Enhancing Crop Yield Prediction and Resource Management: A KNN-Based Approach Coupled with IoT-Driven Smart Irrigation for Rice, Wheat, and Corn Cultivation

PROJECT REPORT

Submitted by

M . SAKTHI SHARAN [RA2011042010120]
SHIVANI D [RA2011042010129]

Under the Guidance of

Dr.M. RAMPRASATH

(Assistant Professor, Department of Data Science and Business Systems)

In partial fulfilment of the Requirements for the Degree of

BACHELOR OF TECHNOLOGY
in
COMPUTER SCIENCE AND BUSINESS SYSTEMS

DEPARTMENT OF DATA SCIENCE AND BUSINESS SYSTEMS

COLLEGE OF ENGINEERING AND TECHNOLOGY

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY
KATTANKULATHUR- 603 203

MAY 2024

Department of Computational Intelligence
SRM Institute of Science & Technology
Own Work* Declaration Form

Degree/ Course : Bachelor of Technology, Data Science and Business Systems

Student Name : M SAKTHI SHARAN, SHIVANI D

Registration Number : RA2011042010120, RA2011042010129

Title of Work : Enhancing Crop Yield Prediction and Resource Management: A KNN-Based Approach Coupled with IoT-Driven Smart Irrigation for Rice, Wheat, and Corn Cultivation

We hereby certify that this assessment compiles with the University's Rules and Regulations relating to Academic misconduct and plagiarism**, as listed in the University Website, Regulations, and the Education Committee guidelines.

We confirm that all the work contained in this assessment is our own except where indicated, and that We have met the following conditions:

- Clearly referenced / listed all sources as appropriate
- Referenced and put in inverted commas all quoted text (from books, web, etc)
- Given the sources of all pictures, data etc. that are not my own
- Not made any use of the report(s) or essay(s) of any other student(s) either past or present
- Acknowledged in appropriate places any help that I have received from others (e.g. fellow students, technicians, statisticians, external sources)
- Compiled with any other plagiarism criteria specified in the Course handbook / University website

We understand that any false claim for this work will be penalized in accordance with the University policies and regulations.

DECLARATION:	
We are aware of and understand the University's policy on Academic misconduct and plagiarism and we certify that this assessment is our own work, except were indicated by referring, and that we have followed the good academic practices noted above.	
M. Sakthi Sharan	D. Shivani
M SAKTHI SHARAN[RA2011042010120]	SHIVANI D[RA2011042010129]

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

KATTANKULATHUR-603203

BONAFIDE CERTIFICATE

Certified that this project report titled "**Enhancing Crop Yield Prediction and Resource Management: A KNN-Based Approach Coupled with IoT-Driven Smart Irrigation for Rice, Wheat, and Corn Cultivation"** is the bonafide work of **M. SAKTHI SHARAN [Reg No: RA2011042010120] and SHIVANI D [Reg No: RA2011042010129]** who carried out the project work under my supervision. Certified further, that to the best of my knowledge, the work reported herein does not form part of any other thesis or dissertation based on which a degree or award was conferred on an earlier occasion for this or any other candidate.

Dr.M. Ramprasath
GUIDE
Assistant Professor
Dept. of DSBS

Dr.M.Lakshmi
HEAD OF THE DEPARTMENT
Dept. of DSBS

Signature of Internal Examiner

Signature of External Examiner

ABSTRACT

.
When water-table pumping is performed with an excessive amount of fossil fuels, extraction ratios are exacerbated, which in turn exacerbates climate change and global warming. This is especially true in regions where water scarcity is a significant problem. Due to the fact that population growth increases the demand for food, sustainable farming requires effective management of groundwater. According to the findings of this research, Internet of Things (IoT) devices can be utilised in conjunction with a K-Nearest Neighbours (KNN) algorithm to automatically determine the type of crop being grown (corn, wheat, or rice) and the most effective method of watering it. Through the utilisation of sensors that detect soil moisture, temperature, humidity, and total dissolved solids (TDS), our system is able to determine on its own how much water each crop need on a daily basis based on the type of growth it experiences. The Arduino UNO microcontrollers and the Adafruit bridge are responsible for managing real-time sensor data, which enables precise irrigation scheduling to take place without the assistance of a person from the outside. In this work, the Internet of Things Smart Irrigation System is presented for the first time. It is a significant advance for farming in the modern realm. Through the provision of automated and data-driven insights to farmers, the system fosters agricultural practices that are both beneficial to the environment and long-lasting, while simultaneously maximising the efficiency of farming at its highest potential level. This innovative technology has the potential to assist farmers in growing a greater quantity of crops while also protecting vital water sources in the long run. A comprehensive solution that has the potential to revolutionise agriculture by eliminating the need for physical labour is shown in this abstract, which demonstrates how the Internet of Things is continuously improving.

ACKNOWLEDGEMENTS

We express our humble gratitude to Dr.C. Muthamizhchelvan, Vice-Chancellor, SRM Institute of Science and Technology, for the facilities extended for the project work and his continued support.

We extend our sincere thanks to Dean-CET, SRM Institute of Science and Technology, Dr.T.V. Gopal, for his invaluable support.

We wish to thank Dr. Revathi Venkataraman, Professor & Chairperson, School of Computing, SRM Institute of Science and Technology, for her support throughout the project work.

We are incredibly grateful to our Head of the Department, Dr.M. Lakshmi Professor, Department of Data Science and Business Systems, SRM Institute of Science and Technology, for her suggestions and encouragement at all the stages of the project work.

We want to convey our thanks to our program coordinator Dr.E.Sasikala, Professor, Department of Data Science and Business Systems, SRM Institute of Science and Technology, for her input during the project reviews and support.

We register our immeasurable thanks to our Faculty Advisor Dr.V.Vijayalakshmi, Assistant Professor, Department of Data Science and Business Systems, SRM Institute of Science and Technology, for leading and helping us to complete our course.

Our inexpressible respect and thanks to my guide, Dr.M. Ramprasath, Assistant Professor, Department of Data Science and Business Systems, SRM Institute of Science and Technology, for providing me with an opportunity to pursue my project under his mentorship. He provided me with the freedom and support to explore the research topics of my interest. His passion for solving problems and making a difference in the world has always been inspiring.

We sincerely thank the Data Science and Business Systems staff and students, at SRM Institute of Science and Technology, for their help during our project. Finally, we would like to thank parents, family members, and friends for their unconditional love, constant support, and encouragement.

M SAKTHI SHARAN

SHIVANI D

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background:

It is anticipated that the global population will reach 9.7 billion by the year 2050, which will need a seventy per cent increase in the amount of food that is produced. Agriculture is an important sector in India, and it makes a considerable contribution to the country's overall GDP growth. On the other hand, it is responsible for the biggest proportion of freshwater use, which highlights the importance of effective resource management.

1.2 Motivation:

The ineffective utilisation of India's abundant natural resources, notably water, is a critical matter that has to be addressed. At the same time that there is a vital need to optimise water usage in agriculture while simultaneously increasing food production, there is also a critical requirement to sustainably support economic growth and fulfil global food demands.

1.3 Objectives:

1. Create an irrigation control system that is based on the Internet of Things and incorporates a variety of technologies in order to maximise water use.
2. Enhance crop productivity by implementing real-time data collecting and prediction algorithms for better irrigation forecasting. This will allow for more accurate irrigation planning.
3. Reduce the load that is placed on farmers by automating laborious irrigation operations that are done within the system.
4. Increase the effectiveness of the use of resources by employing sophisticated sensors to keep track of the current weather and the amount of moisture in the soil in real time.
5. Develop a user-friendly interface, which should include a mobile application, in order to make it simple for farmers to access and control the irrigation system.

1.4 Scope of the Project:

The primary goal of the project is to develop a mobile application that is user-friendly and to automate irrigation procedures by utilising technology such as the Internet of Things (IoT), cloud computing, sensors, and machine learning. In order to achieve accurate irrigation scheduling, it involves monitoring the moisture content of the soil, the meteorological conditions, and the requirements of the crop.

1.5 Significance:

Bringing about a change in agricultural methods in India through the implementation of contemporary technologies is the significance of this. This framework not only tackles the difficulties of water shortage and production, but it also contributes to the development of consumption and production processes that are more sustainable. The initiative is in line with India's economic and environmental aims because it gives farmers more electricity and improves crop quality and output.

CHAPTER 2

LITERATURE SURVEY

Over the course of the past few years, there has been a substantial increase in the investigation and deployment of Internet of Things (IoT)-based smart irrigation systems in the agricultural sector. This shift in perspective has been propelled by important studies, research discoveries, and inventive advancements that collectively map the road for farming practices that are both sustainable and efficient. The purpose of this review is to shed light on the existing state of these systems as well as prospective future advances, as well as to investigate the technological advancements, environmental benefits, and economic implications of these systems.

2.1 Technological Advancements in Smart Irrigation Systems:

In the realm of intelligent irrigation systems, technological developments are one of the primary areas of concentration. For the purpose of developing intelligent and automated irrigation solutions, researchers and innovators have been making use of cutting-edge technologies including as cloud computing, big data analytics, and machine learning. Through the utilisation of these technologies, real-time monitoring, data analysis, and decision-making are made possible, which ultimately results in optimised water management, increased agricultural production, and decreased environmental impact.

2.2 Environmental Benefits of IoT-Based Irrigation:

The implementation of Internet of Things (IoT)-based smart irrigation systems results in a number of positive environmental outcomes. These systems are able to precisely monitor the levels of soil moisture, the weather conditions, and the requirements of the plants by utilising sensors, data analytics, and prediction algorithms. The use of this precision irrigation helps to reduce the amount of water that is wasted, the amount of energy that is consumed, and the promotion of sustainable water management practices, which ultimately contributes to the conservation of the environment.Exploration of IoT applications in educational research, including data-driven insights into student behavior and learning outcomes.

2.3 Economic Implications and Cost-Effectiveness:

Smart irrigation systems that are based on the Internet of Things provide potential consequences from an economic point of view. The cost-effectiveness of these systems over the long run is readily apparent, despite the fact that the initial expenditure required to implement them may be very significant. Farmers can obtain higher returns on investment, improved profitability, and long-term sustainability in agricultural operations by optimising water usage, minimising labour expenses, and increasing crop production. These are all ways that farmers can improve their crop productivity.

2.4 Variations in IoT Solutions for Agriculture:

Several Internet of Things (IoT)-related Smart Agriculture solutions are currently available, each of which provides a distinctive approach to addressing a variety of difficulties that are encountered by farmers. The intricacy of these solutions, the technologies that are utilised, and the types of sensors that are utilised vary based on the particular objectives and requirements. Farmers have access to a wide variety of tools and technologies that can help them improve their irrigation practices. These tools and technologies range from straightforward systems that are integrated with Raspberry Pi and Arduino to sophisticated cloud-based platforms that are equipped with Machine Learning capabilities.

2.5 Case Studies and Innovative Implementations:

The usefulness of Internet of Things (IoT)-based smart irrigation systems has been demonstrated by a multitude of case studies and novel implementations. Using correlated data-based algorithms and cloud computing, for example, R. Nageswara Rao and colleagues [11] were able to successfully install a Precision Agriculture irrigation system, which ultimately led to enhanced output outcomes. Additionally, Thaer Thaher and colleagues [8] developed a cloud-based Internet of Things (IoT) smart irrigation system that demonstrated the integration of a variety of sensors and platforms for the purpose of effective data management and analysis.

2.6 Integration of Renewable Energy for Sustainability:

The utilisation of renewable energy sources for the purpose of achieving sustainability is a noteworthy trend in the field of intelligent irrigation systems. Solar power has been incorporated into Internet of Things (IoT)-based smart irrigation systems by researchers such as El-Taibi Bouali et al. [3]. This has resulted in a large reduction in water use and has promoted environmentally friendly farming methods. The use of renewable energy not only lowers operational expenses but also brings the organisation closer to achieving its worldwide sustainability goals.

2.7 Outline for the existing works :

S.No	**Time Period**	**Title of work**	**Author**	**Analysis**
1.	2023	Application of Internet of Things(IoT) in Agriculture: A review	Mohammed Asif Zamir; Rajendra M Sonar	• Historical meteorology, soil reports, and pest and crop disease detection • AI and IoT to enhance and increase agricultural yield quantity and quality. • Survey and bibliometric analysis are done in the Iot field of agriculture • Discussed several use cases and applications in the agricultural field - crop monitoring, automated irrigation, drone imagery, etc. • Integrating IoT based agriculture with AI, Cloud and Big Data analytics impact ground level and increase crop productivity manifold. • IoT framework for agriculture integrating the above technologies has to be developed to increase GDP in India.
2.	2023	Internet of Things and	Javier Alanya-	• Data from sensors in cloud

		Machine Learning based Intelligent Irrigation System for Agriculture	Arango; Joel Alanya-Beltran; Sathish Kumar Ravichandran; Barinderjit Singh; Archana Sasi	are evaluated using machine learning to recommend solution. ● Agricultural dataset obtained from NIT Bhubaneswar. ● Need binary classifier. ● Genetic engines(ML) techniques like SVM, extrapolation, cluster group are employed on the data. ● Built-in control scheme is added to ranking system. ● Testing shows that suggested approach works. ● Anticipated weather information used to reduce irrigated error. ● SVM model is more efficient than alternatives. ● Multiple cases may work better to decide chemical usage.
3.	2021	Renewable energy integration into Cloud & IOT-based Smart Agriculture	Et-Taibi Bouali, Mohamed Riduan Abid, El-Mahjoub Boufounas, Tareq Abu Hamed, Driss Benhaddou	● Used off-the-shelf cheap nano-Arduinos and free Cloud-based IoT platform(NodeRED) for cost-effectiveness. ● Used smart water metering -by adopting fuzzy logic into smart drip irrigation,the system reduces water consumption upto 71.8%. ● Used renewable energy integration - for energy-efficiency. ● This system is mainly applicable for small and medium farmers in arid and sub-Saharan countries like Morocco. ● As future work ,to enhance solar energy production and storage . To integrate LoRa wireless sensors/actuators

				network and machine learning algorithm for crop requirements.
4.	2021	Water-saving drip irrigation system for photovoltaic power generation based on Internet of Things	Mingze Chen; Zixuan Jin; Tian Fu; Ling Luo; Yingtang Li	● Uses solar energy resources in Northwest China. ● Uses Supply Chain Management, water pump to feedback data from sensors to mobile app for big data analysis. ● Photovoltaic water pumps reduce electric energy and operation costs. ● Can be used in farmland, gardens, and communities
5.	2021	Design of intelligent irrigation and soil loosening system for Agricultural Internet of things	Zhang Chen; Bu Xiuli; Li Yueyang; Zhao Yanli	● Soil humidity sensor integrated to Arduino Uno microcontroller. ● Real-time data is shared with mobile phone through bluetooth. ● Water pump control, the depth automatic adjustment mechanism and execution of soil loosening mechanism is done through mobile.
6.	2020	Smart Irrigation system using Internet of Things	A. Anitha; Nithya Sampath; M.Asha Jerlin	● To identify soil dampness and watering the crops accordingly. ● Soil dampness sensors to measure gauge volumetric water content. ● Microcontroller to pass the information to web utilizing the GPRS module. ● Used ESP8266 Node MCU module, digital temperature and DTH II sensors. ● Sends alert SMS, but data is not stored ● Rain alarm and soil moisture detector circuit

				are also used. ● Future work - predict soil moisture using previous data(cost effective) , further customization as application categorical scenarios, water saving analysis based on an algorithm with multiple nodes which minimizes system cost.
7.	2020	Monitoring of Soil Moisture and Atmospheric Sensors with the Internet of Things (IoT) Applied in Precision Agriculture	Alessandra Dutra Coelho; Bruno Guilherme Dias; Wanderson de Oliveira Assis; Fernando de Almeida Marting	● Soil moisture and Atmospheric sensors connected to a microcontroller carry data using LoRaWan protocol to a gateway and stored in the cloud using IoT concepts. ● An app developed to monitor the data ● Graphs of historical register of data to develop forecasting algorithm. ● FUTURE WORKS:- 1. Three-level sensors to detect moisture at various depths 2. Monitor soil pH 3. Integrate neural network to automate irrigation process 4. Flow controller and sprinklers has been built already 5. Monitor plant growth using image processing algorithm 6. Evaluate different irrigation technique.
8.	2020	Cloud-based Internet of Things approach for smart irrigation system: Design and Implementation	Thaer Thaher, Isam Ishaq	● To conserve time and effort when several fields are distributed in different regions.

				• They proposed an intelligent irrigation framework of WSN And IOT cloud services. • Arduino Uno and XBee ZigBee modules are combined together. YL-69 to monitor soil moisture. • Raspberry Pi to gather, process, transfer data to ThingSpeak IoT Cloud. • Future work includes - addition of multiples sensors, machine algorithms to make proper decision, experiments on real crops and comparison with traditional irrigation system
9.	2020	Smart Agriculture using Internet of Things with Raspberry Pi	Zuraida Muhammed; Muhammed Azri Asyraf Mohd Hafez; Nor Adni Mat Leh; Zakiah Mohd Yusoff	• To cope with the unpredictable weather in Malaysia. • Raspberry Pi 4 Model B microcontroller is used. • Output from DHT22 and soil moisture sensor is displayed on phone and computer. • 24.44% water savings rate can be achieved. • Met the target of water - saving purposes. • Future improvements - pH sensor, light detection, soil condition checker, and crop observation using image processing.
10.	2019	Internet of things monitoring system of modern eco-agriculture based on cloud computing	Shubo Liu, Liqing Guo, Heather Webb, Xiao Ya, Xiao Chang	• In order to enhance the efficiency and safety of production and management of modern agriculture in China. • The design of combining the Internet of Things, cloud computing, big data and modern agriculture is proposed. • A hybrid data storage

				scheme based on NoSql database DynamoDB, relational database Oracle, and file object storage Amazon S3 is designed. ● Integration of Raspberry pi, zigbee module,video surveillance,cloud service (Iaas and Paas) are successfully realized.
11.	2018	IOT-based smart crop-field monitoring and automation irrigation system	R. Nageswara Rao, B. Sridhar	● It is Raspberry Pi based automatic irrigation IOT system. ● Mainly for crop development at low quantity water consumption. ● Sensors are used to measure temperature, humidity of the soil and duration of the sunshine per day. ● Precision Agriculture (PA) with cloud computing is used to optimize the usage of water fertilizers, maximize the crops and analyses the weather conditions of the field. ● In future, machine learning algorithm to be used to process the data and reduce the complexity of the hardware.
12.	2017	IOT-based control & automation of smart irrigation system using bluetooth, sensor, GSM and cloud technology	M Monica, B. Yeshika, G.S Abhishek, H.A Sanjay, Sankar Dasiga	● Arduino uno based automated irrigation IOT system for the Indian scenario. ● Sensors are used to measure the moisture, light and temperature levels for efficient usage of water. ● GSM is used to receive the messages. ● To access the data from cloud using sparkfun.

				• In future , his project can be the use of solar panels in the project to run the motor to save energy
13.	2017	Cloud based data analysis and monitoring of smart multi level irrigation system using IOT	Sänket Salvi, S. A. Framed Jain, H. A. Sanjay, T. K. Harshita, M. Farhana, Naveen Jain, M. V. Suhas	• Used for multilevel farming in urban areas where cultivation space is limited. • It shows reduced water consumption and better power utilization by automatic switching on/off. • Local node is fixed to individual local decision making system, sensors and actuators customized to the selected crop. It communicates to a centralized node via wireless communication. • centralized node is connected to a Cloud Server where the received data will be stored and processed. • In future work, incorporate more sensors like Nitrogen, Potassium, and phosphorous sensors and provide deficient nutrients by Fertigation. • Image processing technique is to monitor the growth and predict the yield.
14.	2017	Cloud service oriented architecture (CSoA) for agriculture through internet of things(IoT) and big data	Pamidi Srinivasulu; M. Sarath Babu; R Venkat; K Rajesh	• This proposal provides services like crop management, marketing, finance management, e-commerce, web services through cloud, etc. • Further reduces unemployment in youth. • Enhances GDP. • Familiarize modern smart agriculture and

				implementation to the farmers.
15.	2017	Internet of things based smart irrigation using regression algorithm	Anusha Kumar; Aremandla Surendra; Harine Mohan; K Muthu Valliappan; N. Krithika	● To provide sustainable solution by automatic monitor and control of irrigation process using IoT. ● Regression algorithm to forecast amount of water required for daily irrigation based sensor provided data. ● Forecasted information can be accessed through the mobile app. ● Fully automated sensor based irrigation system for agricultural field is developed. ● Sensors used - temperature, soil and rain drop sensor. ● Sensors connected to Raspberrry Pi to control electromagnetic valve which operates a motor. ● Cloud stores data periodically and accessed through app. ● Proposed work provides corrective measures and avoids wastage of water.

2.8 Challenges and Insights into the Future:

While there are numerous advantages and breakthroughs involved with the design and implementation of comprehensive automated smart irrigation systems, there are also obstacles that are linked with these technologies. Questions pertaining to interoperability, concerns over data security, and the requirement for standardised protocols and frameworks are all examples of these obstacles. Nevertheless, continuous research and collaborations are being undertaken with the purpose of addressing these problems and paving the way for future breakthroughs in intelligent agriculture.In the long run, Internet of Things (IoT)-based smart irrigation systems provide a revolutionary method to modernising and optimising agricultural processes. These systems have the potential to revolutionise the farming business, promote environmental stewardship, and assure food security for future generations if they are maintained by continual innovation, technological integration, and sustainability programmes.

CHAPTER 3

SYSTEM ARCHITECTURE

3.1 Block Diagram:

Figure 1 depicts the process in which the NodeMCU collects data from sensors that measure temperature, humidity, soil moisture, and total dissolved solids (TDS). This data is employed to control the water pump, guaranteeing the ideal soil moisture levels for the growth of plants. In addition, the NodeMCU transmits this data to Firebase for storage and analysis, while simultaneously sending it to the Raspberry Pi for additional processing. The Raspberry Pi 4 use machine learning algorithms to assess past data, forecast future patterns, and optimize irrigation time for improved resource utilization and crop productivity.

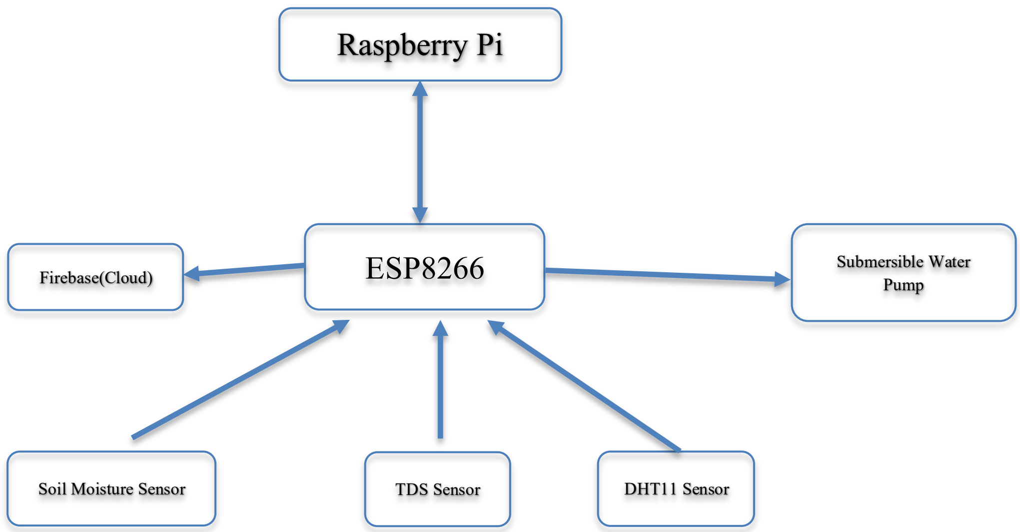


Figure. 1. System Architecture

3.1.1 Raspberry Pi 4:

Raspberry Pi 4 with 4GB RAM is a powerful single-board computer with a 1.5GHz Broadcom BCM2711 quad-core Cortex-A72 processor. Multitasking and memory-intensive operations are improved with 4GB LPDDR4 RAM. 2x802.11ac wireless LAN, Bluetooth 5.0, and Gigabit Ethernet are available. It has USB 3.0 and 2.0 connectors and a microSD card slot for storage expansion. The Raspberry Pi 4 offers dual-display output up to 4K, making it useful for multimedia applications. The tiny form factor and GPIO header make it easy to integrate into projects and applications. The Raspberry Pi 4 is utilised in IoT, home automation, education, and more because of its OS compatibility and extension options.

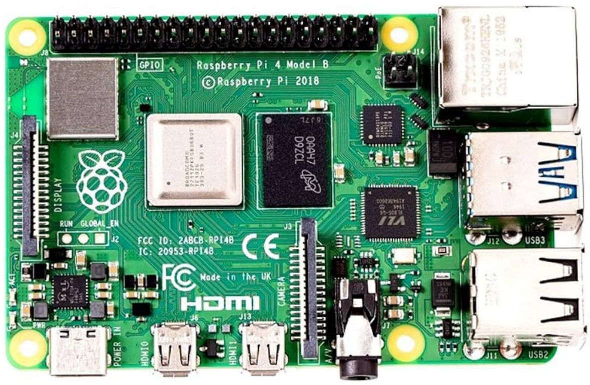


Fig. 2 Raspberry Pi 4 Model B

3.1.2 NodeMCU:

The NodeMCU ESP8266 is a small and flexible development board that includes an embedded ESP8266 chip, which combines a 32-bit microcontroller unit (MCU) with built-in WiFi connectivity. Featuring GPIO ports, analog inputs, and a USB interface, this device offers versatile choices for connecting with sensors, actuators, and other components. The board is compatible with a broad range of input voltages and may be supplied either by a USB connection or an external power source, providing ease and flexibility for a variety of applications. The NodeMCU is equipped with LEDs and a reset button, which make monitoring and troubleshooting simple. The small size of this device makes it ideal for integration into IoT devices, facilitating smooth wireless communication and data transmission.

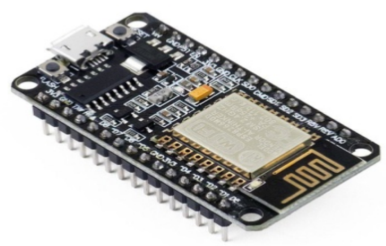


Fig. 3 NODEMCU

3.1.3 TDS Sensor:

TDS (Total Dissolved Solids) metres for Arduino monitor the concentration of dissolved solids in a liquid, usually water, and interface with an Arduino microprocessor for data collecting and processing. These metres usually have a TDS sensor module and electronics to translate sensor readings into digital data the Arduino can analyse.

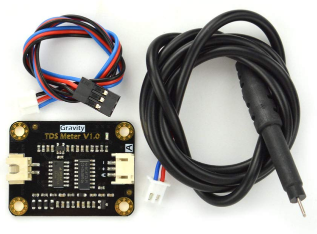


Fig. 4 TDS Sensor

3.1.4 Soil Moisture Sensor:

A soil moisture sensor for Arduino measures soil moisture by measuring electrical conductivity between two electrodes put into the soil. Because soil contains water and ions, conductivity increases with dampness. Conductivity values from these sensors need calibration to match moisture levels. After calibration, the Arduino microcontroller reads sensor input, transforms it into digital values, and calculates soil moisture. Agriculture, gardening, and environmental monitoring can optimise irrigation, prevent water waste, and promote healthy plant growth with this data.

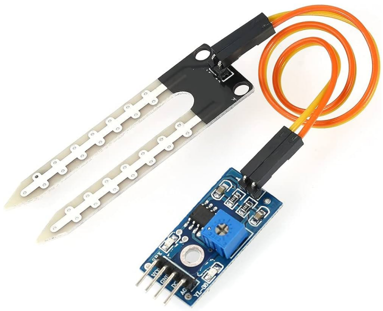


Fig. 5 Soil Moisture Sensor

3.1.5 DHT11:

Arduino-compatible DHT11 digital temperature and humidity sensors are ubiquitous. It accurately measures temperature from 0°C to 50°C and relative humidity from 20% to 90%. The sensor outputs digital signals, making single-wire communication with microcontrollers easy. Built-in signal processing and calibration decrease interface requirements and improve accuracy. Despite its lower accuracy and sampling rate than higher-end sensors, the DHT11 sensor is popular for its cheap power consumption and ease of use. DIY projects, home automation systems, weather stations, and environmental monitoring applications use it to manage and adjust indoor climate.

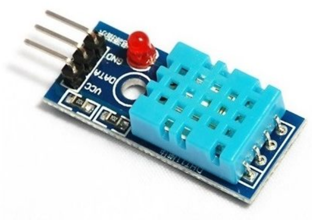


Fig. 6 DHT11 Sensor

3.1.6 5V Submersible Water Pump:

A tiny, efficient 5V submersible water pump uses a 5-volt power supply to function underwater. Aquariums, water fountains, hydroponic systems, and small-scale water circulation projects employ it. The tiny size and straightforward functioning of these pumps make them easy to install and integrate. varied types have varied flow rates and lift heights to meet different needs. They are adaptable and commonly used in DIY projects and hobbyist applications, but users should guarantee correct submersion and power supply compatibility to minimise damage and optimise performance. Overall, 5V submersible water pumps are convenient and reliable for indoor and outdoor water movement.

Fig. 7 Submersible Water Pump

3.1.7 LCD (Liquid Crystal Display) 16 x 2:

Arduino projects often use LCDs to show information and provide visual feedback. These modules are 16x2 or 20x4, depending on the number of characters per line and lines. LCDs link to the Arduino board using parallel or serial interfaces, with parallel requiring more digital pins but transferring data faster. The Hitachi HD44780 and other LCD modules have built-in controllers, simplifying the Arduino interface. Arduino projects use LCDs to display sensor readings, menu systems, and other information, making them useful in electronics prototyping and DIY projects.

Fig. 8 LCD

3.1.8 Relay:

Low-voltage signals from microcontrollers like Arduino are used to operate electrical circuits with a two-channel relay module. Two independent relays turn high-voltage or high-current loads on and off. Each relay has a control input for independent triggering. The control circuit and switching circuit are electrically isolated by these modules, protecting sensitive components. Two-channel relay modules swap loads reliably in home automation, robotics, and industrial control systems.

Fig. 9 2-Channel Relay Module

3.1.9 Jumper Wires:

Electronics and prototyping require jumper wires to connect components, modules, and breadboards. Flexible insulated wires with pins or connectors are typical. Jumper wires can be male-to-male, female-to-female, or male-to-female and come in various lengths, colours, and varieties. They provide rapid prototyping and experimentation by allowing temporary connections during circuit building, testing, and troubleshooting. Due to their simplicity, cost, and convenience of use, jumper wires are utilised in DIY electronics, Arduino-based projects, breadboarding, robotics, and teaching.

Fig. 10 Jumper Wires

3.2 SOFTWARE USED:

3.2.1 Arduino IDE:

The Arduino IDE is a piece of software that lets you write code, compile it, and send it to Arduino microcontroller boards. It makes it easier to program Arduino boards with the C/C++ programming language by giving writers an easy-to-use interface.

3.2.2 Raspberry Pi Terminal and OS:

The Raspberry Pi Terminal is the command-line interface (CLI) that comes with the Raspberry Pi OS. It makes it easy to do things like run scripts, move around in the file system, and install software. Based on Debian Linux, Raspberry Pi OS is optimised for Raspberry Pi hardware and comes with software packages and utilities already loaded.

3.2.3 PyCharm:

PyCharm is an integrated development environment (IDE) for Python programming that has a lot of useful tools, such as code completion, syntax highlighting, debugging, and the ability to work with version control. That means you can use it to make Python programmes, even ones for Raspberry Pi projects.

3.2.4 Firebase:

Firebase is an extensive platform for developing mobile and online applications that provides a diverse array of tools and services to simplify app development and improve user interaction. The platform offers functionalities such as a live database, user verification, cloud-based storage, web hosting, and data analysis, empowering developers to create top-notch applications with speed and effectiveness. The real-time database provided by Firebase enables effortless data synchronization across several devices, guaranteeing that users constantly have access to the most up-to-date information. The authentication service provides robust user authentication and authorization, while the cloud storage enables effortless storage and retrieval of user-generated material. In addition, Firebase hosting offers a scalable and dependable infrastructure for launching web applications, while analytics assists developers in obtaining valuable information about user behaviour and app performance. Overall, Firebase enables developers to effortlessly build powerful and scalable applications, fostering innovation and achieving success in the realm of mobile and online development.

3.2.5 Circuit.io:

Circuit.io is called Tinkercad Circuits. It is an online tool for creating, testing, and sharing electric circuits. It lets people use a web-based interface to make circuits, model how they work, and easily connect Arduino for designing and testing circuits. It also has learning materials and makes it easier for people to work together on technology and Arduino projects.

CHAPTER 4

METHODOLOGIES

Figures 11 depict the integration of different components for an irrigation control system based on NodeMCU and Raspberry Pi. The schematic diagram and flowchart provide a visual representation of this integration.

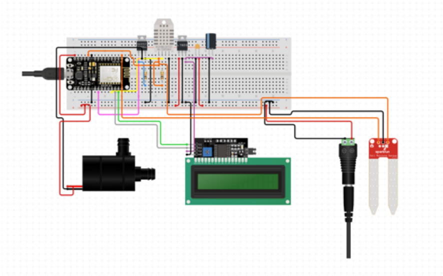


Fig. 11 Schematic Diagram

The diagram illustrates the interconnections between NodeMCU and various sensors, namely a TDS sensor, soil moisture sensor, and DHT11 sensor. Additionally, it shows the management of a 5V submersible water pump through a two-channel relay module. Furthermore, an LCD display is integrated to provide real-time visualization of data. Data is transferred wirelessly over WiFi from a NodeMCU to a Raspberry Pi 4. The Raspberry Pi 4 then utilizes a KNN algorithm model to process the sensor data. This configuration allows for automatic irrigation control using environmental parameters, demonstrating a full Internet of Things (IoT) solution for effective water management.

Figure 12 presents a flowchart that illustrates the sequence of actions performed by the NodeMCU-based system. These actions include collecting data from sensors, controlling irrigation, and presenting information on an LCD screen. The process begins by turning on the NodeMCU and initializing the linked devices. Afterwards, NodeMCU obtains sensor data, which includes readings from the soil moisture sensor.

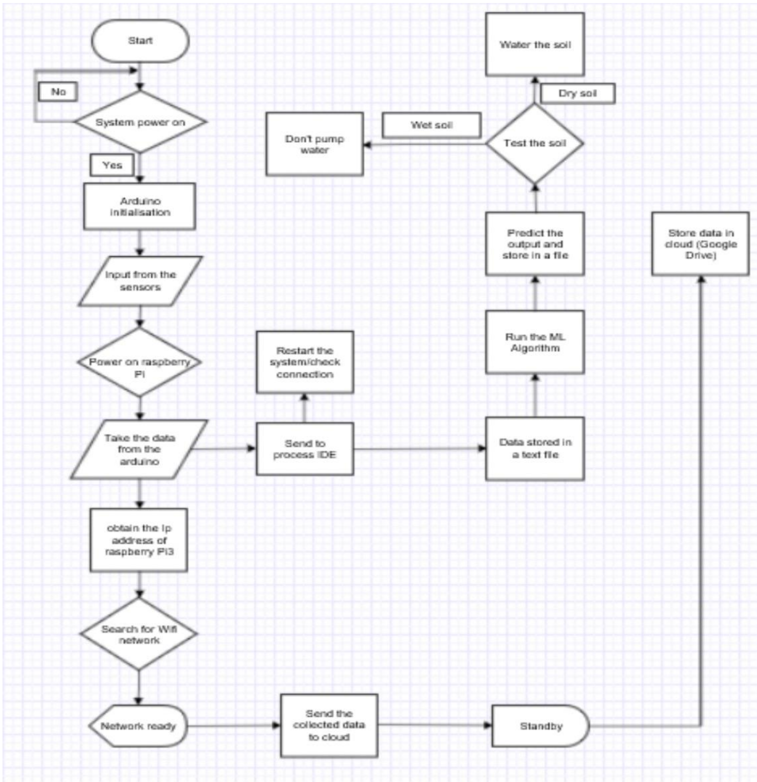


Fig. 12 Flowchart of the sequence occurs in NODEMCU and Raspberry Pi

After collecting data, NodeMCU analyzes the soil moisture levels and compares them to a predetermined threshold in order to determine if irrigation is necessary. When the soil moisture drops below the predetermined threshold, which indicates dry conditions, NodeMCU triggers the water pump through the relay module. On the other hand, if the moisture level goes beyond the threshold, indicating that there is enough moisture in the soil, the pump stays off.

The NodeMCU connects with an LCD display to show current sensor measurements and the condition of the irrigation system, improving user convenience and system engagement.

This flowchart illustrates the combined operation of data collecting, irrigation control, and data display features in the NodeMCU-based system, enabling easier irrigation management and real-time monitoring of environmental conditions.

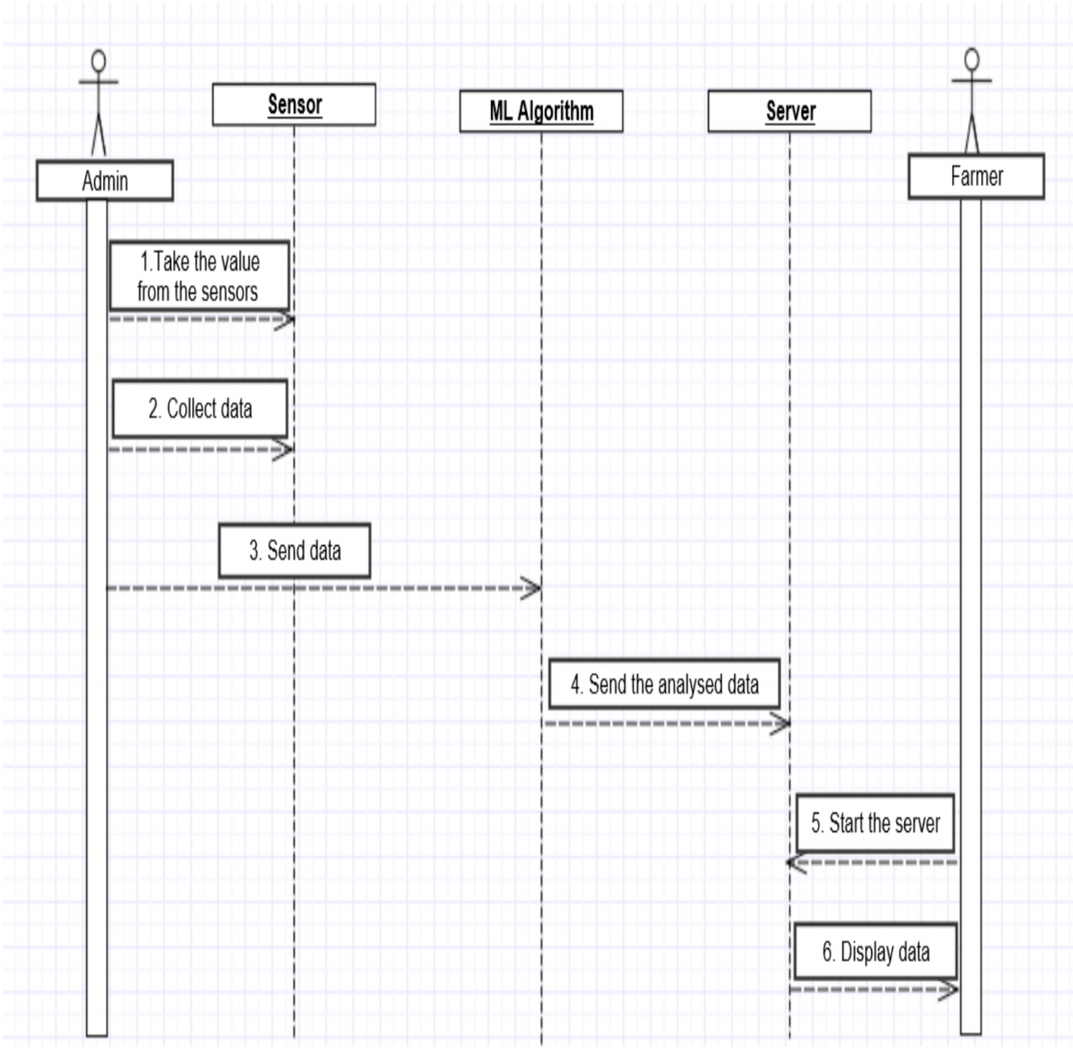


Fig. 13 Sequence Diagram

CHAPTER 5

CODING AND TESTING

5.1 ARDUINO IDE CODE:

The purpose of this Arduino code is to execute a sophisticated irrigation system by utilizing an ESP8266 microcontroller (NodeMCU), a DHT11 sensor for measuring temperature and humidity, and a TDS (Total Dissolved Solids) sensor. The system additionally interfaces with Firebase for the purpose of storing and retrieving data.

Below is a detailed analysis of the code:

The code incorporates essential libraries for WiFi connectivity, Firebase integration, sensor data acquisition, and LCD display manipulation.

The pin definitions state that the analog pin A0 is designated as the input pin for the TDS sensor. Pin D3 is set to function as an input and has a pull-up resistor, most likely intended for a soil moisture sensor. Pin D0 is configured as an output, presumably for the purpose of regulating a water pump or valve.

WiFi Configuration: The code defines the WiFi network credentials (SSID and password) that are required for the NodeMCU to establish a connection with the internet.

Firebase Setup: The Firebase configuration parameters, such as the API key, database URL, and user authentication credentials, are established.

Setup Function: The setup function initializes serial connectivity for debugging purposes. The DHT sensor and LCD display are initialized, and the WiFi connection is formed.

The loop function iteratively retrieves sensor data, such as temperature and humidity from the DHT sensor, as well as the TDS value from the TDS sensor. Subsequently, the sensor values are utilized to refresh the LCD display. In addition, the loop transmits the sensor data to Firebase for storage. The code regulates the water pump or valve by adjusting the output pin D0 based on the signal from the soil moisture sensor on pin D3.

In summary, this code establishes the basis for constructing an intelligent irrigation system that observes environmental conditions and regulates irrigation using up-to-date information. Additionally, it has the capability to store data in the cloud for subsequent analysis and monitoring.

```
#include <Arduino.h>
#include <ESP8266WiFi.h>
#include <FirebaseESP8266.h>
#include <addons/TokenHelper.h>
#include <addons/RTDBHelper.h>
#include <Adafruit_Sensor.h>
#include <DHT.h>
#include <DHT_U.h>
#include <EEPROM.h>
const int analogInPin = A0;
const int analogOutPin = 9;
int sensorValue = 0;
int tds = 0;
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27,16,2);

float temperature = 25,tdsValue = 0;
#define DHTPIN D5
#define DHTTYPE    DHT11
DHT_Unified dht(DHTPIN, DHTTYPE);
int temp,hum;
uint32_t delayMS;



#define WIFI_SSID "PROJECT"
#define WIFI_PASSWORD "123456789"
#define API_KEY "AIzaSyC5Q-66lWOj5kZCl1q7KvYD9ZO9pecFHkw"
#define DATABASE_URL "https://test-d3894-default-rtdb.firebaseio.com"
#define USER_EMAIL "mutants.400@gmail.com"
#define USER_PASSWORD "Ro9710047880"
FirebaseData fbdo;
FirebaseAuth auth;
FirebaseConfig config;
unsigned long sendDataPrevMillis = 0;
unsigned long count = 0;
#if defined(ARDUINO_RASPBERRY_PI_PICO_W)
WiFiMulti multi;
#endif
void setup()
{
  Serial.begin(115200);
```

```
  lcd.init();
  lcd.backlight();
  dht.begin();
  sensor_t sensor;
  dht.temperature().getSensor(&sensor);
  dht.humidity().getSensor(&sensor);
  delayMS = sensor.min_delay / 1000;
  pinMode(D3,INPUT_PULLUP);
  pinMode(D0,OUTPUT);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("CONNECTING");
  lcd.setCursor(0,1);
  lcd.print("TO WIFI.. ");
#if defined(ARDUINO_RASPBERRY_PI_PICO_W)
  multi.addAP(WIFI_SSID, WIFI_PASSWORD);
  multi.run();
#else
  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
#endif
  Serial.print("Connecting to Wi-Fi");
  unsigned long ms = millis();
  while (WiFi.status() != WL_CONNECTED)
  {
    Serial.print(".");
    delay(300);
#if defined(ARDUINO_RASPBERRY_PI_PICO_W)
    if (millis() - ms > 10000)
      break;
#endif
  }
  Serial.println();
  Serial.print("Connected with IP: ");
  Serial.println(WiFi.localIP());
  Serial.println();
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("CONNECTED");
  lcd.setCursor(0,1);
  lcd.print("TO WIFI..");
  delay(1000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("CONNECTING");
  lcd.setCursor(0,1);
  lcd.print("FIREBASE");
  Serial.printf("Firebase Client v%s\n\n", FIREBASE_CLIENT_VERSION);
  config.api_key = API_KEY;
  auth.user.email = USER_EMAIL;
  auth.user.password = USER_PASSWORD;
```

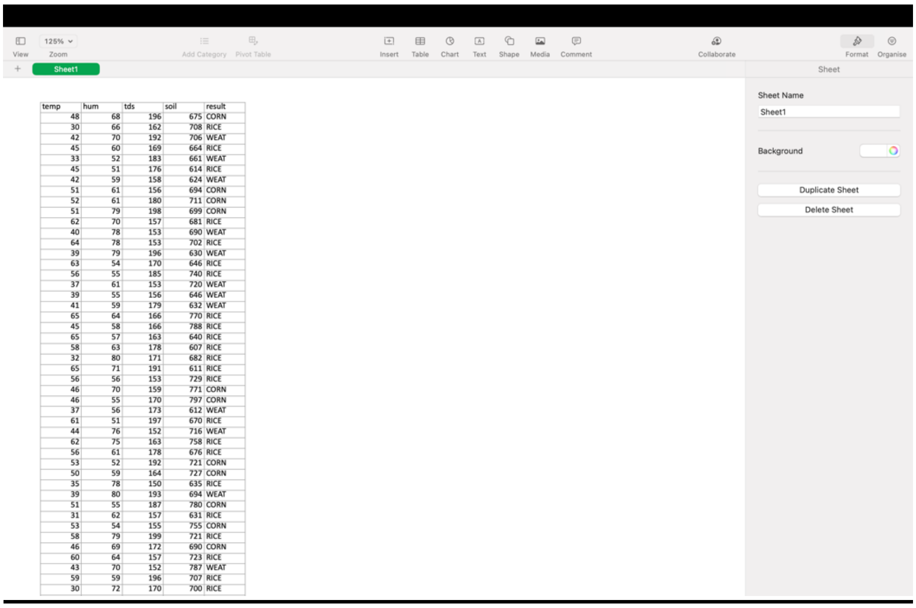
```
  config.database_url = DATABASE_URL;
  config.token_status_callback = tokenStatusCallback;
  //fbdo.setBSSLBufferSize(4096 /* Rx buffer size in bytes from 512 - 16384 /, 1024 / Tx
buffer size in bytes from 512 - 16384 */);
#if defined(ARDUINO_RASPBERRY_PI_PICO_W)
  config.wifi.clearAP();
  config.wifi.addAP(WIFI_SSID, WIFI_PASSWORD);
#endif
  Firebase.begin(&config, &auth);
  Firebase.setDoubleDigits(5);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("CONNECTED");
  lcd.setCursor(0,1);
  lcd.print("FIREBASE");
  delay(1000);
}

void loop()
{
    delay(delayMS);
    sensors_event_t event;
    dht.temperature().getEvent(&event);
    int temp=event.temperature;
    Serial.print(temp);
    dht.humidity().getEvent(&event);
    hum=event.relative_humidity;
    Serial.print(" , ");
    Serial.print(hum);
    sensorValue = analogRead(analogInPin);
    if(sensorValue>131)
    {
      tds = map(sensorValue, 131, 171, 50, 150);
      Serial.print("tds = ");
      Serial.print(tds);
      delay(2);
    }
    else
    {
      Serial.print("tds = ");
      tds=0;
      Serial.print(0);
      delay(2);
    }
    Serial.print(" , ");
    Serial.print(tds);
    Serial.print(" , ");
    Serial.print(digitalRead(D3));
    Serial.println(" , ");
    lcd.clear();
```

```
  lcd.setCursor(0,0);
  lcd.print("TEMP ");
  lcd.print(temp);
  lcd.print(" HUM ");
  lcd.print(hum);
  lcd.setCursor(0,1);
  lcd.print("TDS ");
  lcd.print(tds);
  lcd.print(" SO ");
  lcd.print(digitalRead(D3));
  Serial.printf("Set float... %s\n", Firebase.setFloat(fbdo, F("/PIML/tds"),tds) ? "ok" :
fbdo.errorReason().c_str());
  delay(1000);
  Serial.printf("Set float... %s\n", Firebase.setFloat(fbdo, F("/PIML/soil"),digitalRead(D3)) ?
"ok" : fbdo.errorReason().c_str());
  delay(1000);
  Serial.printf("Set float... %s\n", Firebase.setFloat(fbdo, F("/PIML/temp"),temp) ? "ok" :
fbdo.errorReason().c_str());
  delay(1000);
  Serial.printf("Set float... %s\n", Firebase.setFloat(fbdo, F("/PIML/hum"),hum) ? "ok" :
fbdo.errorReason().c_str());
  delay(1000);
  if(digitalRead(D3)==LOW)
  {
   digitalWrite(D0,LOW);
  }
  else
  {
   digitalWrite(D0,HIGH);
  }

}
```

5.2 Data set for machine learning model :



temp	hum	tds	soil	result
48	68	196	675	CORN
30	66	162	708	RICE
42	70	192	706	WEAT
45	60	169	664	RICE
33	52	183	661	WEAT
45	51	176	614	RICE
42	59	158	624	WEAT
51	61	156	694	CORN
52	61	180	711	CORN
51	79	198	699	CORN
62	70	157	681	RICE
40	78	153	690	WEAT
64	78	153	702	RICE
39	79	196	630	WEAT
63	54	170	646	RICE
56	55	185	740	RICE
37	61	153	720	WEAT
39	55	156	646	WEAT
41	59	179	632	WEAT
65	64	166	770	RICE
45	58	166	788	RICE
65	57	163	640	RICE
58	63	178	607	RICE
32	80	171	682	RICE
65	71	191	611	RICE
56	56	153	729	RICE
46	70	159	771	CORN
46	55	170	797	CORN
37	56	173	612	WEAT
61	51	197	670	RICE
44	76	152	716	WEAT
62	75	163	758	RICE
56	61	178	676	RICE
53	52	192	721	CORN
50	59	164	727	CORN
35	78	150	635	RICE
39	80	193	694	WEAT
51	55	187	780	CORN
31	62	157	631	RICE
53	54	155	755	CORN
58	79	199	721	RICE
46	69	172	690	CORN
60	64	157	723	RICE
43	70	152	787	WEAT
59	59	196	707	RICE
30	72	170	700	RICE

Fig 14 . Data Set

5.3 KNN – Model :

This Python script creates a communication interface between a NodeMCU (ESP8266) microcontroller and a host computer across a local network using sockets. The NodeMCU is designed to wirelessly transmit sensor data, which the script then receives, processes, and sends to a Firebase real-time database for storage and monitoring purposes.

The code starts by importing essential libraries such as socket, time, pandas, and firebase. This program imports a CSV file that contains sensor data from the past and divides it into separate sets for training and testing purposes. These sets are then used to train a K-Nearest Neighbors (KNN) machine learning model. Subsequently, the model undergoes training and its performance is assessed.

Subsequently, the script initiates a socket server on the host machine, associating it with a designated IP address and port. The program actively awaits incoming connections from the NodeMCU and, once a connection is established, consistently receives sensor data. The data is analyzed, and specific measurements from each sensor (temperature, humidity, TDS, and soil moisture) are retrieved.

The script employs the firebase library to communicate with the Firebase real-time database. After receiving sensor data, it transmits the data to Firebase and stores it in the relevant pathways. Furthermore, it utilizes the trained KNN model to make predictions about an action by analyzing the sensor values. These predictions are then sent to Firebase.

In summary, this script allows for the immediate tracking and recording of sensor data from a NodeMCU device to a Firebase database. This enables the ability to remotely monitor and manage environmental conditions.

5.3.1 CODE :

```
import socket
import time
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from firebase import firebase

data = pd.read_csv('datase4.csv')
X = data[['temp', 'hum', 'tds', 'soil']]
Y = data['result']

X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.30, random_state=42)

KNN = KNeighborsClassifier(n_neighbors=1)
KNN.fit(X_train, Y_train)

print("Model Score: ", KNN.score(X_test, Y_test))

firebase = firebase.FirebaseApplication('https://your-firebase-database-url.firebaseio.com/',
None)

HOST = '192.168.1.100'
PORT = 12345
sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
sock.bind((HOST, PORT))
sock.listen(1)

while True:
    conn, addr = sock.accept()
    print('Connected to NodeMCU at', addr)

    try:
        while True:
            data = conn.recv(1024).decode('utf-8')
            if not data:
                break

            sensor_data = data.split(',')
            temp, hum, tds, soil = map(int, sensor_data)

            firebase.put('/sensor_data', 'temperature', temp)
            firebase.put('/sensor_data', 'humidity', hum)
            firebase.put('/sensor_data', 'tds', tds)
            firebase.put('/sensor_data', 'soil_moisture', soil)

            predicted_action = KNN.predict([[temp, hum, tds, soil]])
            firebase.put('/predicted_actions', 'action', predicted_action[0])
    finally:
        conn.close()
```

CHAPTER 6

SYSTEM REQUIREMENTS

5.1 Hardware Setup:

Connect the TDS sensor, soil moisture sensor, DHT11 sensor, 5V submersible water pump with a two-channel relay, and an LCD to the NODEMCU according to the provided schematic diagram.

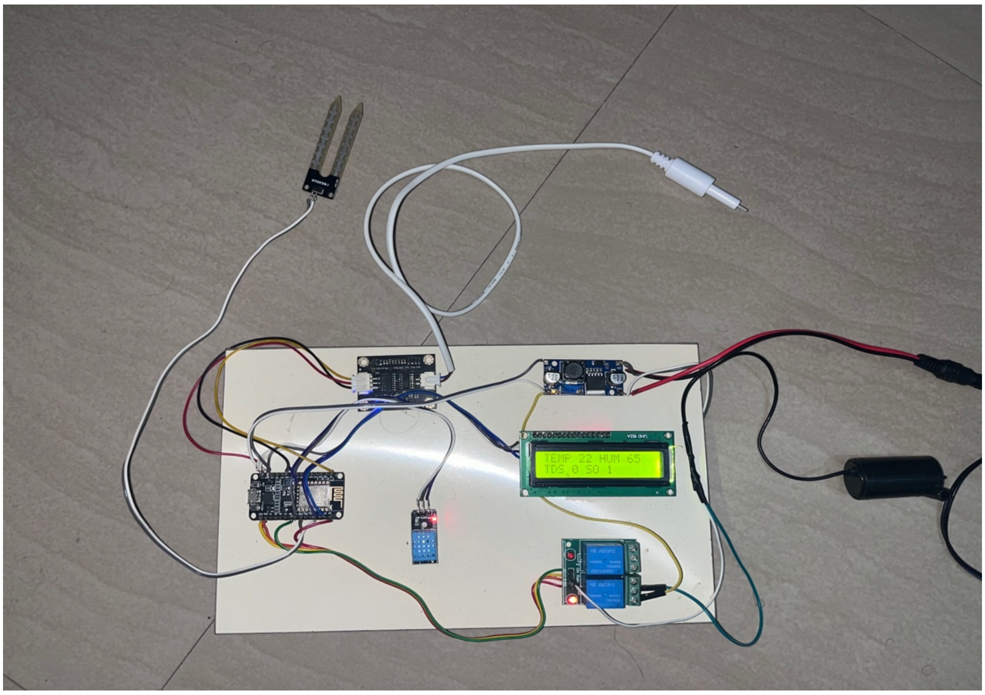


Fig. 15 Experimental Setup

5.1.1 Code Development:

- Develop NodeMCU code to read data from the TDS sensor, soil moisture sensor, and DHT11 sensor.
- Implement logic to display sensor readings on the LCD.
- Write code to control the water pump based on sensor readings using the two-channel relay module.

5.1.2 Raspberry Pi Integration:

- Establish wireless communication between the NodeMCU and Raspberry Pi for data transmission.
- Configure the Raspberry Pi to receive sensor data from the NodeMCU via WiFi
- Set up the Raspberry Pi to transmit sensor data to the cloud platform.

5.2 Software Development:

5.2.1 Machine Learning Model Development:

- Develop a K-Nearest Neighbours (KNN) algorithm model in the Raspberry Pi code editor using Python.

- Pre-process sensor data, including normalisation or feature scaling if needed.

- Train the KNN model using the collected sensor data and validate its performance.

5.2.2 Data Transmission to Firebase:

- Configure and set up the Firebase platform to receive data from the Raspberry Pi.

- Send sensor data and machine learning predictions to Firebase using the Raspberry Pi.

5.2.3 Experimental Validation:

- Test the integrated system in a real-world environment to validate its functionality.

- Monitor sensor readings, pump control actions, and machine learning predictions.

- Analyse the results and assess the system's performance in controlling irrigation based on environmental parameters.

5.3 Testing and Debugging:

After the hardware configuration has been finished and the software components have been developed, the next essential process is testing and debugging to ensure that the system performs as it was intended to. This phase consists of a number of processes that are completed in order to validate the functioning, discover any problems, and make any necessary improvements.

5.3.1 Hardware Testing:

To begin, it is necessary to carry out hardware testing in order to guarantee that all sensors are correctly connected and that the relay module is able to efficiently regulate the water pump based on the readings from the sensors. Examine the LCD to ensure that it displays the required amount of correct sensor data. To guarantee that there is no disruption in communication or functionality, it is necessary to first test each component separately and then combine them.

5.3.2 Software Testing:

After that, proceed to the testing of the software, beginning with the code for the NodeMCU. Determine whether or not the NodeMCU is capable of reliably reading data from the sensors and displaying it on the LCD. Check to see that the logic that is used to operate the water pump based on the readings from the sensors when utilising the relay module is functioning properly.

5.3.3 Integration Testing:

Following the testing of each individual component, the next step is to undertake integration testing between the Raspberry Pi and the ZeroMCU. Make sure that the wireless communication is properly established, and that the sensor data can be communicated from the NodeMCU to the Raspberry Pi through the use of your WiFi network. A verification of the data reception on the Raspberry Pi and its transfer to the cloud platform, such as Firebase, should be performed.

5.3.4 Machine Learning Model Testing:

In order to confirm the functionality of the machine learning model, it is necessary to input sensor data, then use the KNN method to make predictions, and then evaluate the accuracy of these predictions. It is important to conduct exhaustive testing with a variety of datasets in order to guarantee the resilience and dependability of the model when it comes to predicting irrigation control actions.

5.3.5 Firebase Data Transmission Testing:

Following the configuration of the Raspberry Pi to send sensor data and machine learning predictions to Firebase, it is necessary to undertake testing in order to verify that the data transmission is carried out without any interruptions. You should check the Firebase console to make sure that the data is being received and stored on the cloud platform in the correct manner.

5.3.6 Experimental Validation and Performance Analysis:

In conclusion, it is necessary to carry out experimental validation in a real-world setting that is indicative of agricultural settings. Monitor the readings from the sensors, watch the actions taken by the pump control system based on the sensor data and the predictions made by machine learning, and record the performance of the system over time. It is necessary to conduct an analysis of the findings in order to determine how effective the system is in managing irrigation depending on environmental parameters.

While the testing and debugging process is in progress, it is important to keep a record of any problems that arise, identify and correct any faults that occur in the code or hardware connections, and make incremental improvements in order to maximise the system's efficiency and dependability. It is essential to perform routine testing and validation in order to guarantee that the intelligent irrigation system functions effectively and achieves the goals that have been set.

5.4 Optimization:

In order to increase the system's efficiency, accuracy, and dependability, optimisation entails making adjustments to a number of different aspects of the system. One example of this is the process of optimising the machine learning model by modifying its parameters, modifying the algorithms, or introducing additional information in order to achieve more accurate predictions. Improving real-time data processing and lowering latency are two additional benefits that can be achieved by optimising data transport technologies.

5.5 Deployment:

Upon completion of the optimisation process, the intelligent irrigation system is prepared for implementation in agricultural settings. Deploy the system by putting the various hardware components, such as the water pump, sensors, NodeMCU, relay module, and Raspberry Pi, in the area that has been selected for irrigation. For reliable readings, it is important to ensure that the sensors are properly calibrated and aligned.

CHAPTER 7

RESULTS AND DISCUSSION

The created Intelligent IoT-based Automated Irrigation System incorporates NodeMCU as the microcontroller and Raspberry Pi 4 as the processing unit. To monitor temperature, soil moisture levels, and water quality, sensors are strategically placed in the soil to measure soil moisture, temperature, and Total Dissolved Solids (TDS). The sensors effectively establish a connection with the NodeMCU, facilitating the transmission of sensed data for subsequent processing. In addition, the NodeMCU is connected to an actuator for the water pump to provide automated watering.

The collected data is transmitted through WiFi to the control unit of the Raspberry Pi 4. The present study utilises a K-Nearest Neighbours (KNN) machine learning algorithm to forecast the appropriateness of soil conditions for cultivating rice, wheat, or maize. This prediction is based on the analysis of sensor data, specifically TDS values. The machine learning algorithm is hosted on the Raspberry Pi 4, which can train datasets on several soil conditions, including dry, somewhat dry, wet, and slightly wet. This enables the programme to make accurate predictions.

By the anticipated crop needs, the Raspberry Pi 4 transmits control signals to the NodeMCU, thereby directing the water pump to initiate irrigation in the field. Moreover, data about the irrigated field is maintained on a cloud-based website, which can be accessed by farmers for monitoring and managing it. **Fig. 16** illustrates the complete prototype. Furthermore, **Fig. 17** illustrates the configuration of the Raspberry Pi 4 environment, which functions as an Edge-level processor for conducting intelligent analysis. This analysis utilises the KNN machine learning algorithm to forecast soil conditions by analysing captured soil moisture, temperature, and TDS data, as well as trained datasets specifically designed for various soil types.

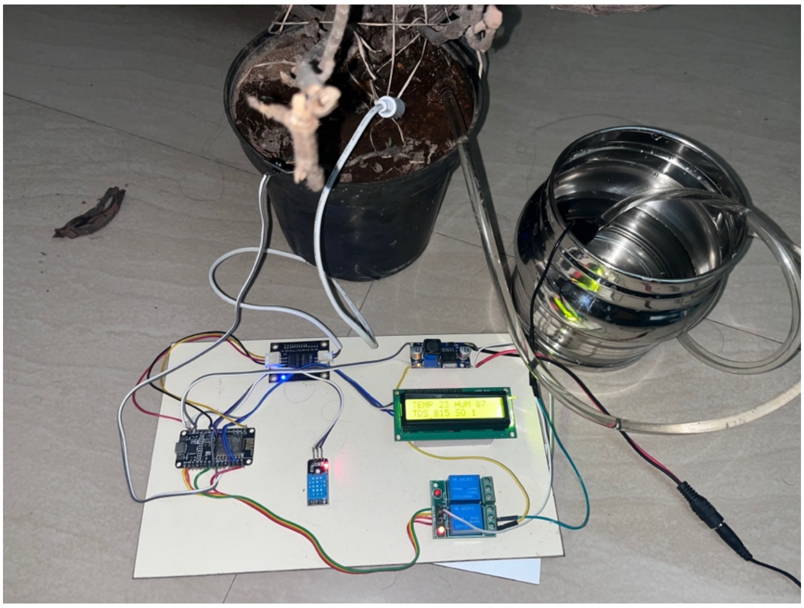


Fig. 16 Complete Setup

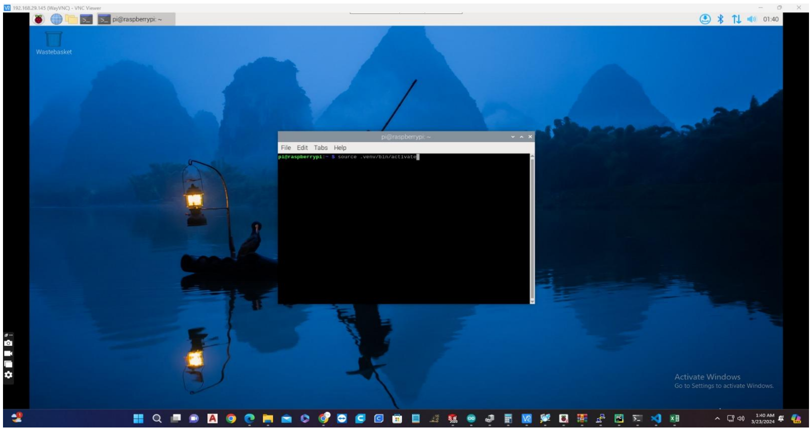


Fig. 17 Raspberry Pi OS and Terminal

Based on the notional values of rice-specific characteristics, including temperature, humidity, and TDS (Total Dissolved Solids) values recorded in the cloud platform Firebase, **Fig. 18** illustrates the suggested crop as Rice. The forecast is derived from the analysis performed by the system, employing machine learning algorithms to establish a correlation between climatic circumstances and the ideal parameters for crop development.

Fig. 19 depicts the execution of the K-Nearest Neighbours (KNN) algorithm within the terminal interface of the Raspberry Pi operating system and shows a score of 65%. The method is currently being executed on the pre-processed dataset that has been uploaded into the system and is designated as dataset4.csv. The dataset is expected to include historical or experimental data on different environmental parameters and their corresponding crop types. This data will be used to train and validate a machine-learning model that predicts crop types based on current environmental conditions.

Fig. 18 Firebase output visualisation

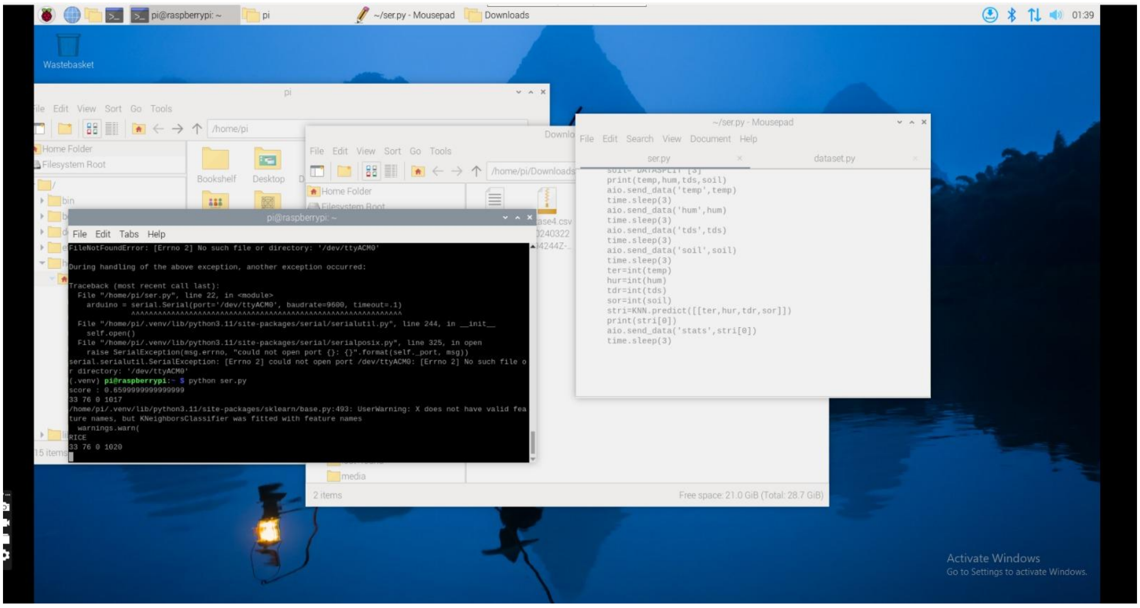


Fig. 19 KNN suggesting the crop in Raspberry Pi and Score of the Model

The operational state of the water pumps in response to soil moisture levels, as sensed by the soil moisture sensor, is depicted in **Fig. 20**. In the given context, the NodeMCU initiates the activation of the water pumps, as evidenced by the lit status of the pump indicators or the noticeable physical displacement of the pumps. The activation process is initiated by the logic of the NodeMCU to address the issue of dry soil conditions through the initiation of irrigation.

Furthermore, the liquid crystal display (LCD) simultaneously presents up-to-date environmental information, encompassing temperature, humidity, and Total Dissolved Solids (TDS) measurements. The purpose of presenting this data is to offer consumers a thorough understanding of the present environmental conditions within the monitored region. The presentation of this data facilitates the surveillance and control of environmental variables, facilitating well-informed decision-making about irrigation and crop management approaches.

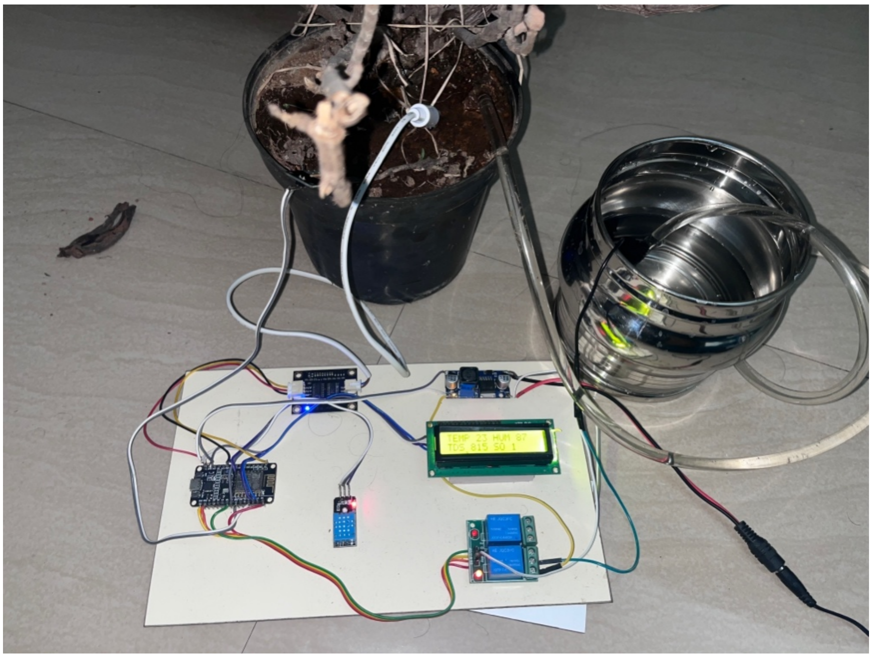


Fig. 20 Water Pumping

CHAPTER 8

BENEFITS

Putting in place advanced irrigation systems has a number of possible advantages.

7.1 Water Conservation and Resource Efficiency:

In order to achieve effective water management, it is necessary to implement modern irrigation systems that incorporate Internet of Things sensors and cloud-based storage. It is possible to achieve exact irrigation scheduling with the collection of real-time data on soil moisture levels and climatic conditions. This makes it possible to reduce water waste and conserve this essential resource.

7.2 Enhanced Agricultural Productivity:

Farmers are able to optimise irrigation systems based on the requirements of their crops by utilising technologies such as machine learning algorithms and predictive analytics. Because of this, crop yields are improved, plant quality is improved, and total agricultural production is boosted.

7.3 Cost Reduction and Profitability:

There is a reduction in the operational costs that are associated with manual watering systems thanks to the incorporation of Internet of Things technology. Agricultural methods that are more cost-effective and increase farmers' profitability can be achieved through the implementation of automated systems, which guarantee optimal resource utilisation.

7.4 Sustainable Agricultural Practices:

Sustainable agriculture practices are encouraged through the implementation of Internet of Things-based smart irrigation systems. Long-term sustainability in agricultural operations can be achieved by the utilisation of water in an effective manner, the reduction of energy consumption, and the minimization of environmental damage.

7.5 Data-Driven Decision Making:

Providing farmers with relevant insights is made possible by the collecting of real-time data and the subsequent analysis of that data using machine learning algorithms. Decision-making that is informed by data makes it possible to make proactive adjustments to irrigation systems, pest control measures, and crop management practices, which ultimately results in superior outcomes.

7.6 Technological Advancements for Rural Development:

The implementation of modern irrigation systems that make use of Internet of Things technologies and cloud computing helps to stimulate technical improvements in locations that are considered to be rural. This not only improves the digital infrastructure but also provides farmers with cutting-edge instruments, which in turn adds to the general development of rural areas and the expansion of the economy.

7.7 Mitigation of Water Scarcity Challenges :

When it comes to regions like India that are struggling with water scarcity, the implementation of irrigation systems that are effective is absolutely necessary. Through the optimisation of water usage, the reduction of water waste, and the promotion of responsible water consumption and production practices, irrigation solutions that are enabled by the Internet of Things facilitate the mitigation of water scarcity challenges.

7.8 Scalability and Adaptability:

Systems that are based on the Internet of Things are modular in nature, which enables them to be scalable and adaptable to different environmental circumstances and agricultural requirements. Farmers have the ability to expand or adjust their irrigation installations in response to shifting crop varieties, land areas, or climate patterns, which ensures flexibility and resilience.

7.9 Empowering Farmers with Technology:

In order to provide farmers with technology that is easily accessible, advanced irrigation systems incorporate mobile applications that are friendly to users and interfaces that are straightforward.

Farmers are able to devote their attention to strategic decision-making and crop management as a result of this simplicity of operation, monitoring, and control.

7.10 Contribution to National Economic Growth:

The increased agricultural productivity that is a direct result of the use of innovative irrigation systems is a key contributor to the expansion of the national economy. Gross domestic product (GDP) is increased, employment opportunities are created, and overall socioeconomic development is fostered when the agricultural sector is thriving.

CHAPTER 9

CONCLUSION AND FUTURE WORK

To summarize, our intelligent irrigation technology provides a convincing option for maximizing water efficiency in agricultural operations. Our technology utilizes real-time monitoring of environmental elements such as soil moisture, temperature, and humidity to accurately schedule irrigation based on the specific requirements of crops. Our findings throughout the rice cultivation period in Thirukazhukundram demonstrated the significant capacity of our approach to conserve water, in contrast to conventional irrigation techniques. As an example, conventional techniques, which entail submerging the field in water every 3 days, utilized around 30,000 to 35,000 litres of water and necessitated 7 hours of irrigation. Our technology cuts water usage by over 50% by combining soil moisture and TDS data, taking into account the water needs of rice crops at 10-11mm per cycle. The substantial decrease in water usage highlights the effectiveness of our intelligent irrigation technology in encouraging environmentally friendly farming methods.

To provide additional evidence for our conclusions, we performed experiments in a controlled setting with a potted plant. The findings of our study showed that our intelligent irrigation system consistently decreased water usage while maintaining ideal soil moisture levels for plant development. By extending these findings to broader agricultural contexts, we can safely state that our system can transform water management methods, not just for rice farming but for a diverse array of crops. In the future, researchers can concentrate on improving the system's algorithms and including more sensors to achieve full environmental monitoring. Furthermore, conducting comparison analyses between our intelligent irrigation system and conventional approaches in different geographic areas might yield significant observations regarding its scalability and flexibility. This, in turn, can promote the widespread implementation of effective water management practices in agriculture.

CHAPTER 10

REFERENCES

[1] R. N. Rao and B. Sridhar, "IoT-based smart crop-field monitoring and automation irrigation system," 2018 2nd International Conference on Inventive Systems and Control (ICISC), Coimbatore, India, 2018, pp. 478-483, doi: 10.1109/ICISC.2018.8399118.

[2] S. Liu, L. Guo, H. Webb, X. Ya and X. Chang, "Internet of Things Monitoring System of Modern Eco-Agriculture Based on Cloud Computing," in IEEE Access, vol. 7, pp. 37050-37058, 2019, doi: 10.1109/ACCESS.2019.2903720.

[3] T. Thaher and I. Ishaq, "Cloud-based Internet of Things Approach for Smart Irrigation System: Design and Implementation," 2020 International Conference on Promising Electronic Technologies (ICPET), Jerusalem, Palestine, 2020, pp. 32-37, doi: 10.1109/ICPET51420.2020.00015.

[4] M. Monica, B. Yeshika, G. S. Abhishek, H. A. Sanjay, and S. Dasiga, "IoT based control and automation of smart irrigation system: An automated irrigation system using sensors, GSM, Bluetooth and cloud technology," 2017 International Conference on Recent Innovations in Signal Processing and Embedded Systems (RISE), Bhopal, India, 2017, pp. 601-607, doi: 10.1109/RISE.2017.8378224.

[5] S. Salvi et al., "Cloud-based data analysis and monitoring of smart multi-level irrigation system using IoT," 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Palladam, India, 2017, pp. 752-757, doi: 10.1109/I-SMAC.2017.8058279.

[6] J. Alanya-Arango, J. Alanya-Beltran, S. K. Ravichandran, B. Singh, A. Sasi and D. Gangodkar, "Internet of Things and Machine Learning based Intelligent Irrigation System for Agriculture," 2022 5th International Conference on Contemporary Computing and Informatics (IC3I), Uttar Pradesh, India, 2022, pp. 67-72, doi: 10.1109/IC3I56241.2022.10073254.

[7] E. -T. Bouali, M. R. Abid, E. -M. Boufounas, T. A. Hamed and D. Benhaddou, "Renewable Energy Integration into Cloud & IoT-Based Smart Agriculture," in IEEE Access, vol. 10, pp. 1175-1191, 2022, doi: 10.1109/ACCESS.2021.3138160.

[8] A. Anitha, N. Sampath and M. A. Jerlin, "Smart Irrigation system using Internet of Things," 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE), Vellore, India, 2020, pp. 1-7, doi: 10.1109/ic-ETITE47903.2020.271.

[9] A. Kumar, A. Surendra, H. Mohan, K. M. Valliappan, and N. Kirthika, "Internet of things based smart irrigation using regression algorithm," 2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT), Kerala, India, 2017, pp. 1652-1657, doi: 10.1109/ICICICT1.2017.8342819.

[10] A. D. Coelho, B. G. Dias, W. de Oliveira Assis, F. de Almeida Martins and R. C. Pires, "Monitoring of Soil Moisture and Atmospheric Sensors with Internet of Things (IoT) Applied in Precision Agriculture," 2020 XIV Technologies Applied to Electronics Teaching Conference (TAEE), Porto, Portugal, 2020, pp. 1-8, doi: 10.1109/TAEE46915.2020.9163766.

[11] Z. Muhammad, M. A. A. M. Hafez, N. A. M. Leh, Z. M. Yusoff and S. A. Hamid, "Smart Agriculture Using Internet of Things with Raspberry Pi," 2020 10th IEEE International Conference on Control System, Computing and Engineering (ICCSCE), Penang, Malaysia, 2020, pp. 85-90, doi: 10.1109/ICCSCE50387.2020.9204927.

[12] P. Srinivasulu, M. S. Babu, R. Venkat, and K. Rajesh, "Cloud service-oriented architecture (CSoA) for agriculture through Internet of things (IoT) and big data," 2017 IEEE International Conference on Electrical, Instrumentation and Communication Engineering (ICEICE), Karur, India, 2017, pp. 1-6, doi: 10.1109/ICEICE.2017.8191906.

[13] M. A. Zamir and R. M. Sonar, "Application of Internet of Things (IoT) in Agriculture: A Review," 2023 8th International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2023, pp. 425-431, doi: 10.1109/ICCES57224.2023.10192761.

[14] M. Chen, Z. Jin, T. Fu, L. Luo, and Y. Li, "Water-saving drip irrigation system for photovoltaic power generation based on Internet of Things," 2021 IEEE International Conference on Computer Science, Electronic Information Engineering, and Intelligent Control Technology (CEI), Fuzhou, China, 2021, pp. 233-236, doi: 10.1109/CEI52496.2021.9574523.

[15] Z. Chen, B. Xiuli, L. Yueyang and Z. Yanli, "Design of intelligent irrigation and soil loosening system for Agricultural Internet of things," 2021 International Conference on Machine Learning and Intelligent Systems Engineering (MLISE), Chongqing, China, 2021, pp. 326-329, doi: 10.1109/MLISE54096.2021.00068.

[16] D. Pal and S. Joshi, "AI, IoT and Robotics in Smart Farming: Current Applications and Future Potentials," 2023 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS), Erode, India, 2023, pp. 1096-1101, doi: 10.1109/ICSCDS56580.2023.10105101.

[17] Kumari, S.; Tulshyan, V.; Tewari, H. Cyber Security on the Edge: Efficient Enabling of Machine Learning on IoT Devices.

[18] David Corral-Plaza, Inmaculada Medina-Bulo, Guadalupe Ortiz, Juan Boubeta-Puig, A stream processing architecture for heterogeneous data sources in the Internet of Things, Computer Standards & Interfaces, Volume 70, 2020, 103426.

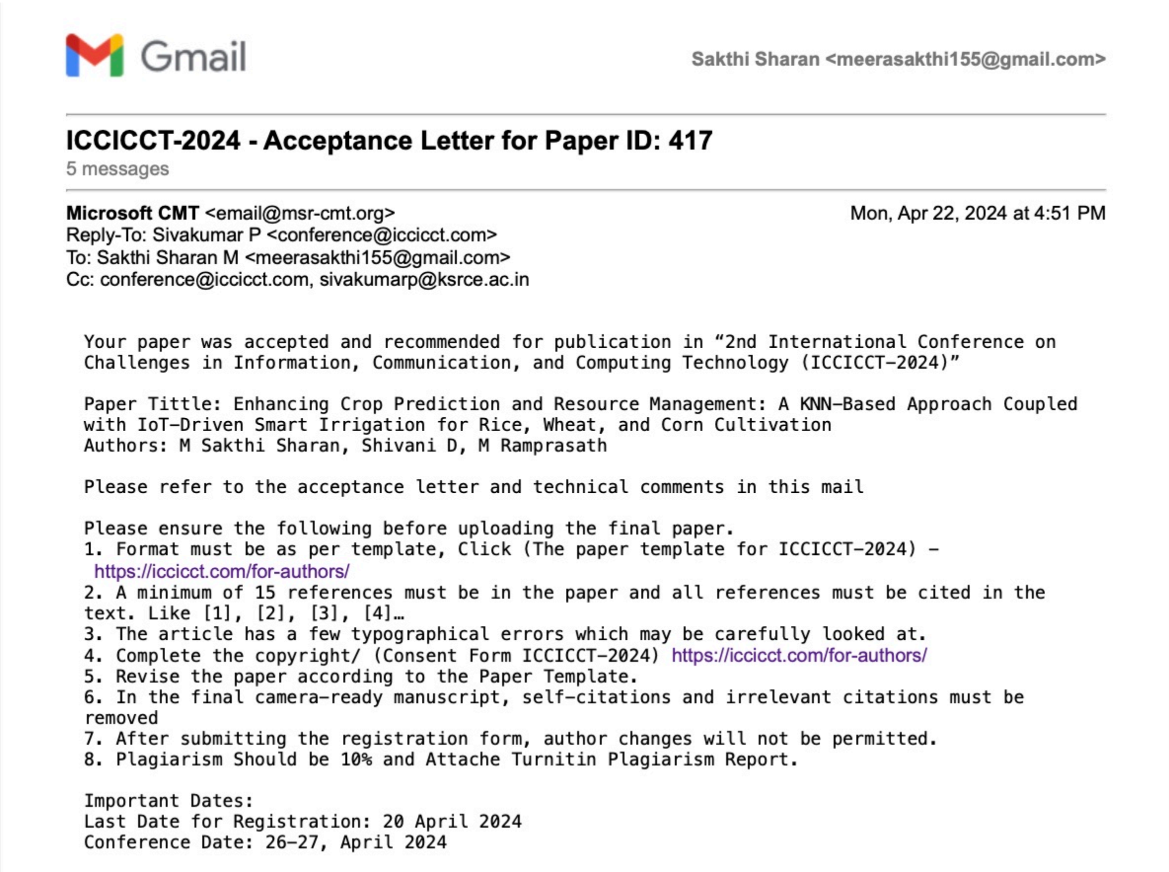
[19] Youness Tace, Mohamed Tabaa, Sanaa Elfilali, Cherkaoui Leghris, Hassna Bensag, Eric Renault, Smart irrigation system based on IoT and machine learning, Energy Reports, Volume 8, Supplement 9, 2022, Pages 1025-1036, ISSN 2352-4847.

[20] A. A. Esmail et al., "Smart irrigation system using IoT and machine learning methods," 2023 5th Novel Intelligent and Leading Emerging Sciences Conference (NILES), Giza, Egypt, 2023, pp. 362-367, doi: 10.1109/NILES59815.2023.10296736.

APPENDIX A

CONFERENCE PRESENTATION

Our paper on Enhancing Crop Yield Prediction and Resource Management: A KNN-Based Approach Coupled with IoT-Driven Smart Irrigation for Rice, Wheat, and Corn Cultivation was presented at ICCICCT 2024 conference hosted by Taylor & Francis : Open Access Conference Proceedings. Our paper got accepted as paper ID: 417 with a plagiarism of just 3 %. Thereby, we attached our certification for the presentation below in Fig A.2, A.3 and A.4.



Gmail

Sakthi Sharan <meerasakthi155@gmail.com>

ICCICCT-2024 - Acceptance Letter for Paper ID: 417

5 messages

Microsoft CMT <email@msr-cmt.org> Mon, Apr 22, 2024 at 4:51 PM
Reply-To: Sivakumar P <conference@iccicct.com>
To: Sakthi Sharan M <meerasakthi155@gmail.com>
Cc: conference@iccicct.com, sivakumarp@ksrce.ac.in

Your paper was accepted and recommended for publication in “2nd International Conference on Challenges in Information, Communication, and Computing Technology (ICCICCT-2024)”

Paper Tittle: Enhancing Crop Prediction and Resource Management: A KNN-Based Approach Coupled with IoT-Driven Smart Irrigation for Rice, Wheat, and Corn Cultivation
Authors: M Sakthi Sharan, Shivani D, M Ramprasath

Please refer to the acceptance letter and technical comments in this mail

Please ensure the following before uploading the final paper.
1. Format must be as per template, Click (The paper template for ICCICCT-2024) – https://iccicct.com/for-authors/
2. A minimum of 15 references must be in the paper and all references must be cited in the text. Like [1], [2], [3], [4]…
3. The article has a few typographical errors which may be carefully looked at.
4. Complete the copyright/ (Consent Form ICCICCT-2024) https://iccicct.com/for-authors/
5. Revise the paper according to the Paper Template.
6. In the final camera-ready manuscript, self-citations and irrelevant citations must be removed
7. After submitting the registration form, author changes will not be permitted.
8. Plagiarism Should be 10% and Attache Turnitin Plagiarism Report.

Important Dates:
Last Date for Registration: 20 April 2024
Conference Date: 26-27, April 2024

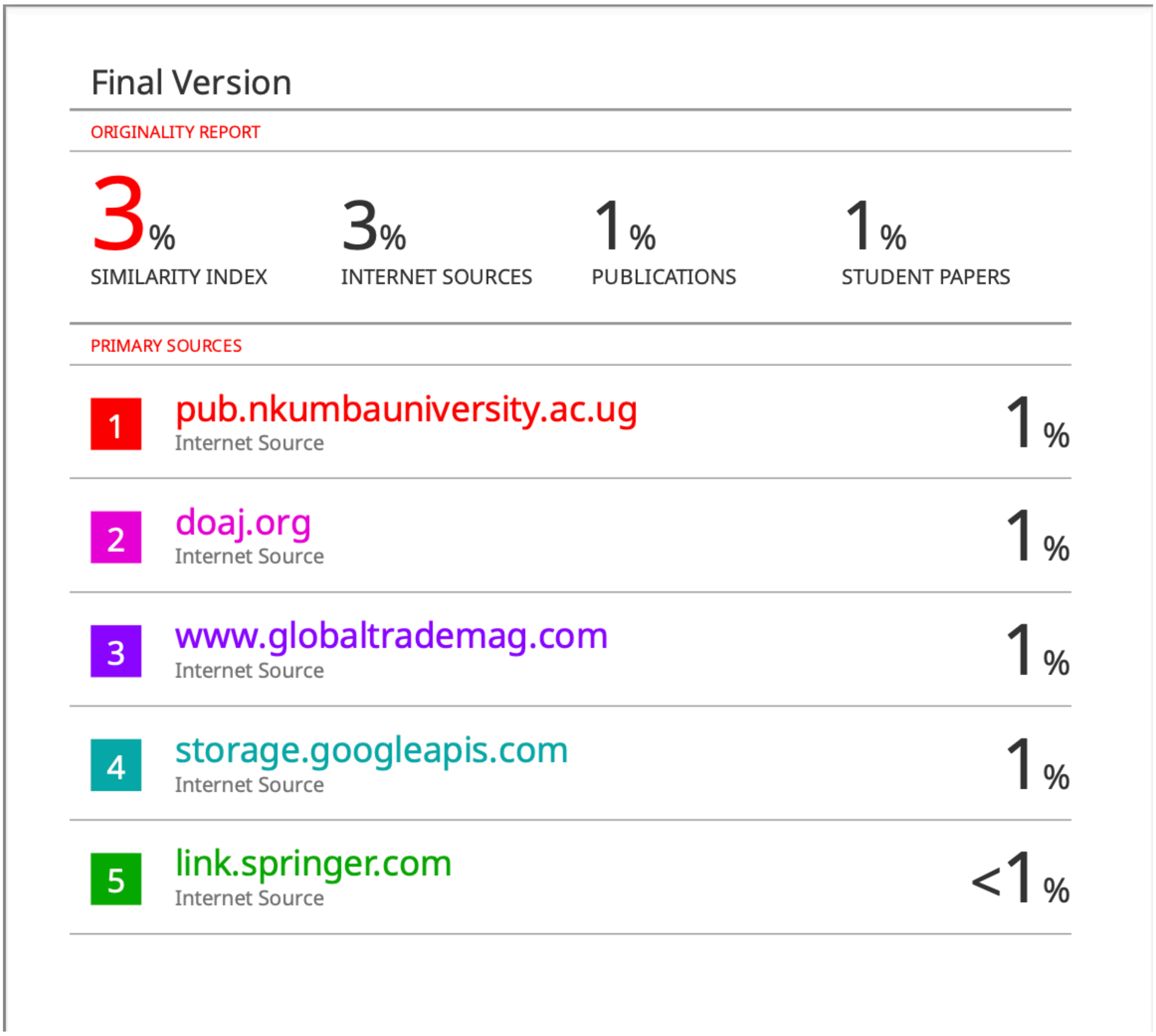
Fig A.1 ICCICCT 2024 Acceptance

Fig A.2 Certificate 1

Fig A.3 Certificate 2

APPENDIX B

PLAGIARISM REPORT


Final Version

ORIGINALITY REPORT

3%	3%	1%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	pub.nkumbauniversity.ac.ug Internet Source	1%
2	doaj.org Internet Source	1%
3	www.globaltrademag.com Internet Source	1%
4	storage.googleapis.com Internet Source	1%
5	link.springer.com Internet Source	<1%

Fig A.4 plagiarism report