

An Intelligent Water Management Framework for Irrigating Urban Gardens in Technologically Advanced Cities

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ABSTRACT

The Innovative Water Management Protocol for Urban Garden Irrigation within Smart Cities introduces a novel strategy for sustainable urban agriculture. This approach harnesses cutting-edge technologies to optimize water usage in irrigation, integrating intelligent sensors, data analysis, and automated processes. By utilizing up-to-date information on soil moisture, weather patterns, and plant requirements, the protocol ensures precise and effective water distribution, minimizing waste. Moreover, it integrates IoT-enabled devices for remote monitoring and management, enabling urban gardeners to oversee irrigation systems effortlessly via mobile applications. This initiative not only conserves water resources but also fosters environmental sustainability and resilience in response to climate change. Additionally, it enhances food security by promoting efficient urban farming techniques. The Innovative Water Management Protocol illustrates the harmonious relationship between technology and agriculture, contributing to the development of smarter and more environmentally friendly urban environments.

Keywords : Urban farming, Irrigation, Current, IOT, Cloud.

I. INTRODUCTION

Urban agriculture has emerged as a critical component of sustainable development within rapidly evolving smart cities. In this context, the integration of advanced technologies into urban gardening practices offers promising solutions to address water

scarcity and promote environmental resilience. Central to this endeavor is the Smart Water Protocol for Irrigation in Urban Gardens within Smart Cities, which represents a pioneering approach towards sustainable urban agriculture. This protocol serves as a blueprint for leveraging innovative techniques to optimize water management in urban gardening,

ensuring efficient resource utilization while mitigating environmental impact.

At its core, the Smart Water Protocol harnesses a fusion of smart sensors, data analytics, and automated systems to revolutionize irrigation practices in urban settings. By leveraging realtime data on soil moisture levels, weather conditions, and plant requirements, the protocol facilitates precise and targeted water delivery, thereby minimizing wastage and enhancing resource efficiency. Furthermore, the integration of Internet of Things (IoT)enabled devices enables remote monitoring and control, empowering urban gardeners to manage irrigation systems seamlessly through mobile applications. This combination of technological innovations not only streamlines irrigation processes but also fosters a more sustainable and resilient urban agriculture ecosystem.

Beyond its immediate benefits in water conservation and efficiency, the implementation of the Smart Water Protocol holds broader implications for urban sustainability and food security. By promoting environmentally conscious urban farming practices, this protocol contributes to the creation of more intelligent and ecofriendly urban landscapes. Moreover, its emphasis on efficient resource utilization and climate resilience underscores its role in addressing contemporary challenges posed by rapid urbanization and climate change. In essence, the Smart Water Protocol exemplifies the transformative potential of technology in advancing sustainable urban agriculture and shaping the future of smart cities.

Furthermore, the adoption of the Smart Water Protocol not only benefits the environment and enhances food security but also fosters community engagement and empowerment. By providing urban gardeners with access to advanced technologies and knowledge, the protocol enables them to play an active role in sustainable food production within their

communities. Through participation in the implementation and management of smart irrigation systems, individuals gain a deeper understanding of the interplay between technology, agriculture, and environmental stewardship. This hands-on involvement not only strengthens community bonds but also cultivates a sense of ownership and responsibility towards the shared goal of building resilient and sustainable urban food systems. Thus, the Smart Water Protocol not only revolutionizes urban gardening practices but also catalyzes positive social change, empowering communities to embrace a more sustainable way of living.

II. RELATED WORKS

"SWAP: Intelligent Water Management Protocol for Urban Garden Irrigation in Smart Cities" by Authors are SABDULAZIZ ALDEGHEISHEM, NABIL ALRAJEH, LAURA GARCÍA, and JAIME LLORET (Senior Member, IEEE) are affiliated with various academic institutions. S. Aldegheishem is associated with the Urban Planning Department at the College of Architecture and Planning, King Saud University, Riyadh, Saudi Arabia. N. Alrajeh is affiliated with the Biomedical Technology Department at the College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia. L. García and J. Lloret are both affiliated with the Instituto de Investigación Para la Gestión Integrada de Zonas Costeras, Universitat Politècnica de València, Gandia, Spain. Said it as The recent surge in Smart City initiatives, exemplified by projects like Smart Santander and Barcelona Smart City, underscores the growing interest in urban innovation. Within the multifaceted framework of Smart City development, effective water management emerges as a critical priority, especially in regions facing water scarcity challenges. Leveraging alternative water sources such as treated sewage water and rainwater collection presents viable solutions for addressing water needs without solely relying on potable water. Consequently, the deployment of

intelligent systems for irrigating urban green spaces holds significant importance in efficiently managing water resources while fulfilling urban landscaping requirements. This paper introduces a communication protocol tailored for smart irrigation systems within the Smart City framework. The protocol facilitates seamless communication between devices utilizing both LoRa and WiFi wireless technologies. Field tests conducted in an urban setting using affordable devices demonstrate the protocol's effectiveness. Specifically, the results indicate optimal performance, with minimal packet loss achieved through the introduction of a 500 ms delay at the central hub node during message transmission between WiFi and LoRa networks.

"Smart Water Protocol for Urban Garden Irrigation in Smart Cities (SWAP)" Authors Abdulaziz Aldegheshem, Urban Planning Department, College of Architecture and Planning, King Saud University, Riyadh, Saudi Arabia. Nabil Alrajeh, Biomedical Technology Department, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia wrote that The adoption of Smart City initiatives has seen a significant increase in recent years, exemplified by projects like Smart Santander and Barcelona Smart City. Within the spectrum of Smart City domains, effective water management holds particular significance, especially in regions facing water scarcity challenges. Moreover, alternative water sources such as treated sewage water or harvested rainwater offer viable solutions to address nonpotable water demands. Thus, the deployment of intelligent systems for watering urban green spaces becomes crucial for efficiently managing water resources and fulfilling urban water needs. This paper introduces a communication protocol tailored for smart irrigation systems developed within the Smart City framework. The protocol facilitates seamless communication between devices utilizing both LoRa and WiFi wireless technologies. Field tests conducted in an urban setting using lowcost devices demonstrate the

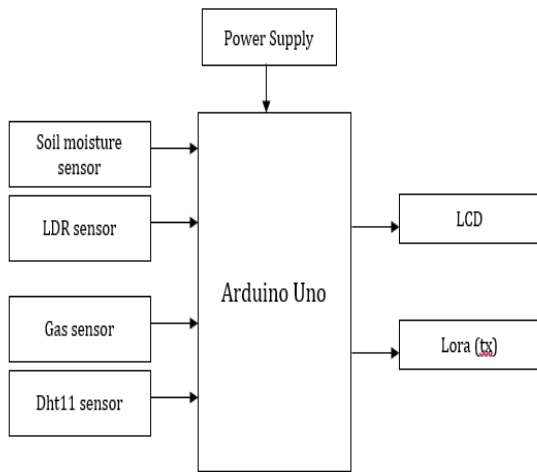
efficacy of the proposed protocol, with minimal packet loss achieved through the introduction of a 500 ms delay at the central hub node during message transmission between WiFi and LoRa networks.

III. PROPOSED METHOD

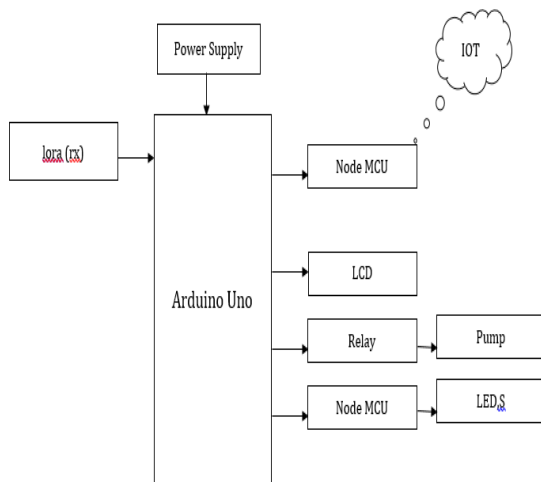
The Smart Water Protocol proposed for urban garden irrigation in smart cities leverages advanced technology to enhance water management efficiency significantly. This approach utilizes a network of smart sensors strategically positioned in garden soil to continuously monitor crucial parameters like soil moisture levels and weather conditions. These sensors relay realtime data to a centralized control system, which employs sophisticated algorithms to analyze the information and determine precise irrigation requirements. The protocol integrates automated irrigation systems capable of adjusting based on the analyzed data, ensuring optimal water distribution across different garden areas. Moreover, IoTenabled devices enable remote monitoring and control via userfriendly mobile applications, empowering urban gardeners to manage their irrigation systems conveniently. By incorporating weather forecasts, the system enhances its predictive capabilities, adapting to changing environmental conditions effectively. This method not only enhances water conservation efforts but also promotes sustainable urban agriculture by minimizing water wastage and facilitating tailored irrigation practices tailored to diverse plant needs. Additionally, when the LDR sensor detects a LORA signal, the LED activates, and the soil moisture sensor triggers the pump on/off function. The system monitors gas sensor and DHT11 values, uploading them to the IoT server for further analysis.

Block Diagram

TX:



RX:



Hardware Used in this project are:

Arduino Uno

Arduino is a versatile opensource electronics platform that has gained popularity for its accessibility and flexibility in prototyping various projects. It consists of both hardware and software components, offering a userfriendly environment for beginners and experienced makers alike to create interactive electronic devices. At its core, an Arduino board serves as the hardware platform, equipped with input and output pins that can be easily programmed to interact with sensors, actuators, and other electronic components. The Arduino Integrated Development Environment (IDE) provides a simplified

programming interface based on the C/C++ programming language, enabling users to write and upload code to the Arduino board effortlessly. With a vast community of enthusiasts and extensive documentation available online, Arduino fosters a collaborative environment where users can share knowledge, code snippets, and project ideas. This democratization of electronics prototyping has led to the widespread adoption of Arduino in various fields, including education, home automation, robotics, and IoT applications.



Moreover, Arduino's modularity and expandability make it suitable for a wide range of projects, from simple LED blinkers to complex robotics systems. Users can easily extend the capabilities of their Arduino boards by adding shields specialized addon boards that provide additional functionalities such as wireless communication, motor control, or sensor interfaces. This modular approach allows for rapid prototyping and iteration, empowering users to quickly bring their ideas to life without the need for extensive electronics knowledge or specialized tools. Furthermore, Arduino's compatibility with a plethora of sensors, actuators, and other electronic modules available in the market further enhances its versatility, enabling users to experiment with different components and create custom solutions tailored to their specific needs. Overall, Arduino's simplicity, affordability, and extensibility have made it a popular choice among hobbyists, students, educators, and professionals alike, driving innovation and creativity in the world of electronics and beyond.

Lora

LoRa, short for Long Range, is a wireless communication technology renowned for its

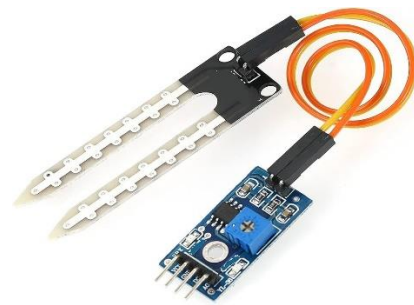
longrange capability and low power consumption, making it an ideal choice for various IoT applications. Developed by Semtech, LoRa operates on unlicensed radio frequency bands, allowing for widespread adoption without the need for costly licenses. The technology utilizes spread spectrum modulation techniques to achieve longrange communication, reaching distances of several kilometers in urban environments and even further in rural areas. LoRa devices typically consist of lowpower transceivers equipped with LoRa modulation technology, enabling them to transmit small packets of data over long distances while consuming minimal energy. This makes LoRa particularly suitable for applications requiring longrange communication, such as smart agriculture, asset tracking, and smart city infrastructure.



One of the key advantages of LoRa technology is its ability to penetrate obstacles and provide reliable communication in challenging environments. LoRa's robustness against interference and its ability to operate in noisy radio frequency environments make it highly resilient in urban settings where other wireless technologies may struggle. Additionally, LoRa's low power consumption extends battery life significantly, enabling longterm deployments without frequent battery replacements. These features have propelled LoRa to the forefront of the IoT landscape, driving innovation in various industries and enabling the creation of scalable, costeffective IoT solutions. As the demand for longrange, lowpower communication continues to grow, LoRa remains a pivotal technology driving the expansion of the Internet of Things, offering unparalleled connectivity for a wide range of applications.

Soil Moisture Sensor

A soil moisture sensor is a crucial component in modern agricultural and gardening practices, serving to monitor and manage the water content in soil. These sensors typically employ various technologies to measure soil moisture levels accurately. One common approach involves using probes or electrodes inserted into the soil, which detect changes in electrical conductivity caused by moisture presence. As the soil moisture increases, the conductivity between the probes changes, providing a direct indication of soil moisture levels. Another method utilizes capacitancebased sensors, which measure the dielectric permittivity of the soil, a property influenced by moisture content. These sensors offer advantages such as noninvasiveness and the ability to measure moisture at different depths within the soil profile.



The data collected by soil moisture sensors is invaluable for optimizing irrigation practices, preventing both under and overwatering, which can detrimentally affect plant health and yield. By providing realtime information about soil moisture levels, these sensors enable farmers and gardeners to make informed decisions regarding irrigation scheduling and water application rates. This not only conserves water resources but also promotes more efficient water usage, ultimately contributing to sustainable agricultural practices. Moreover, soil moisture sensors play a vital role in precision agriculture, allowing for targeted irrigation strategies tailored to the specific needs of different crops or areas within a field. Overall, the integration of soil

moisture sensors into agricultural systems represents a significant advancement in improving water management practices and enhancing overall crop productivity.

LDR Sensor

The Light Dependent Resistor (LDR) sensor, also known as a photoresistor, is a passive electronic component that exhibits a change in resistance based on the intensity of incident light. Comprised of a semiconductor material, the resistance of the LDR decreases as the amount of light falling on it increases, and conversely, it increases in darkness. This unique property makes LDRs invaluable in various applications, particularly in light detection and control systems. Commonly used in lightsensitive circuits and devices, LDR sensors play a crucial role in automatic street lighting systems, security alarms, and camera exposure control mechanisms. Their responsiveness to light levels allows them to detect changes in ambient light conditions swiftly, enabling these systems to adapt and respond accordingly. Moreover, LDR sensors are relatively inexpensive, simple to integrate, and consume minimal power, making them a preferred choice in numerous electronic projects and industrial applications.



Furthermore, LDR sensors find extensive use in environmental monitoring systems and agricultural automation. In these contexts, LDRs help measure daylight duration, assess plant canopy coverage, and optimize greenhouse environments by regulating artificial lighting. By providing realtime data on light intensity variations, LDR sensors contribute to enhancing crop growth, ensuring optimal conditions for photosynthesis, and maximizing agricultural

productivity. Additionally, their compatibility with microcontrollers and IoT devices facilitates remote monitoring and control of lighting systems in smart farming setups. The versatility and reliability of LDR sensors make them indispensable tools across a wide range of fields, offering efficient solutions for light detection and management tasks while promoting energy conservation and sustainability efforts.

Gas Sensor

A gas sensor, a critical component in various technological applications, plays a pivotal role in detecting and monitoring the presence of specific gases in the environment. These sensors operate based on diverse principles, including chemical reactions, electrical conductivity changes, or optical absorption, depending on the gas to be detected. One of the key advantages of gas sensors is their ability to provide realtime data, enabling prompt response to hazardous situations such as gas leaks or air pollution. These sensors find extensive use in industries, homes, and environmental monitoring systems, contributing to safety and health standards by alerting individuals or triggering automated systems when gas concentrations exceed predefined thresholds. Additionally, advancements in gas sensor technology have led to the development of compact, lowpower sensors suitable for integration into portable devices and IoT systems, further expanding their utility in various domains.

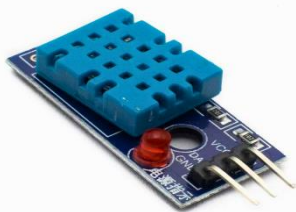


Furthermore, gas sensors have seen significant advancements in sensitivity, selectivity, and reliability, driven by ongoing research and development efforts. These improvements have enabled the detection of trace gas concentrations, even in complex environments with multiple gas species present.

Moreover, modern gas sensor technologies often incorporate calibration mechanisms and compensation algorithms to enhance accuracy and minimize false alarms. In environmental monitoring applications, such as air quality assessment, gas sensors contribute crucial data for policymakers and researchers to understand pollution patterns and formulate mitigation strategies. With the increasing emphasis on sustainability and environmental stewardship, gas sensors are poised to play an even more significant role in ensuring safe and healthy living environments while facilitating the transition towards cleaner energy sources and reduced emissions.

DHT11 Sensor

The DHT11 sensor is a widely used component in various electronic projects and systems, renowned for its simplicity and reliability in measuring temperature and humidity levels. Featuring a compact design and low cost, the DHT11 sensor is popular among hobbyists, educators, and professionals alike. Its functionality is based on a capacitive humidity sensor and a thermistor to measure temperature. The sensor provides digital output, making it easy to interface with microcontrollers such as Arduino boards. One of the key advantages of the DHT11 sensor is its straightforward usage—it requires minimal external components and can be connected directly to a microcontroller's digital input/output pins. This simplicity makes it accessible to beginners and enables quick integration into a wide range of projects, including weather stations, home automation systems, and environmental monitoring devices.



In addition to its ease of use and affordability, the DHT11 sensor offers reasonably accurate measurements suitable for many applications. While it may not provide laboratory-grade precision, its

performance is sufficient for most noncritical purposes, such as monitoring ambient conditions in indoor environments or controlling simple climate control systems. However, it's important to note that the DHT11 sensor has limitations, particularly in terms of its response time and accuracy under extreme conditions. For applications requiring higher precision or faster response times, alternative sensors with greater capabilities may be more suitable. Nonetheless, for many hobbyist and educational projects where cost-effectiveness and simplicity are prioritized, the DHT11 sensor remains a popular choice, serving as a reliable tool for temperature and humidity sensing in a wide array of electronic applications.

NodeMCU

NodeMCU is a versatile opensource IoT platform that has gained popularity for its ease of use and wide range of applications. Built around the ESP8266 WiFi module, NodeMCU offers a lowcost solution for creating connected devices and IoT projects. One of its key features is its compatibility with the Arduino IDE, allowing developers to leverage the extensive Arduino ecosystem and libraries while benefiting from the builtin WiFi capabilities of the ESP8266. This makes it straightforward for both beginners and experienced developers to prototype and deploy IoT applications quickly.

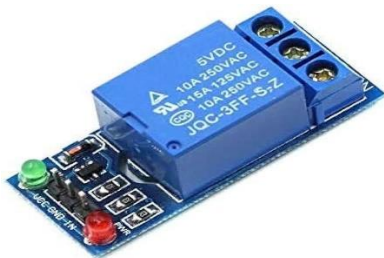


Moreover, NodeMCU supports the Lua scripting language, providing an alternative programming option for those who prefer a higherlevel scripting language. Lua scripts can be uploaded directly to the NodeMCU board, offering flexibility and simplicity in developing IoT applications without the need for complex compilation processes. With its compact size, low power consumption, and abundant GPIO pins, NodeMCU is well-suited for a variety of IoT projects,

including home automation, sensor monitoring, and remote control applications. Its affordability and accessibility have made it a popular choice among hobbyists, students, and professionals alike, driving innovation in the rapidly expanding field of IoT.

Relay

A relay is an electromechanical switch that controls the flow of electricity in a circuit. It consists of a coil and one or more sets of contacts. When an electrical current passes through the coil, it generates a magnetic field that activates the contacts, either opening or closing the circuit. Relays are commonly used in a variety of applications where the control of highpower devices is required, such as in industrial automation, automotive electronics, and home appliances. They offer several advantages, including isolation between the control and load circuits, allowing for safe operation and protection of sensitive control components. Additionally, relays are versatile and can be easily integrated into existing systems, providing flexibility in circuit design and implementation.



One of the key features of relays is their ability to provide electrical isolation between the control and load circuits. This isolation helps prevent electrical noise and interference from affecting the control circuit, ensuring reliable operation even in noisy environments. Relays also offer protection to sensitive control components by acting as a buffer between the lowpower control circuit and the highpower load circuit. This isolation is particularly important in applications where the control circuit operates at a different voltage level or requires different signal characteristics than the load circuit. Furthermore, relays are highly versatile and can be configured to perform various switching functions, such as normally

open (NO), normally closed (NC), and changeover (CO), making them suitable for a wide range of applications. Whether in industrial automation, automotive systems, or household appliances, relays play a crucial role in controlling the flow of electricity and ensuring the proper operation of electrical systems.

Pump (DC)

A DC water pump is an essential component in various applications, particularly in situations where a reliable water supply is needed. These pumps are designed to operate using direct current (DC) electricity, making them suitable for use in offgrid or remote locations where AC power sources may be unavailable or impractical. DC water pumps come in various sizes and designs, ranging from small, portable units for personal use to larger, more powerful pumps for industrial or agricultural applications. Their versatility and efficiency make them ideal for tasks such as water circulation, irrigation, drainage, and water transfer.



One significant advantage of DC water pumps is their energy efficiency. Compared to traditional AC pumps, DC pumps often consume less power, making them more costeffective and environmentally friendly over the long term. Additionally, DC pumps can be easily integrated with renewable energy sources such as solar panels or wind turbines, further reducing their operational costs and environmental impact. Their compact size and lightweight construction also make them easy to install and maintain, making them an attractive option for both residential and commercial users. Overall, DC water pumps play a crucial role in ensuring reliable water supply in a wide range of

applications while offering energy efficient and sustainable solutions for water management needs.

LCD

Liquid Crystal Display (LCD) technology has become ubiquitous in various electronic devices, revolutionizing the way information is displayed and consumed. LCDs utilize the unique properties of liquid crystals placed between two transparent electrodes to control the passage of light. When an electric current is applied, these liquid crystals align to allow light to pass through or block it, creating images or text. One of the key advantages of LCDs is their energy efficiency compared to traditional cathode ray tube (CRT) displays, making them ideal for portable devices like smartphones, tablets, and laptops. Additionally, LCDs offer high resolution and sharp image quality, enhancing the user experience across different applications, from gaming to video streaming.



Furthermore, LCD technology has evolved over the years to offer various types of displays, including twisted nematic (TN), inplane switching (IPS), and organic light emitting diode (OLED) screens, each with its unique features and benefits. TN LCDs, known for their fast response times, are commonly used in applications where speed is crucial, such as gaming monitors. IPS LCDs, on the other hand, provide wider viewing angles and better color accuracy, making them suitable for professional graphics work and multimedia consumption. OLED displays, utilizing organic compounds that emit light when an electric current is applied, offer unparalleled contrast ratios and deep blacks, resulting in vibrant and lifelike images. Overall, LCD technology continues to drive innovation in the display industry,

shaping the way we interact with digital content in our daily lives.

Power supply

In our system, the power supply plays a crucial role in maintaining a steady and regulated electrical environment essential for the optimal operation of its components. To achieve this goal, we integrate a DC to DC converter, which combines a voltage regulator and a bridge rectifier. The bridge rectifier is central to the power supply, as it converts the incoming alternating current (AC) from the source into a pulsating direct current (DC). This rectification process is vital because it establishes a one-way flow of electricity, laying the foundation for a more stable power input. After rectification, the voltage regulator is employed to refine and stabilize the pulsating DC output. By utilizing this component, we ensure that the voltage supplied to the system remains consistent, thereby reducing potential fluctuations that could adversely affect the performance of sensitive electronic components.

Moreover, the voltage regulator assumes a critical function in maintaining a stable power provision throughout the entirety of the system. Its task involves sustaining voltage levels within predetermined thresholds, effectively safeguarding interconnected components against fluctuations and thereby reinforcing the system's reliability. The fusion of a bridge rectifier and voltage regulator not only converts incoming electrical signals into usable energy but also ensures a continuous and uniform power distribution to the intricate array of components. This steadiness not only augments the efficacy of the electronic system but also extends its operational longevity.

Advantages and Applications

ADVANTAGES

- Efficiency
- Automation
- Sustainability
- Adaptability
- Convenience

- Optimization
- Conservation
- Integration

APPLICATIONS

- Efficiency
- Sustainability
- Precision
- Automation
- Conservation
- Adaptability
- Integration
- Reliability
- Optimization
- Empowerment

IV. RESULTS

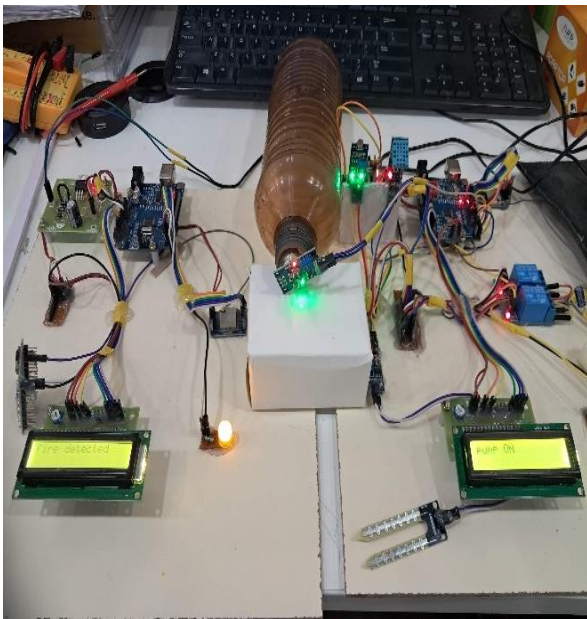


Fig 1. Total project kit

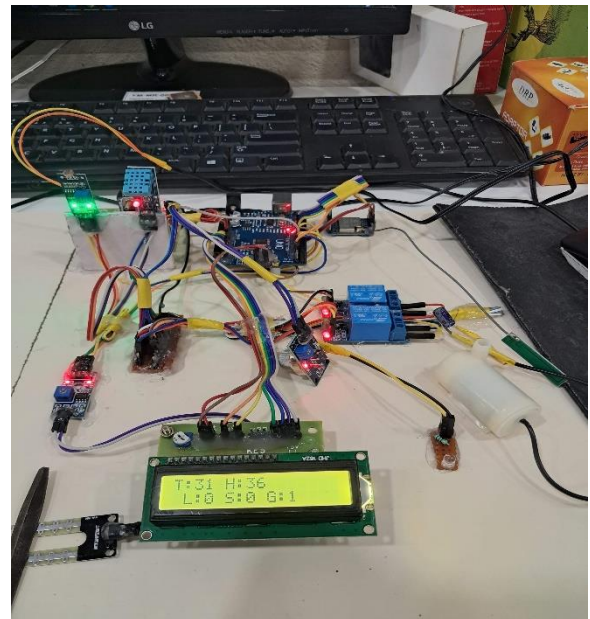


Fig 2. S shows zero when soil moisture sensor detected and pump will be turned on

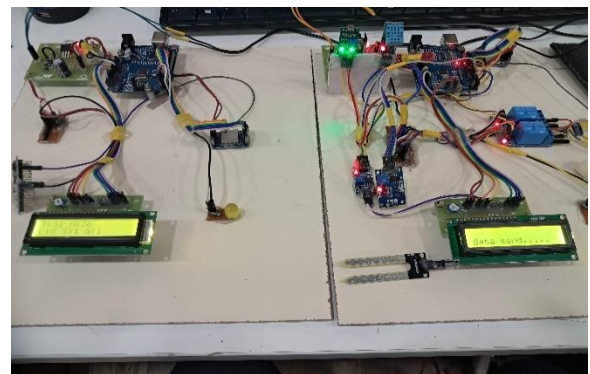


Fig 3. Data sent through LORA module

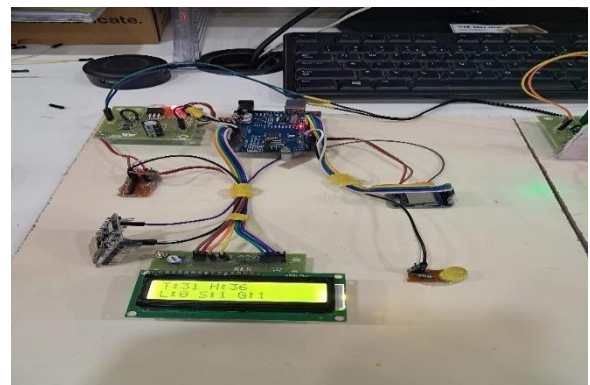


Fig 4. When fire or smoke detected through gas sensor pump will be turned on

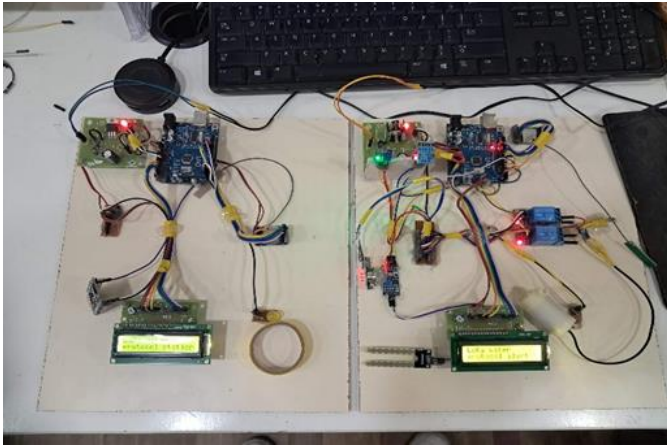


Fig 5. Title displayed in both transmitter and receiver kit

V. CONCLUSION

In conclusion, the Smart Water Protocol offers a groundbreaking solution for urban garden irrigation within smart cities, harnessing cutting-edge technology to revolutionize water management practices. Through the deployment of a network of strategically placed smart sensors, realtime monitoring of essential parameters such as soil moisture levels and weather conditions is made possible. This data is then processed by a centralized control system equipped with sophisticated algorithms, allowing for precise determination of irrigation requirements and the seamless adjustment of automated irrigation systems. Furthermore, the integration of IoT-enabled devices enables remote monitoring and control, empowering urban gardeners to manage their irrigation systems effortlessly through userfriendly mobile applications. By incorporating weather forecasts, the protocol enhances its predictive capabilities, ensuring adaptation to changing environmental conditions. Overall, this method not only enhances water conservation efforts but also fosters sustainable urban agriculture by minimizing water wastage and facilitating tailored irrigation practices tailored to diverse plant needs. The additional functionality, where the system responds to LDR sensor signals and monitors gas sensor and DHT11 values, further underscores its versatility and

potential for comprehensive water management in urban environments.

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