Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 4, No.1, April : 2025

NODE TO NODE COMMUNICATION FOR SUSTAINABLE AGRICULTURE

N.Gopi, Assistant Professor, ECE Department, NRIIT, Agiripalli, Vijayawada.
K. Divakar Reddy, Student, ECE Department, NRIIT, Agiripalli, Vijayawada.
K. Prapul Kumar, Student, ECE Department, NRIIT, Agiripalli, Vijayawada.
M. Naveen Babu, Student, ECE Department, NRIIT, Agiripalli, Vijayawada.
K. Suresh, Student, ECE Department, NRIIT, Agiripalli, Vijayawada.
M.Dhanush Kumar,Student, ECE Department, NRIIT, Agiripalli, Vijayawada.

ABSTRACT:
Sustainable agriculture is essential for ensuring food security while conserving natural resources. With the growing need for efficient farming practices, real-time monitoring and automation have become critical. This study presents a node-to-node communication system designed to enhance agricultural efficiency by deploying multiple sensor nodes equipped with temperature, moisture, and rain sensors. These nodes continuously collect environmental data and relay it to a central main node, which processes the information and automates key agricultural operations, such as irrigation control based on soil moisture levels. This intelligent system optimizes water usage, minimizes resource wastage, and improves crop productivity while reducing labor costs and manual intervention. By integrating wireless communication and automation, the system ensures precision in farming, making agriculture more sustainable and adaptable. The proposed solution is highly scalable and can be tailored to various agricultural environments, offering farmers a smart**,** data-driven approach to modernizing traditional farming practices.
Keywords: Automated Irrigation, Precision Farming, Sustainable Agriculture Node-to-Node Communication, Wireless Sensor Networks (WSN).

INTRODUCTION:
Agriculture plays a crucial role in ensuring food security and economic stability, yet traditional farming methods often lead to inefficient resource utilization, particularly in irrigation management. Conventional irrigation systems either overuse water or fail to provide adequate moisture, leading to reduced crop yields and increased environmental strain [1]. The integration of Internet of Things (IoT) technology in agriculture has introduced smart farming techniques that optimize water consumption and enhance productivity through automation and real-time monitoring [2]. To address the inefficiencies of traditional irrigation, this work proposes a node-to-node agriculture monitoring system, leveraging wireless communication for real-time environmental monitoring and automated irrigation control. The system employs Arduino and ESP8266 modules, configured as NRF communication modules, enabling seamless wireless data transmission between sensor nodes and a central processing unit. Each sensor node is equipped with soil moisture, temperature, and rain sensors, which continuously monitor field conditions and transmit data to a main node. Based on predefined threshold values, the system autonomously controls irrigation by switching water pumps on or off to maintain optimal soil moisture levels. Additionally, the inclusion of a rain sensor prevents unnecessary watering during precipitation events.
Unlike traditional sensor-based irrigation systems that rely on direct wired connections, this project integrates wireless transmission via ESP8266 modules, enhancing scalability and reducing installation complexity. The collected environmental data is further uploaded to the ThingSpeak cloud platform, enabling remote monitoring and historical analysis of soil conditions. This cloud-based feature allows farmers to access real-time field data from any location using a Smartphone or computer, thus minimizing manual intervention, reducing labor costs, and increasing efficiency [3]. Several studies have explored IoT-based smart irrigation systems to optimize water usage and improve crop health.

Research in [4] demonstrates how a sensor-based system can monitor crop fields and automate irrigation decisions using cloud-based analytics. Similarly, in [5], a smart agricultural monitoring system was developed to track environmental parameters and provide real-time alerts, reducing human dependency in farm management. Other works [6] have proposed wireless sensor network-enabled precision farming techniques, focusing on cost-effective and scalable irrigation automation. Building upon these advancements, the proposed node-to-node communication framework aims to further enhance irrigation efficiency, scalability, and adaptability in modern farming applications. By leveraging IoT, cloud computing, and automation, this system presents a sustainable and smart irrigation approach that reduces water wastage, lowers operational costs, and enhances overall agricultural productivity. Its modular design ensures that additional sensor nodes can be integrated seamlessly, making it adaptable to various agricultural setups. This project contributes to the advancement of precision agriculture, where data-driven decision-making and automated processes lead to optimized resource utilization and improved crop yield, ultimately supporting sustainable farming practices.

LITERATURE:

Smart agriculture has gained significant attention due to the increasing demand for efficient resource management. Several studies have introduced IoT-based agricultural monitoring and automation systems that aim to optimize water consumption and improve crop yields.

An IoT-based crop field monitoring and irrigation automation system is discussed in [7], where sensors collect real-time data from the field and transmit it to a cloud-based server. The system automates irrigation based on predefined thresholds, ensuring optimal moisture levels while preventing water wastage. The approach in [8] focuses on a smart agriculture monitoring system where farmers manually check and verify environmental parameters. By integrating wireless sensor networks and IoT technologies, the system improves accuracy and efficiency in decision-making.

The study in [9] highlights the use of wireless sensor networks for real-time monitoring of agricultural conditions. The system employs cloud computing to process data and provide remote access to farmers through web and mobile interfaces. This reduces the reliance on manual labor and enhances the precision of irrigation management. Additionally, research in [10] explores a cost-effective and scalable IoT-based irrigation system that leverages smart sensing and automation technologies. The study demonstrates how cloud-integrated systems can provide insights into soil moisture levels, weather conditions, and irrigation schedules, allowing farmers to make informed decisions.

Furthermore, IoT-based smart agriculture has been explored as a solution to traditional inefficiencies in farming practices. The existing systems primarily rely on historical data and manual interventions, leading to suboptimal performance. However, the proposed node-to-node communication system overcomes these limitations by enabling real-time data transmission and automated control of irrigation. By integrating wireless sensor networks with cloud computing, the system ensures precise water management, reducing unnecessary water usage and improving overall crop health. The literature suggests that while various IoT-based solutions exist for smart agriculture, most systems lack scalability and real-time adaptability. This project builds upon these previous studies by introducing a flexible and modular approach that enables seamless communication between multiple sensor nodes. By leveraging wireless communication, cloud storage, and automated decision-making, the proposed system provides a comprehensive solution to modern irrigation challenges.

METHODOLOGY:

The proposed Node-to-Node Communication System for Sustainable Agriculture is designed to enhance irrigation efficiency through wireless sensor networks and real-time automation. The methodology involves sensor deployment, data acquisition, wireless data transmission, decision-

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 4, No.1, April : 2025

making, and cloud-based monitoring to provide an integrated solution for precision agriculture. The system architecture consists of multiple sensor nodes, a central main node, actuator modules, and cloud integration for remote monitoring. Each sensor node is equipped with a soil moisture sensor to measure soil water content, a temperature sensor to monitor environmental conditions, and a rain sensor to detect precipitation. These sensors are connected to an Arduino microcontroller, which processes the collected data and transmits it wirelessly using ESP8266 modules. The ESP8266 modules are configured as NRF communication nodes, allowing seamless data exchange between the sensor nodes and the main node.

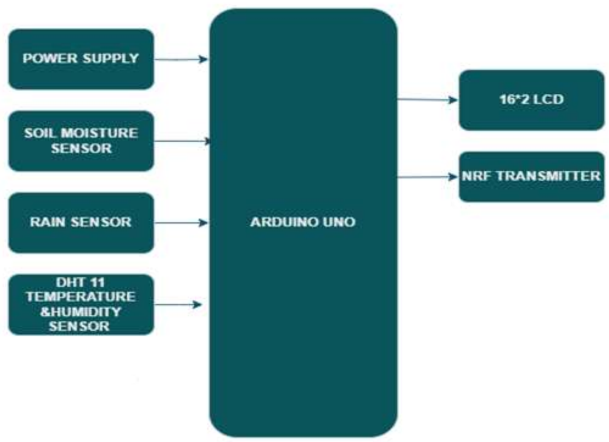


Fig 3.1: Transmitter section

The main node, acting as the base station, receives data from the sensor nodes and processes it based on predefined threshold values. If the soil moisture level is found to be below the required limit, the main node triggers the water pump to activate irrigation. Conversely, if adequate moisture is detected or rainfall is occurring, the system halts irrigation to prevent overwatering. This automated decision-making ensures efficient water management, minimizing wastage and optimizing crop hydration. To enhance usability and accessibility, the system is integrated with the ThingSpeak cloud platform for remote monitoring. The main node uploads real-time sensor data to the cloud, allowing farmers to access field conditions from any location using a smart phone or computer. This cloud-based approach enables users to analyze historical data trends and make informed agricultural decisions. Additionally, the system reduces the dependency on manual labor by automating irrigation, thereby decreasing operational costs and improving efficiency.

The communication workflow of the system follows a structured sequence. First, sensor nodes collect data at regular intervals and transmit it wirelessly to the main node. The main node then processes the received data and determines the irrigation requirements based on soil moisture levels and weather conditions. If the system detects a need for irrigation, the corresponding water pump is activated; otherwise, the system remains idle to conserve water. Simultaneously, all collected data is sent to the cloud for real-time monitoring, where farmers can view the current status and make necessary adjustments remotely.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 4, No.1, April : 2025

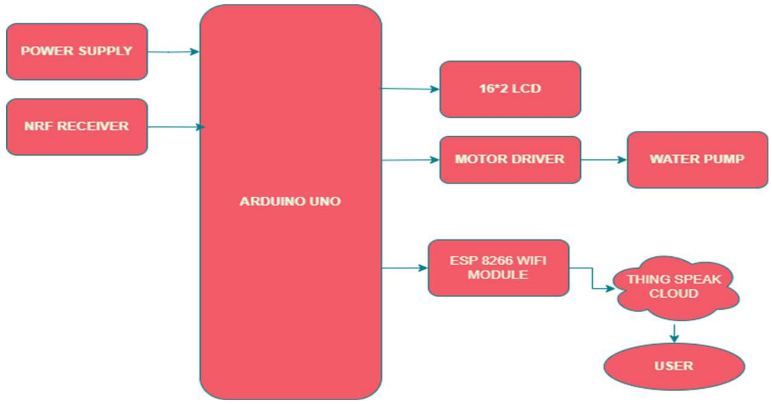
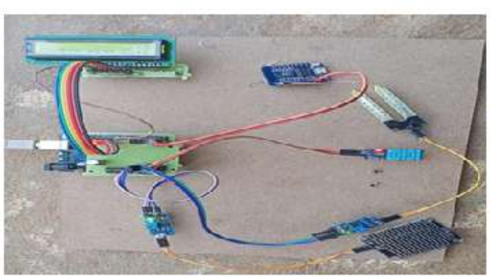


Fig 3.1: Receiver section

A key advantage of this methodology is its scalability, allowing additional sensor nodes to be incorporated as needed to cover larger agricultural areas. The wireless communication system eliminates the need for extensive wiring, making installation cost-effective and adaptable to different farm sizes. Moreover, automation reduces the risk of human error in irrigation management, ensuring crops receive optimal water supply without unnecessary intervention. The overall, work gives a smart and sustainable solution for modern agriculture by integrating IoT-based monitoring, automated decision-making, and real-time cloud access. The system enhances resource efficiency, minimizes water wastage, and contributes to the broader goal of precision farming and sustainable agricultural practices.

RESULTS :

The results of the Node-to-Node Communication System for Sustainable Agriculture demonstrate the efficiency of the wireless communication network, real-time data monitoring, and automated irrigation control. The system was successfully implemented with multiple sensor nodes communicating with a central main node, allowing seamless data transmission and intelligent decision-making for irrigation management. The following figures illustrate the key components and functionalities of the system. **Figure 1.a),1. b)** represent **Node 1 and Node 2**, respectively. These nodes are deployed in different areas of the agricultural field, where they collect real-time environmental data, including soil moisture levels, temperature, and rainfall conditions. Each node is equipped with ESP8266 modules, enabling them to transmit collected data wirelessly to the main node.



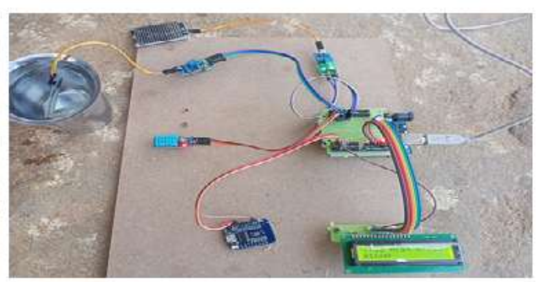


Fig 1.a) Node 1 1.**b)** Node 2

Figure 2.a) illustrates the Main Node, which acts as the central processing unit of the system. It receives data from multiple sensor nodes, processes the information, and determines whether irrigation is required based on predefined threshold values. The main node also controls the activation and deactivation of the water pump, ensuring optimal water distribution based on real-time soil conditions. **Figure 2.b)** presents the Total System Architecture, which showcases the interaction between sensor

nodes, the main node, and the cloud-based monitoring system. This integration enables seamless data transmission and automation, reducing the need for manual intervention in irrigation management.

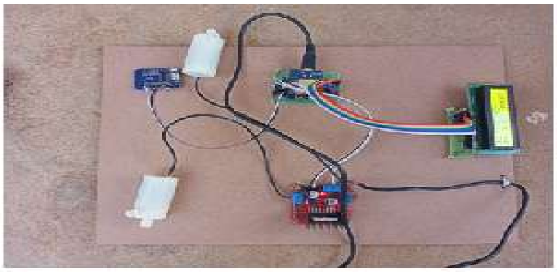
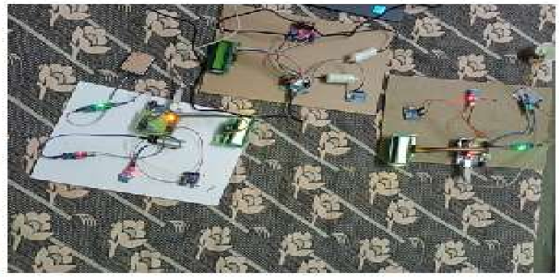



Fig 2.a) Main Node 2.**b)** Total System Architecture

Figure 3.a) highlights the Agri Crop App, a mobile and web-based application developed for real-time monitoring and crop prediction. This app allows farmers to view real-time sensor data, track historical trends, and make informed decisions regarding irrigation and crop selection. **Figure 3.b)** demonstrates the Prediction Process, where the system uses collected environmental data, including soil parameters, to predict the most suitable crop for cultivation. This feature enhances precision farming by recommending crops based on current soil conditions and climate factors.

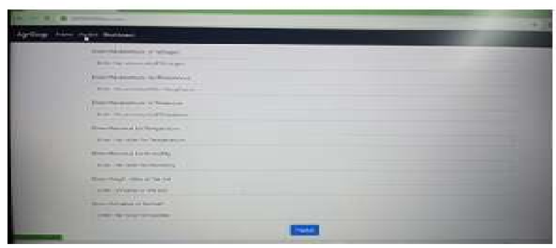


Fig 3.a Agri Crop App **3. b)** Crop prediction process

Figure 4.a) displays the Values of NPK (Nitrogen, Phosphorus, and Potassium) in the Soil, which are critical nutrients required for plant growth. The system measures and records these values, providing insights into soil fertility and nutrient availability. **Figure 4.b)** shows the Predicted Crop Based on NPK Values, where the system analyzes soil nutrient levels and suggests the best crop to cultivate. This feature helps farmers make data-driven decisions, improving crop yield and resource efficiency.

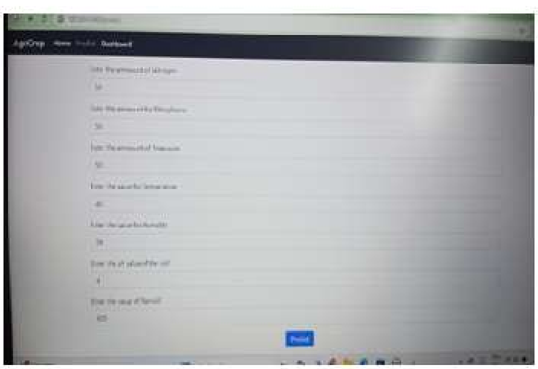
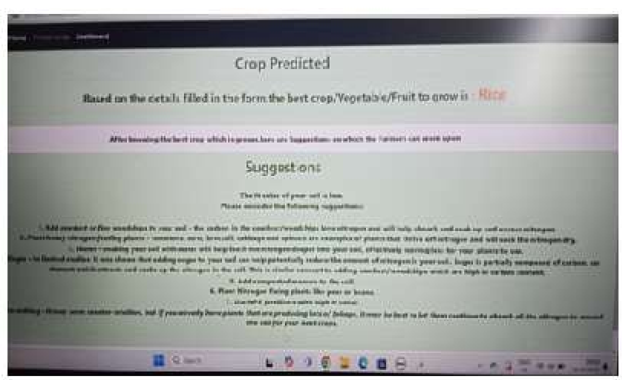



Fig 4.a Values of NPK in soil **4. b)** Predicted Crop Based on NPK Value

Overall, the results validate the effectiveness of the proposed system in enhancing sustainable agriculture. The automated irrigation system minimizes water wastage, while the integration of IoT and cloud computing provides real-time monitoring and crop prediction capabilities. The successful implementation of wireless sensor networks and automated control mechanisms ensures precision farming, making the system a valuable tool for modern agricultural practices.

CONCLUSION:

The Node-to-Node Agriculture Monitoring System using Arduino and ESP8266 successfully automates irrigation based on real-time environmental conditions, integrating soil moisture, temperature, and rain sensors to optimize water usage while reducing both wastage and manual intervention. The main node efficiently processes data received from sensor nodes and controls water pumps, ensuring precise irrigation management. Additionally, real-time data is uploaded to the ThingSpeak cloud, allowing farmers to remotely monitor field conditions. The system's wireless communication approach eliminates complex wiring, making it cost-effective, scalable, and adaptable to various agricultural settings. Future enhancements could include integrating a webcam for crop monitoring, implementing speech-based controls for accessibility, incorporating GPS for precise location tracking and weather updates, and supporting regional languages to improve usability for farmers. Overall, this project provides a smart, sustainable solution for precision agriculture, enhancing crop yield and resource management.

REFERENCES :

1. Sebin Sabu1 and Nora Elizabeth, "Kerela floods- A model of rescue and rehabilitation using information technology and social media based crowdsourcing", IEEE India info. Vol. 13 No. 3 Jul-Sep 2018.
2. H.A. Rahman, " Global climate change and its effects on natural habitat and environment in Malaysia," Malaysian J. Environ. Manag., vol. 10, no. 2,pp.17-32,2009.
3. H. Hamidon, "Flood level indicator and risk warning system for remote location monitoring flood observatory system",WSEAS Trans. Syst. Control, vol. 5, no.3,pp. 153-163,2010
4. Z.M. Taib,N.S. Jaharuddin,and Z.D. Mansor, " A review of flood disaster and disaster in Malaysia" International journal of Accounting and business management, vol. 4,no.3,2016.
5. A.M. Leman, K.A. Rahman, M.N.M.Salleh, I.Baba, D.Feriyanto, L.S.C. Johnson, and S.N Hidayah M., "A review of flood catastrophic management in malaysia, " ARPN Journal of Engineering and applied sciences, vol.11,no. 14, Jul 2016.
6. W,Lo, J.H. Wu, F.P. Lin, and C. H. Hsu, "Cyber surveillance for flood disaster," sensors (Switzerland),2015.
7. A. Al-Faquha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayahs, "Internet of things: A survey on enabling technologies, protocols, and applications," IEEE Communications surveys Tutorials, vol. 17, no. 4,pp. 2347-2376,Fourthquarter 2015.
8. M. Mathematic and R. Grace, "Flood alert management system using iota and microcontroller," International journal of innovative research in computer and communication engineering, vol. 5, no. 4, April 2017.
9. S. Zaid, B. Sharma, K. Raghuwaiya, A. Chand, S. Prasad, and A. Jacquier, "ARPN Journal of Engineering and applied sciences, 2015.
10. S.J. Priya, S. Kashaya, E. Arena, J. A. M. Julie, and V. Ranjani, "Flood monitoring and alerting system," International journal of computer engineering and technology (IJCET), vol. 8, no. 2,p.15, Mar 2017.