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Iot Smart Irrigation System for Precision Agriculture; A Case of Kayonza Irrigation and Integrated Watershed Management Project (KIIWMP)

Rukirande Brice
Master's

Supervisor by Dr. Musoni Wilson Ph.D.
Information Communication and Technology (ICT). University of Kigali (UoK)
Kigali, Rwanda

Abstract:- The application of new technologies of irrigation in the agriculture sector in Rwanda has been among the major contributor to the growth and advancement of this sector.

We have seen dams being constructed for keeping water and be used to irrigate crops, pivot irrigation systems are being implemented and used for irrigation in some part of Rwanda and impressive irrigation project building up like the Nasho Solar-Powered Irrigation Project and the Kayonza Irrigation and Integrated Watershed Management Project where we have conducted our study.

The implementation of irrigation projects not only increases the food production of an area when compared to rain-fed agriculture but also significantly improves the reliability of the production process by ensuring proper water control.

This study will concentrate on the explaining functionalities of an IoT smart irrigation system and developing a prototype system for the Rwandan agriculture board and looking into what would be the effects of the technology in terms of water resource management in the agriculture sector.

Keywords:- *IoT, IoT Sensor, Smart Irrigation, smart Agriculture, IoT platform, AgIoT, ICT4Ag.*

I. INTRODUCTION

The Government strategies to introduce ICT in agriculture (ICT4Ag); policies such as Crop intensification program (CIP) implementation, and modern agricultural technologies will play significant role to embrace the use of new technologies in the agriculture sector.

The IoT smart irrigation technology is the most advanced irrigation system which can be used for getting advanced to efficiently handle more sophisticated tasks, increase production using less water resources. With increasing demands and shortage of labour across the globe, introduction of AI and IoT technologies such as sensors, drones, and robots in the agriculture, are starting to gain attention among the farmers.

II. STATEMENT OF THE PROBLEM

Ensuring food security has become a challenge in Sub-Saharan Africa (SSA) and Rwanda due to combined effects of climate change, high population growth, and relying on rain fed farming. This has led to a high demand for an increase in food production which requires a shift from conventional ways of farming to an advanced precision agriculture to produce more for less.

The government of Rwanda has invested in big irrigation projects and developed an irrigation master plan.

This study will provide insights and highlight the benefits of implementing smart irrigation systems in the Rwandan agriculture.

The aim of this project is to motivate the ministry of agriculture, to introduce smart farming practices as one of the solutions to tackle the above-mentioned challenges.

III. CONSEPTS

This section provides a quick introduction to IoT Smart Irrigation key terminologies and devices.

A. Smart Farming

Smart farming refers to managing farms using modern Information and communication technologies to increase the quantity and quality of products while optimizing the human labour required. It focuses on providing the agricultural industry with the infrastructure to leverage advanced technologies including big data, the cloud and the internet of things (IoT) for tracking, monitoring, automating and analysing operations(Bernstein, 2019).

B. IoT Based Irrigation System

It's an automated irrigation system that uses sensors, microcontrollers, cloud services and internet to control the water pump to irrigate water to the farm field and monitor the condition of soil moisture, temperature, and pressure of the farm field and capable of responding to the sensed data(Alexander S. Gillis, 2022).

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C. Internet of Things (IoT)

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction(Alexander S. Gillis, 2022).

D. Arduino UNO

The Arduino Uno is a popular microcontroller board that is commonly used for building various electronics projects and prototypes. It's part of the Arduino platform, which provides an open-source environment for hardware and software development. The Arduino Uno is particularly well-suited for beginners and hobbyists due to its simplicity and versatility(Ismailov & Jo'rayev, 2022).

Fig. 1. Arduino UNO Device

E. GSM – SIM900

The GSM SIM900 module is a versatile cellular communication module that allows devices to communicate over the Global System for Mobile Communications (GSM) network. It's commonly used in various applications, such as remote monitoring, telemetry, IoT (Internet of Things) projects, and embedded systems that require cellular connectivity(Dasiga, 2017).

Fig. 2. GSM SIM900 Device

F. Soil moisture sensor FC-28

The FC-28 soil moisture sensor is a commonly used electronic device designed to measure the moisture content of soil. It's often used in various applications, such as agriculture, gardening, and environmental monitoring, to determine when to water plants and crops. The sensor provides a simple and cost-effective way to monitor soil moisture levels and automate irrigation systems(Dasiga, 2017).

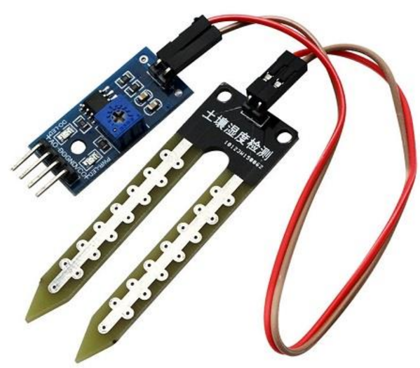

Fig. 3. Soil moisture sensor FC-28

G. LCD Display

An LCD (Liquid Crystal Display) is a type of flat-panel display technology that uses liquid crystals to produce images. It is commonly used in various electronic devices such as computer monitors, television screens, smartphones, tablets, digital cameras, and more. LCDs have largely replaced older display technologies like cathode ray tube (CRT) displays due to their thinner profile, lower power consumption, and better image quality(Cowan, 2002).

Fig. 4. LCD Display Screen 2x16

IV. METHODOLOGY

The research methodology for this study will consist of literature and document review, collection of data and analysis, interview, focus group discussion and site visit. Three steps of research will be carried out in this study.

A. Research Methodology

In this study, secondary quantitative research method will be utilised to be able to have the expected results. We will get deeper insights in assessing the impact of the IoT smart irrigation system to the Rwanda agriculture sector. The quantitative data collection will be used to get the widest aspect of the subject. To collect all the necessary data for this study, we will use the combination of all related data available on the internet, libraries, government, and non-government sources.

B. Data Collection and Description

As mentioned before, there are two types of data usually applied in research: primary and secondary data (Zikmund, 2003). Primary data are the data that someone collects on his own with a definite purpose in mind, whereas secondary data have already been collected by other researchers with diverse purposes in mind (Javaheri, 2007). Secondary data are categorized as internal and external data. The internal data are produced inside the organization for which the research is being performed and the external data are generated by sources outside the company (Malhotra and Birks, 2003). As stated, for data mining approaches secondary data are usually used.

V. FINDINGS

In this chapter the researcher will present the findings from the research work and will deeply explain the functionalities of the developed IoT smart irrigation prototype.

A. IoT Smart Irrigation System Prototype Flowchart

The system begins by reading the soil's moisture parameters, as seen in the flowchart above, and sending them to the microcontrollers. If the moisture sensing parameters are below the normal level, measures are taken to activate the pump and irrigate the soil.

The controlling steps are done to stop the pump and the irrigation when the soil moisture reaches the desired level in accordance with the system setup. The system reads the soil moisture sensor parameters again and repeats the operation.

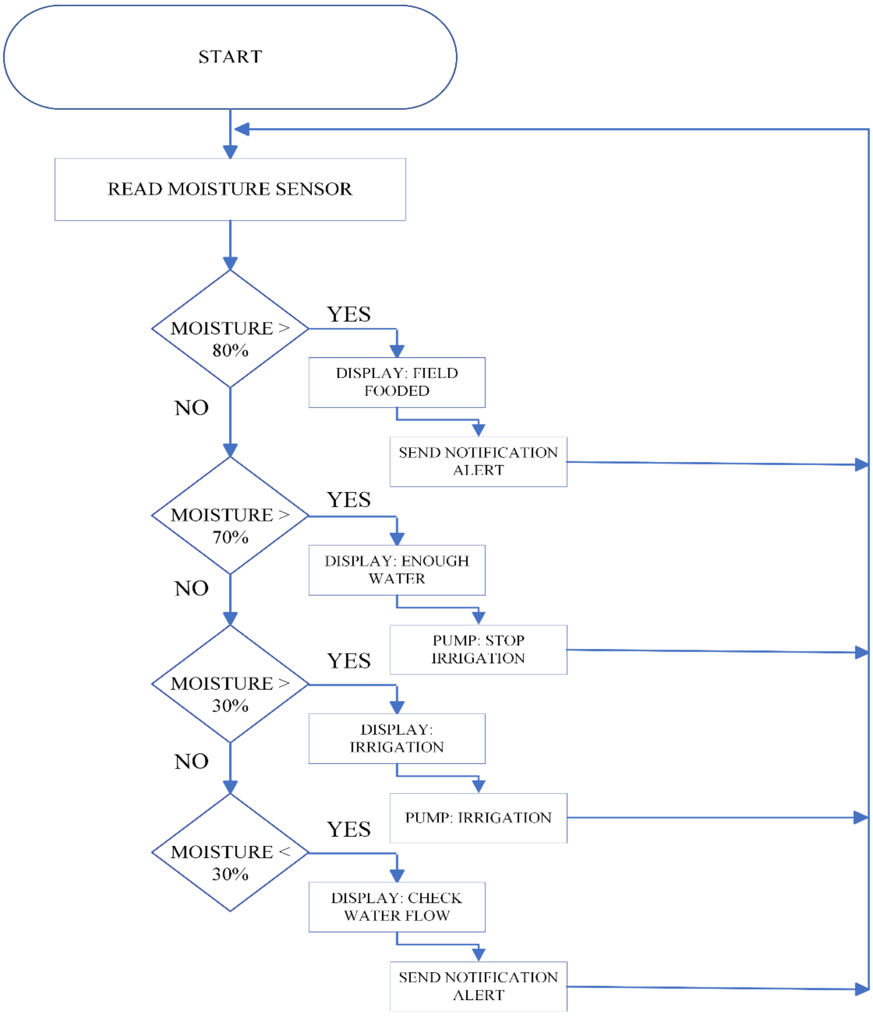

Fig. 5. (Own) IoT Smart Irrigation System Flowchart

B. IoT Smart Irrigation Prototype Diagram

The results of the moisture, temperature, and threshold level calculations can be obtained through sensors. It is possible to analyse the properties of the soil and determine the water that the soil requires. The soil's need for water supply can be predicted, thus irrigation is done properly using smart techniques.

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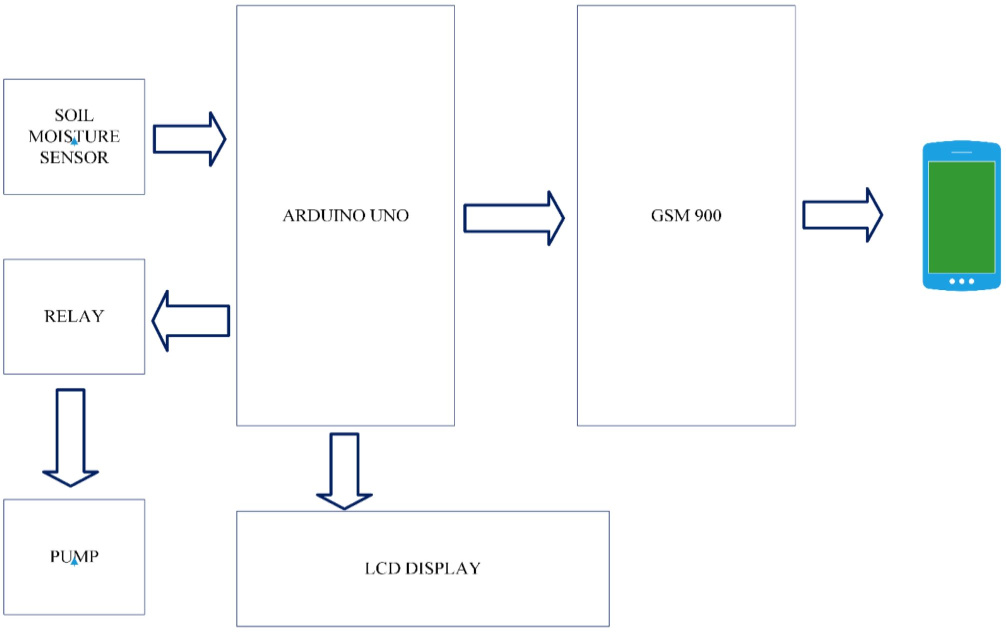

Fig. 6. (Own) IoT Smart Irrigation Prototype Diagram

C. IoT Smart Irrigation System Prototype

An algorithm has been developed into Arduino UNO device to control the actions of the systems and ensure the system is capturing soil moisture data and be able to send precise actions to be done. The coding was done using C programming language.

Step 1: Start system and synchronizes the connections between main parts, Arduino UNO and the computer, the relay and the pump, the GSM device and the soil moisture sensor.

Step 2: System read soil moisture sensor FC-28 and continuously sensing the soil conditions and send parameters to Arduino UNO.

Step 3: The soil moisture measure collected from sensors are sent to Arduino UNO for analysis and displayed to the screen.

Step 4: The system can check the soil moisture level and know when the soil need to be irrigated and will release water at the needed level.

Step 5: If the soil moisture goes beyond or below set threshold, the system can send call or send text notification to alert the farmer.

Fig. 7. (Own) IoT Smart Irrigation system Prototype

Fig. 8. (Own) IoT Smart Irrigation system Arduino developent using C programin

VI. CONCLUSION

Water is a fundamental resource that underpins all aspects of agriculture. Rwanda like in other parts of the world, is being affected by the climate change and should take measures to fight against climate effects and especially in the agricultural sector to continue assure food security to its citizens.

Rwanda through it major irrigation project like the Kayonza Irrigation and Integrated Watershed Management Projects (KIIWMP) and the Nasho Solar-Powered Irrigation Project among others, but improvements need to be done.

RECOMMENDATIONS

Improvements need to be done in terms of water resource management and the IoT smart irrigation system could be the answer to the problem. for this to be effective, Rwanda should be prepared.

- Invest in new technology equipment for small scale first and large scale in the future,
- To invest in skills development among the government technicians and the farmers,
- Improve internet penetration as the IoT smart irrigation system has its data part located in the cloud,
- Improve electricity penetration in the rural area or invest in solar and other renewable energy to help operate the new system.

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