upon guesswork, smart irrigation systems work on the principles of seamless connectivity, automation, and precision. These systems have the potential to save water by creating slated irrigation efficiently via the usage of technology that enables the system to cater to the current conditions. These systems exploit moisture

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sensors, and localized weather data or the amalgamation of both, to offer only the required water content. The IoT-enabled devices enable the farmers to gather real-time data based on the ecological conditions, observe the equipment performance, and create data-driven decisions that augment crop cultivation (Ektos, 2024). The need for an intelligent and fully automated irrigation control system amalgamating low-cost sensors is thereby witnessing a widespread demand across the different regions of the country.

Businesses are largely integrating pioneering technologies into their product offerings to contribute to a sustainable future. The application or development of a smart irrigation model in large-scale agricultural lands plays a pivotal role, offering practical benefits to the farmers. Continued innovation and research, growing strategic initiatives, coupled with efforts to incentivize and educate the farmers, are projected to bolster the widespread demand for smart irrigation systems in India (Shah, 2024). To cater to the changing scenario, the Indian Irrigation systems must adopt water-efficient techniques to drive productivity without compromising biodiversity, water, and soil. With the concerted efforts from the government, farmers, and the private sector, along with the right innovation, will help attain the necessary performance results.

The article delves into the benefits of smart irrigation models with a wireless sensor networking system for real-time monitoring purposes. It also discusses the use of smart irrigation systems by various Indian states, with a key emphasis on the companies offering these products or models. The technological shift is expected to make the agricultural sector more efficient and profitable. With the rising adoption and awareness, the concept of smart irrigation is poised to become the foundation

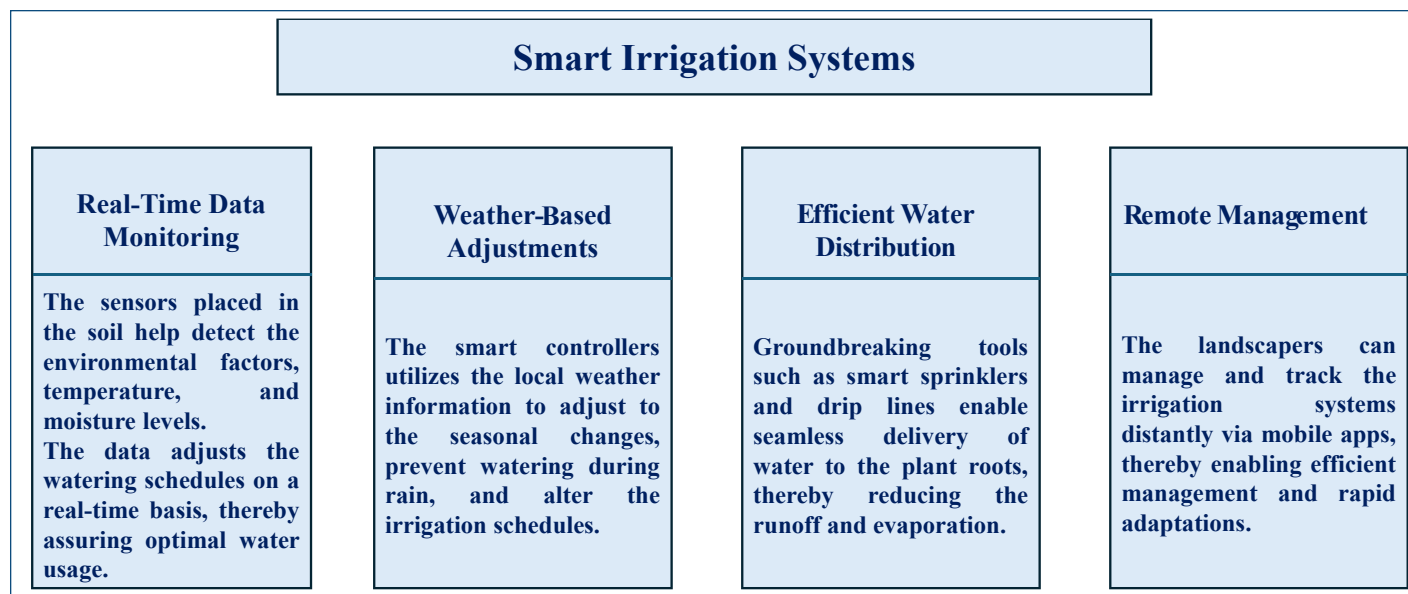
stone of the Indian agricultural strategy, thereby ensuring environmental sustainability and food security over the forecasted period.

Literature Review

With the agricultural sector in India gearing up for a tech-driven future, smart irrigation, along with digital farming, is set to be a pillar of growth. Embracing steadfast precision technologies, government policies, AI-driven solutions, and smartphone apps have led to a significantly forward-looking and robust agricultural status in India. The growing efforts towards environmental management, resource efficiency, and integration are projected to reshape the trajectory of Indian agriculture.

In response to increasing water scarcity and climate change, making the right choice from conventional and modern irrigation methods is pivotal for farmers and professionals alike. Extensive usage of the traditional scheduling of irrigation methods (based on soil, plant, and weather moisture conditions) lacks information required for accurate irrigation, and often leads to under- or over-irrigation of fields (Ahmed, 2023).

The incorporation of state-of-the-art technologies, such as smart irrigation systems connected via IoT, helps minimize waste, optimize water usage, and augment resilience alongside unpredictable scarcity and rainfall. Accepting the power of IoT in the domain of smart irrigation systems has the potential to transform water resources. With the growing demand for efficient irrigation systems, the synergy between water management and IoT has become a necessity. The usage of weather data integration, sensors, and IoT helps smart irrigation systems, to cater to the issues related to conventional systems. This can be illustrated as:



Source: (Rain, 2025).

Exhibit 1: How Smart Irrigation Systems Provide Solutions?

Amalgamation of sensors with wireless technology and microcontrollers helps in measuring the weather, temperature, and soil moisture conditions on a real-time basis (Sayed, 2025). Unlike conventional irrigation controllers that work on predetermined programmed timers and schedules, the smart irrigation controllers also monitor the plant water usage and evaporation to mechanically regulate the watering schedule to the real conditions of the site. Inclusion of these IoT devices helps deliver nutrients and water to crops with optimal quantity, placement, and timing, thereby guaranteeing efficacious usage of resources and augmented crop performance (González Perea, 2018; Costanzo, 2024).

Status of Indian Irrigation System

The irrigation sector plays a crucial role in India’s agricultural landscape, stabilizing the farm incomes, augmenting climate resilience, and enabling food security. The agricultural sector accounts for approximately 80 percent of the available water. Nearly 688 billion cubic

metres of water are consumed by the farm (Staff, 2018). Irrigation stands as an inevitable aspect for augmenting agricultural production, but accessibility to water remains a combative issue.

With the usage of factors such as climatic and soil variation, plant responses to water deficits, soil properties, changes in weather conditions, pioneering technologies such as smart irrigation bolster productivity and help save water. These state-of-the-art systems have transformed the way water is used and managed, thereby making the farms more environmentally friendly, convenient, and efficient. Incorporation of different components such as soil moisture sensors, rain sensors, remote monitoring alerts, weather stations, automated control units, Wi-Fi-connected controllers, cloud computing, and IoT connectivity by the market players minimizes wastage, promotes healthy plant growth, and augments water efficiency, making it an ideal choice for farmers and professionals.

Research Methodology

This study includes various information gathered through different secondary sources such as journals, research papers, articles, trade reports, and company annual reports. Various innovations across the different industries, as well as businesses, were particularly considered. Additionally, the study was based on the different strategies, initiatives, and measures taken by the different companies in different states towards the adoption of smart irrigation systems.

Research Questions

- How Smart Irrigation Systems offer solutions?
- What are the different factors driving the adoption of smart Irrigation systems by Indian professionals?
- Different challenges in the implementation of smart irrigation systems in the farming practices?
- Different initiatives and solutions adopted by the Indian companies in terms of irrigation methods and practices for a better and a connected future.

Significance of the Study

This study emphasizes on offering an in-depth analysis of the Modern Irrigation systems and practices. With the IoT enabled sensors and devices, factors such as pest detection, crop monitoring, water management, soil monitoring, weather-related adjustments, and more, becomes easier for the farmers and professionals. The ways adopted by the market players to boost the agricultural productivity and cater to the sustainable issues, have also been emphasized upon.

Scope of the Study

- This study provides emphasis on the different products or solutions of pioneering irrigation systems being adopted by the market players in the different regions of India.

Statewise Analysis in India

Kerala

Market Player Offering Smart Irrigation System Solutions in Kerala

AR Agritech

About the Company: AR Agritech, headquartered at Vaikom, Kerala, is the provider of smart irrigation services and solutions for a sustainable future. The company operates through a network of a wide range of professionals with its services across agricultural growers, groundkeepers, educational and government institutions, homeowners, and other segments (AGRITECH, About Us, n.d.).

Solutions Offered: The company offers water-saving, scientifically designed, sustainable, and innovative irrigation systems tailored to meet the evolving needs of gardeners and farmers. It focuses on catering to the varied range of customers to augment the overall sustainability and productivity of the lands. Key solutions offered includes (AGRITECH, Products, n.d.):

- *Micro Irrigation:* Micro Irrigation focuses on optimizing the usage of water, reducing the usage of resources, and capitalizing crop productivity. The concept acts as a viable and sustainable solution for the water-scarce locations because it precisely matches the water delivery to the crop requirements, thereby leading to water-saving, in comparison to traditional irrigation methods. Micro irrigation also helps in improving the quality and yield of crops, as well as augmenting nutrient management, and energy efficiency (Akram, 2024).

Tamil Nadu

Market Players Offering Smart Irrigation System Solutions in Tamil Nadu

Mobitech Wireless Solution

About the Company: Mobitech Wireless Solution was founded in 2008 and is headquartered in Perundurai, Tamil Nadu. The company is engaged in offering innovative and sustainable irrigation solutions. Mobitech operates with its distribution and operating facilities in different areas, with its range of services such as community and micro irrigation, greenhouses, as well as digital farming solutions. The company is also the provider of IoT-based services, such as weather-based and sensor-based agriculture (solution, 2008).

Solutions Offered: The products offered by the company cater to the segment:

- Automation
- Drip Irrigation

Nile Controllers

About the Company: Nile Controller, headquartered at Coimbatore, Tamil Nadu, has been at the forefront of innovation. Founded in 2005, the company is engaged in the integration of pioneering technologies to deliver inclusive solutions for water management across agricultural, industrial, and domestic sectors (Controllers, 2005).

Solutions Offered: Nile Controller is a pioneer in offering mobile-based automatic water pump starters and controllers, making a substantial impact on the agricultural sector. The solutions offered by the company help optimize water usage, maximize crop yield, and bolster agricultural productivity. Sustainability, reliability, and precision are thereby the key aspects considered for the solutions offered.

The company offers solutions for the segments:

- *Agricultural Automation:* The smart automation solutions offered by the company enable the optimization of water and irrigation usage. The advanced controllers enable the farmers to efficiently simplify water management, conserve resources, manage sustainability, and augment productivity.
- *Domestic Automation:* From real-time water level monitoring to automated water pump controllers, the company ensures water conservation, efficiency, and convenience for the residents.

Kothari Group

About the Company: Kothari Group, headquartered in Chennai, was founded in 1980. The company's products cater to the industrial domain with smart piping solutions and the agricultural domain with an array of accessories and pipes for irrigation. The company operates with nearly 2,200 channel partners, 14 warehouses, 7 units, and 1,600 associates across the different locations across country (Group, n.d.).

Solutions Offered: Kothari sprinkler irrigation systems are the key manufacturer of irrigation and agricultural equipment. The products offered by the company cater to

the segments of:

- Drip Irrigation
- Sprinkler Irrigation

Karnataka

Market Player Offering Smart Irrigation System Solutions in Karnataka

Avanijal Agri Automation

About the Company: Avanijal Agri Automation, headquartered in Bangalore, was established in 2013. The company is the developer of a fertigation controller and irrigation automation device intended to deliver agricultural services with minimum electricity, labour, and water. The products offered by the company help monitor the water levels and manage several bore wells, open wells, and water sources by linking them to farmers via the network, thereby bolstering the agricultural productivity (Avanijal, 2013).

Solutions Offered: Avanijal - Installation of Irrigation Management System:

The fertigation and irrigation activities on the farm require human intervention to control the resources diligently. Avanijal's irrigation automation enables seamless control and monitoring of irrigation practices based on a user's specific conditions and input on the ground. The wireless nodes collect soil moisture data from the sensors, thereby wirelessly controlling the valves from the controller. In addition to these systems, the farmers also use Avanijal's app and remotely control the whole system, thereby ensuring that their entire fields are fertigated and irrigated on time, with constant monitoring. Hence, the real-time monitoring processes through the app help keep the farmers updated.

New Delhi

Market Player Offering Smart Irrigation System Solutions in New Delhi

Automat Industries Pvt. Ltd.

About the Company: Automat Industries Pvt. Ltd., headquartered in New Delhi, was founded in 1972. The company is the largest manufacturer of fertigation,

filtration, and irrigation sprinklers. The company offers nearly 350 Irrigation products and operates in approximately 100 countries.

The company emphasizes transforming the agricultural industry by offering farmers environment-friendly and intelligent irrigation solutions to increase the farmers' income, optimize the usage of water, and augment the productivity of crops. Leveraging precision farming equips the farmers with smart technologies to circumvent the misuse of water and land (Industries, Accelerating Growth in Modern Irrigation, n.d.).

Solutions Offered: The solutions offered by the company includes:

- *Impact Sprinklers:* The Impact Sprinklers, designed by Automat, emphasize attaining longevity and performance and cater to the needs of modern irrigation systems. The products offered are available in tough engineering-grade polymer, aluminium, and brass. Further, these sprinklers ensure uniform operation and coverage at low water pressure levels, thereby optimizing yields in the agricultural fields. The different Impact Sprinklers include metal and plastic sprinklers.
- *Micro Sprinklers:* The micro sprinklers operate at low water pressure levels, assuring overhead irrigation in vegetable and fruit fields along with orchards and vineyards.
- *Fertigation:* The fertigation products offered are high-quality and high-yielding, a mix of fertilizer, water, and added nutrients delivered at regular intervals. The fertigation products offer effective harvest quality and fertigation performance, along with saving of energy use, labour, time, and fertilizer, as well as lesser water usage.

Maharashtra

Market Player Offering Smart Irrigation System Solutions in Maharashtra

Jain Irrigation Systems Limited

About the Company: Jain Irrigation Systems Limited, headquartered in Jalgaon, Maharashtra, is the largest micro-irrigation company in the world. Founded in 1989, the company is engaged in the manufacture of a

full range of precision-irrigation products. The company offers services from agronomic support to soil survey to engineering design, wherein it takes care of a scattering of 2300-acre Hi-Tech Agri Institute, a training and extension centre, a demo, and a farm resource R&D. The company operates with nearly 33 manufacturing bases in over 4 continents. The company's products are supplied in more than 126 countries, from nearly 11,000 distributors and dealers across the world (Systems, About Us, n.d.).

Solutions Offered: The products offered by the company include (Systems, World class Products Technology, n.d.):

- *Sprinkler Irrigation:* The Jain Sprinkler system is a versatile and unique irrigation system that assures seamless installation, affordability, high-quality, and maximum water saving. The products offered are made of chemical-resistant and high-strength engineering plastics to maintain cost economics and attain functional satisfaction. The products offer structured coverage for all types of farmlands be it large or small area. The products offered in the segment include plastic sprinklers, metal sprinklers, rainguns, landscape & garden sprinklers, quick-connect pipes, and quick-connect fittings.
- *Micro and Mini Sprinklers:* The different products offered under this segment include: mini sprinkler systems, under-tree irrigation systems, micro sprinklers & assemblies, misters & assemblies, jets & assemblies, bubblers, foggers & assemblies, and fittings & accessories.
- *Drip Irrigation Systems:* "Jain Drip" is an economically viable and appropriate system to offer a calculated quantity of water at the root zone of every plant at methodical intervals, to ensure that the plants do not suffer from strain or stress of over- or under-watering. The Jain Micro Irrigation Systems are made from high-quality virgin raw materials (that cater to the international standards, are reliable, and durable) via advanced machinery. Whether it is mango, sugarcane, vegetables, grapes, apple, banana, cotton, coffee, tea, teakwood, flowers, or others, the company offers a suitable micro irrigation system for all kinds of crops. Varied types of components offered by the company are exported to different countries of Far East Asia, Middle East Asia, South East, Africa, America, and Europe.

- *Jain Spirit PRO*: The Jain Spirit PRO Controller is a groundbreaking device planned to optimize and streamline the irrigation system for large and small agricultural operations. It is a mobile app-based operation with regulated time entry for flexible fertigation and irrigation valves.

Mahindra Agri Business

About the Company: Mahindra & Mahindra, a trusted partner for Indian farmers and a worldwide leader in tractors, focuses on redefining the boundaries in agriculture. Mahindra Agri Business has sprung up as a game-changer, providing solutions that revolutionize farming. The company focuses on bolstering a positive change via market linkages, services, and innovations (Business, n.d.).

Solutions Offered: Key business segments offered by the company can be illustrated as: Seeds, Crop Care, Micro Irrigation, Seed Potato, and Fruits.

Micro Irrigation: Acquired in 2011, the Mahindra EPC Irrigation Limited (MEIL) is a publicly listed Micro Irrigation company. The technology saves water by nearly 50 percent and augments productivity. The EPC with cutting-edge technology offers high-quality and industry-leading sprinklers and drip irrigation solutions to farmers.

Market Trends Impacting the Adoption of Smart Irrigation in India

Rising Government Initiatives to Back the Adoption of Smart Irrigation

Firming up the sector by guaranteeing sustainable water management, building sufficient infrastructure, and modernizing the irrigation systems is projected to augment the overall agricultural productivity. The government of India has announced the implementation of schemes and targeted programmes to incentivise the efficacious water irrigation practices. The Indian Government has prioritized water conservation and irrigation development practices to bolster the irrigation facilities and contribute to the productivity and profitability of the agricultural sector.

In addition to this, the government is also engaged in the implementation of several programs multiple programs

to encourage water conservation via smart irrigation technologies, backing the smart irrigation market in India. The role of the government is limited to offering financial assistance, technical support, and being catalytic in terms of the prevailing schemes being executed by the Ministry of Jal Shakti. The launch of various incentives and subsidies is projected to make sprinkler and drip irrigation more affordable.

The Initiatives launched by the Government of India are illustrated as (Delhi, 2022)

In 2015-16, the Government announced the launch of the “Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)” to augment the physical accessibility of water on farms and amplify the cultivable area under irrigation, announce the launch of sustainable water conservation practices, and improve the on-farm water use efficiency. This scheme is referred to as the Umbrella Water Scheme, implemented by the Department of Water Resources, River Development, and Ganga Rejuvenation, that is the Har Khet Ko Pani (HKKP), and the Accelerated Irrigation Benefits Programme (AIBP). The HKKP scheme comprises of sub-components: Ground Water (GW) Development, Renovation and Restoration (RRR) of Water Bodies, Surface Minor Irrigation (SMI), Repair, and Command Area Development & Water Management (CAD&WM).

The PMKSY scheme also comprises two other schemes:

- Department of Land Resources - Watershed Development component (WDC).
- Department of Agriculture and Farmers Welfare - Per Drop More Crop (PDMC).

The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) has been approved to continue to 2025-26, with the elongation of the groundwater component. Further, the investments for the initiatives have been elevated for the Micro-Irrigation Systems (MIS) via the Micro-Irrigation Fund (MIF), which plays a key role in financing groundbreaking irrigation projects by providing 2 percent interest to the states on loans.

Growing Demand for IoT and AI in Irrigation Systems in India

The amalgamation of Internet of Things and Artificial Intelligence (AI) are becoming a keystone in the modern

agricultural sector, particularly in revolutionizing the irrigation systems. The integration can be illustrated as:

- *Real-Time Data Collection and Analysis:* The IoT-based systems rely on sensors, measure precipitation, humidity, temperature, and soil moisture, as well as offer infrastructure for data transmission and collection. These sensors disseminate data to cloud-based platforms, wherein the AI-based systems leverage the gathered data, and optimize irrigation schedules, guaranteeing that water is applied only when required. This is further anticipated to augment crop yields and minimize electricity consumption and wastage of water. The machine learning techniques, comprising of neural networks and regression models, help analyze large datasets to reveal correlations and complex patterns that are instantly distinct. For instance, to create a precise irrigation plan as per stated fields, the AI-based systems need to influence in regional crop health, soil conditions, and weather forecasts (Harun, 2024).
- *Predictive Analytics:* The Machine Learning (ML) algorithm helps augment the irrigation schedules with the help of soil moisture sensor inputs as well as real-time weather data, to project the amount of water required per field. On the basis of the data, the machine learning algorithms can seamlessly compute the effective duration and frequency of irrigation, thereby evading unwanted water consumption, with a guarantee that the crop receives sufficient water to augment the growth rate. These models are also used to identify irrigational gaps and inefficiencies, resulting in water saving, thereby reducing downtime. Further, the AI/ML models also help detect early signs of pests or diseases, thereby minimizing the dependency on chemical treatments (Mag, 2024). Hence, predictive analytics bolstered by AI enables the farmers to make decisions on the basis of real-time and historical data and project the irrigation needs.
- *Automated Precision:* Based on the AI analysis, the smart IoT controllers can mechanically regulate the irrigation systems (such as sprinklers or drip lines) to offer a precise quantity of water when and where required.

Challenges Hindering the Adoption of Smart Irrigation Technology in India

Adoption of smart irrigation in India comes with a varied set of challenges owing to the diversified infrastructure limitations, fragmented landholding patterns, and socio-economic diversity. A few of these challenges are illustrated as:

- *Lack of Technical Knowledge Among Farmers*

The complexity of the systems poses a challenging task, necessitating the need for proper education and training initiatives to guarantee effective maintenance and utilization of the irrigation controllers. Hence, to keep pace with the changing scenario, farmers need to have in-depth knowledge about the adoption and understanding of IoT-driven technology.

- *High Initial Costs*

High costs of installation and technology pose a significant hindrance to the adoption of smart irrigation systems. Nevertheless, the long-term potential benefits, such as enhanced productivity and water savings, often compensate for these costs. Hence, developing cost-effective solutions that offer tangible benefits with a positive return on investment for farmers is the need of the hour (Venkatesh, 2024).

- *Scarcity of Water or Over-Irrigation*

In India, groundwater accounts for nearly 60 percent of the irrigation systems, resulting in decisive over-extraction, which further poses a significant challenge in the implementation of smart irrigation practices (Kushwaha, 2024).

Conclusion

With the escalating climate conditions and the rising global temperatures, the efficacy in water management is gaining momentum. Addressing the challenges of water scarcity is a pressing need of the time. The state-of-the-art technologies, such as smart irrigation systems, that amalgamate IoT technologies, machine learning, and real-time data are witnessing a significant rise. Unlike the conventional methods, the modern techniques modify the

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