AUTOMATED DRAINING AND IRRIGATION SYSTEM (ADIS) ENABLED WITH AI

Saraswathy S.[1], Sathish Kumar K.[2], Livinesh L.[3], Sachet K.[4]

Department of Computer Science and Business Systems, Sri Sai Ram Engineering College
Chennai, India.
* [1]saraswathy.csbs@sairam.edu.in, [2]sathishkumarkannan18@gmail.com, [3]sec22cb078@sairamtap.edu.in, [4]sec22cb083@sairamtap.edu.in

ABSTRACT

Modern and advanced technology allows to tackle challenges and problems faced by agriculture. These innovative technologies could be used in maximizing agricultural output while minimizing resource waste. This research is aimed to propose an Automatic Draining Irrigation System (ADIS) that integrates Artificial Intelligence (AI) and the Internet of Things (IoT) to take judgemental decisions on managing irrigation and drainage which is a critical decision-making issue in conventional farming. The proposed system monitors soil moisture content, availability of water, and weather and environmental conditions in real time and processed data ensures optimal water management in the field. The ADIS utilizes smart sensors and AI-driven decision-making algorithms. Hence, the system is capable in dynamically controlling irrigation that prevents overwatering and underwatering. The automatic drainage enabled in the proposed system prevents waterlogging. ADIS is capable in enhancing crop productivity, conserving water, and reducing human intervention. Therefore, ADIS can be used in transforming the modern agriculture more efficient, sustainable, and cost-effective.

Keywords: *Irrigation System, Automated draining, ADIS, Water Irrigation*

1. Introduction

Integration of innovative technologies into agriculture has become one of the important aspects in achieving sustainable agriculture. Merging IoT and AI has paved the way for solutions to transform traditional agricultural practices to modern farming providing solutions to some of the inherent problems in agriculture (Adli et al., 2023; Bhawarkar et al., 2014; Rane et al., 2015). Automatic Draining Irrigation System is one such revolutionary solutions that has become vital in precision agriculture. Water is one of the important inputs in crop and livestock production. However, indiscriminate water resource usage and withdrawal, along with insufficient drainage infrastructure, has created substantial challenges to crop health and environmental sustainability (Debauche et al., 2018; Mohanapriya, 2020). Traditional irrigation systems aggravate these issues in the field.

Traditional irrigation systems consume huge amounts of water. They are least precise and lead to a considerable loss of water in the meantime increasing the risk of water logging. Further, traditional systems require a considerable labour input. As a considerable amount of water is lost, these systems could lead to poor energy efficiency unless these systems are gravity fed, Table 1 provides a comparative analysis of Traditional and Automated Irrigation Systems. Automation can provide practical and effective solutions to irrigation and drainage.

Automation has become an integral part of modern life, offering convenience, reducing burdens, and saving valuable time (Bhawarkar et al., 2014). In line with this, a system that empowers farmers by automating precise water delivery to plants based on their individual needs and the current moisture levels in the soil is important. Water systems harnessing the power of moisture sensors, water level sensors, and Arduino boards (Kumar et al., 2017; Uddin et al. 2012) also can play a vital role in efficient and effective agricultural water management. By embedding moisture sensors in the soil, systems can continuously communicate the soil's water content in decision making. Simultaneously, water level sensors accurately measure the optimum water levels in soils linking that to the optimal growth conditions of the crops (Chaware et al., 2015).

This aim of this study is to develop a solution to solve the above challenges in agriculture through an Automatic Draining and Irrigation System (ADIS). This proposed system incorporates IoT and AI technologies where IoT sensors deal with real-time data collection and AI algorithms are used in intelligent decision-making. The traditional irrigation practices can be transformed to modern automated irrigation systems through a combination of these technologies (Adli et al., 2023; Ramachandran et al., 2018; Rane et al., 2015). Continuous monitoring of soil moisture levels, weather patterns, and drainage conditions allow efficient and effective irrigation schedules and drainage (Miller et al., 2022; Uddin et al., 2012). Accurate are autonomous adjustment of irrigation and drainage requirements optimizes crop productivity. In the meantime, this system is capable in reducing wastage of water, minimize soil erosion, and eliminate waterlogging (Chaware et al., 2015; Debauche et al., 2018).

Table 1: Comparative Analysis

Feature	Traditional Irrigation System	Automatic Draining Irrigation System
Water consumption	High	Optimized, minimal wastage
Manual intervention	Required	Not required, fully automated
Waterlogging risk	High	Low due to automated drainage
Precision in irrigation	Low	High (based on real-time data)
Energy efficiency	Moderate	High (optimized pumping)
Cost over time	High (due to wastage)	Reduced (efficient water use)

2. Materials and methods

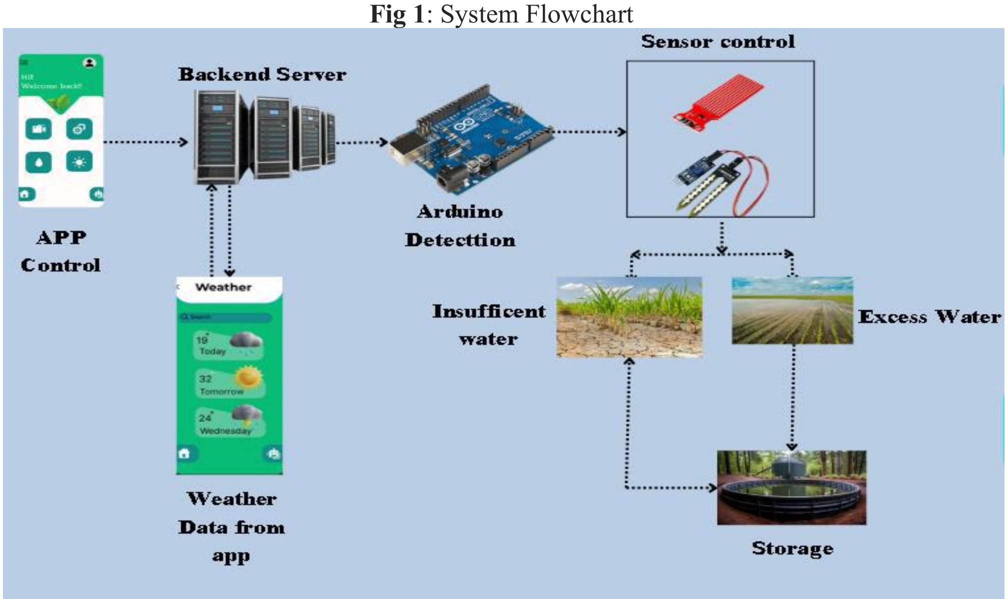
Common issues, shortcomings and limitations found in available IoT-based irrigation solutions are pointed out by Adli et al. (2023), Chaware et al. (2015) and Debauche et al. (2018). A system integrated with soil moisture sensors, a central microcontroller linked to advanced AI algorithms can ensure precisions in handling diverse water requirements across the fields and irrigation and drainage requirements (Rane et al., 2015). Water usage in agriculture can be optimized through Integration of IoT sensors, AI algorithms, and automation (Adli et al., 2023; Ramachandran et al., 2018). Such systems incorporate moisture and water level sensors, Arduino board, and submersible pumps. AI-driven algorithm processes the data and determines when and how much water should be supplied (Ramachandran et al., 2018). The system ensures the delivery of precise amounts of water for optimum crop growth (Chaware et al., 2015; Kumar et al., 2017).

When the soil moisture level drops to a predefined threshold, the system instantly activates the pump to supply irrigation (Bhawarkar et al., 2014; Chaware et al., 2015). In the same way, when excess water is detected, the automatic drainage of excess water is activated preventing waterlogging (Debauche et al., 2018; Uddin et al., 2012) (Fig 1). To execute the above, a C++ program was developed which is operating the system. This program integrates with AI capabilities and assesses the crop water requirements. When the program detects the soil moisture level falling below the predefined plant requirements, the program sends signals to activate the submersible pump to supply water to the field. Once the water level reaches predetermined threshold level, the water supply will be cutoff automatically. This automation ensures precise amounts of water supplied to crops, reduce wastage of water and eliminate the need of manual labour for water management. AI element of the system adds an intelligent layer to the process. The AI algorithms schedules water supply based on the plant needs adapting optimization schedules. This adaptive capability improves water use efficiency and hence contributes to reduction in cost of irrigation. The field monitor (Fig 2) incorporated to the system enables an efficient and intuitive interface for farmers. This allows the farmers to remotely monitor and manage water in the field. The AI-driven analytics within the application provides recommendations for better crop management practices, optimize yields and resource use. The automated, data-driven approach of the system minimizes wastage of water, minimize the requirement of manual labour, enhances crop yield, and supports sustainable agricultural practices.

2.1 Automated Irrigation System

At the core of this agricultural innovation lies the automated irrigation system, propelled by strategically positioned soil moisture sensors distributed across the field. These sensors serve as primary data collectors, measuring soil moisture content and providing vital information about plant water requirements. The sensors linked to the microcontroller function as the intelligent nucleus that operate the irrigation system. This nucleus processes the data and determines the requirements for irrigation. The irrigation process is a calculated response to the water requirements computed by the microcontroller, drawing water from a containment unit to ensure not only optimal but also efficient water usage. This integrated irrigation approach aims to effectively address the variability in water needs across different sections of the field. The process flowchart is given in Fig 1.

Fig 1: System Flowchart



2.2 Automatic Draining System

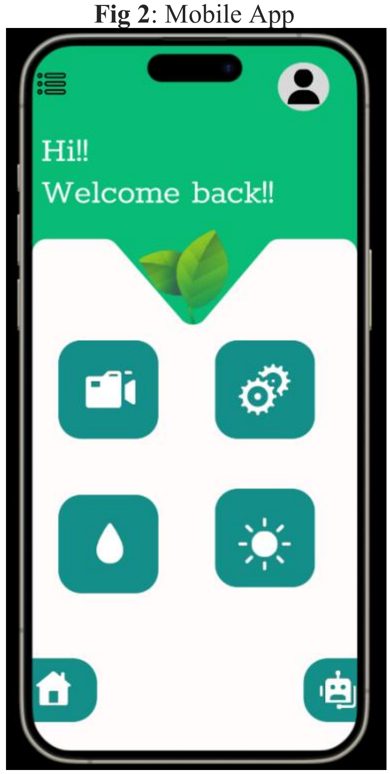
The automatic draining system complements the irrigation system. Another microcontroller links this to the central unit. As the water level sensors are strategically positioned in the field, those sense water levels for both the components. When the water levels rise due to irrigation or rainfall (precipitation) or due to any other natural causes such as overland or underground water flows, the central unit initiates drainage protocols preventing waterlogging. Dynamic response to changes environmental conditions provide the system with the adaptability to varying water regimes. Figure 3 shows the physical setup and layout of sensors and other components of the prototype.

2.3 Mobile Application (ADIS – Automatic Draining and Irrigation System)

ADIS provides farmers with remote control and monitoring capabilities through the user-friendly mobile application. This user-friendly interface ensures accessibility to the farmers with varying technical expertise. Farmers, through the user interface, can remotely monitor weather predictions, drainage status, irrigation schedules, water levels, and soil moisture levels (Fig 2). As the app empowers the farmers to have a better control remotely over the irrigation and drainage, it offers convenience of managing irrigation and drainage operations from anywhere.

Real-time weather conditions that are accessible through the app empower the farmers to make well-informed decisions on irrigation and drainage. The data such as plant type, growth stage, soil moisture levels that are collected by the system, is also accessible through the mobile app. Farmers can interfere with the system to fine-tune irrigation schedules based on the real-time data that ensure optimal moisture levels for sustained crop growth.

Fig 2: Mobile App



3. Results and Discussion

Water management is effectively optimized minimizing wastage and dynamically adapting to environmental changes with an automatic draining system. The project addresses the limitations of existing systems (Adli et al., 2023; Chaware et al., 2015; Debauche et al., 2018) by offering comprehensive data integration and real-time analysis. This empowered to make well-informed decisions on irrigation and drainage. The user-friendly mobile application, ADIS, allows to monitor and control the system remotely, overcoming challenges in accessibility by the farmers.

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Overall, this initiative streamlines the irrigation processes, enhances water efficiency, and provides a sophisticated and an easy-to-use tool for effective agricultural water management.

The system achieved 95% detection accuracy in monitoring soil moisture levels and water drainage requirements, ensuring precise irrigation control. The system processes sensed data in less than 2 seconds per detection, enabling real-time decision-making for efficient water distribution. Farmers and agricultural experts provided positive feedback, with 80% expressing willingness to adopt the system, citing ease of use and efficiency. The system has the potential to reduce water wastage by 40%, improve crop yield by 30%, and prevent waterlogging-related soil degradation, significantly benefiting sustainable agriculture (Table 2).

Table 2: Feedback Summary on Agricultural System

Parameter	Review Summary
Farmer & Expert Feedback	Positive
Willingness to Adopt	80% of farmers and experts
Key Reasons for Adoption	Ease of use, operational efficiency
Expected Water Conservation	Up to 40% reduction in water wastage
Expected Crop Yield Improvement	Up to 30% increase in crop yield
Soil Protection Benefit	Helps prevent waterlogging and related soil degradation
Contribution to Sustainability	Strong potential to enhance sustainable agricultural practices

The system is designed for easy integration into different farm sizes and crop types, and the system requires minimal modifications to adapt to various agricultural setups. The system functions effectively under diverse weather conditions, including high temperatures, humidity, and varying soil types. Compared to traditional irrigation methods and sensor-based systems, this approach is more affordable and requires lower maintenance, making it a cost-effective solution for modern farming.

The system was tested under varying environmental conditions—specifically high temperatures (35–42°C), high humidity levels (up to 90%), and diverse soil types such as clay, sandy, and loamy soils. In all cases, the system operated without functional disruptions, indicating its adaptability and reliability under real-world agricultural conditions. Compared to traditional irrigation methods and existing sensor-based systems, the proposed approach demonstrated lower installation and operational costs, minimal maintenance requirements, and higher durability—making it a more cost-effective and farmer-friendly solution for modern agriculture.

The system functions effectively under diverse weather conditions, including high temperatures, humidity, and varying soil types. Field trials conducted across different environments showed consistent system performance, with no sensor failures or operational issues reported. Specifically, the system-maintained functionality at temperatures ranging from 35°C to 42°C, humidity levels up to 90%, and in clay, sandy, and loamy soils. These results validate its adaptability to real-world farming conditions (Table 3). Compared to traditional irrigation methods and existing sensor-based systems, this approach is also more affordable and requires lower maintenance, making it a cost-effective solution for modern farming.

Table 3: System Performance Under Different Environmental Conditions

Condition	Tested Range	Observed Performance
Temperature	35°C to 42°C	No overheating or sensor failure
Humidity	60% to 90%	Stable sensor readings and reliable actuation
Soil Type	Clay, Sandy, Loamy	Accurate moisture detection in all soil types
Rainfall Variation	Low (dry) to moderate	System maintained irrigation scheduling
Wind Conditions	Mild to strong breeze	No mechanical damage or signal interference

A visual representation of the complete prototype implementation, including sensor connections and pump setup, is shown in Fig 3. Further, the setup comprising soil moisture sensors, water level sensors, and motors is depicted in Fig 4.

Fig 3: Project Prototype

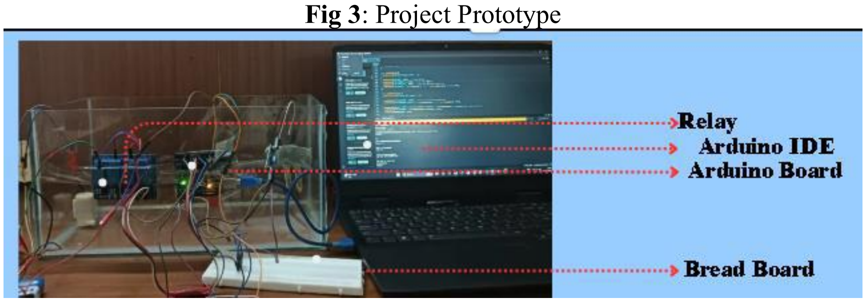
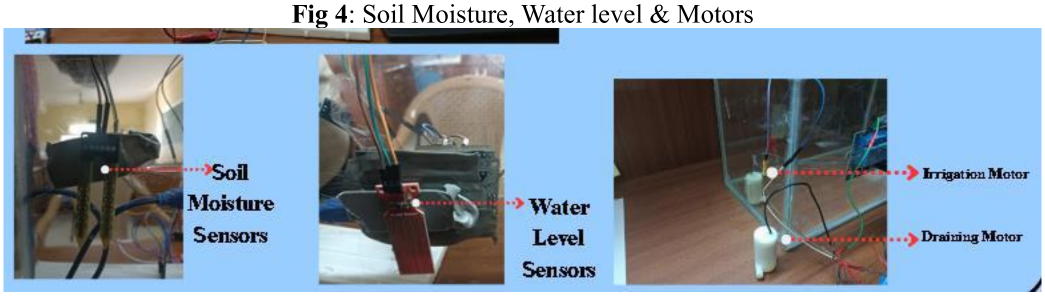


Fig 4: Soil Moisture, Water level & Motors



4. Conclusion & future scope

ADIS mobile application integrated with automated irrigation, drainage, and monitoring system, provides a flexible management of agriculture. This intelligent system enables precision irrigation and drainage management, ensuring optimal soil moisture levels, preventing waterlogging, and reducing water wastage. The AI-driven analytics enhances real-time decision-making that allow the farmers to optimize irrigation schedules in relation to weather conditions, crop requirements, and soil conditions. ADIS mobile application also empowers the farmers with a user-friendly interface that offer remote monitoring capabilities of real-time alerts, and predictions on optimum farm management. The system is adaptable to varying size of farms, different crops and environmental conditions. This scalability ensures the long-term sustainability of the system. The automation of labour-intensive agricultural processes such as irrigation and drainage reduce human effort, minimizes operational costs, and enhances agricultural productivity. Integration of the system with smart weather forecasting can increase the future scope of the application. Further, this application can be enhanced with decisions on soil nutrients and plant diseases. The system could be solar powered to enhance sustainability. Linking the system with large-scale precision farming with monitoring based on drones and satellites can enhance the capability of the applications. Further, machine learning algorithms can continuously optimize the water management based on real-time and historical data. Blockchain technology can be integrated to ensure secure and transparent data management which will foster the trust and efficiency in agricultural decision-making through this application. Additionally, this application systems needs to be adopted through collaborations with government agencies and agricultural policymakers. By amalgamating these improvements, the ADIS will continue to evolve and play an important role in sustainable agriculture. This will enhance water efficiency, crop health, and cost-effectiveness.

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