Czech University of Life Sciences Prague

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Bachelor Thesis

IoT iot island systems in Agriculture

Akshay Hande

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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BACHELOR THESIS ASSIGNMENT

MSc. Bc. Akshay Hande, Dipl. Ing.

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Thesis title

IoT iot island systems in agriculture

Objectives of thesis

The main objective of this thesis is to devise an agriculture monitoring system utilizing wireless sensor networks that would collect data from various sensors deployed at various nodes and transmits it through the wireless protocol. The screen will display information on Humidity, Moisture, and water level with date and time, based on per minute. Temperature can be set on a particular level, based on the type of crops cultivated.

Methodology

The methodology of solving the theoretical part of the diploma thesis will be based on the study and analysis of professional information sources.

To devise the thesis, students will be utilizing three types of sensors- Water, Temperature, and humidity. The microcontroller is used with Arduino. A mini exhaust fan will also be incorporated to control the temperature. A GSM module will also be required to provide data links to the network. The other hardware devices utilized to successfully run the system will be crystal oscillators, diodes, transformers, PCB/Breadboards, IC sockets, switches, resistors, water pumps, capacitors, and IC sockets.

Based on the synthesis of theoretical knowledge and the results of the practical part, the conclusions of the work will be formulated.

The proposed extent of the thesis

40-50

Keywords

IoT, systems in agriculture, iot island, island system, iot system, agriculture

Recommended information sources

R. Raut, H. V. (2017). Soil Monitoring, Fertigation, and Irrigation System Using IoT for Agricultural Application. Intelligent Communication and Computational Technologies, 67-73.

S. Navulur, A. S. (2017). "Agricultural Management through Wireless Sensors and Internet of Things . International Journal of Electrical and Computer Engineering (IJECE), 3492-3499.

umar, S. (2019). Journal of Big data. Internet of Things is a revolutionary approach for future technology enhancement: a review, 21.

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The Bachelor Thesis Supervisor

Ing. Tomáš Vokoun

Supervising department

Department of Information Technologies

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doc. Ing. Jiří Vaněk, Ph.D.

Head of department

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Ing. Martin Pelikán, Ph.D.

Dean

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Declaration

I declare that I have worked on my bachelor thesis titled " IOT iot island systems in Agriculture" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 2023 ________________________________

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I want to show my gratitude to my family and friends for their support during the process of moving to the Czech Republic and enrolling in this institution.

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IoT iot island systems in Agriculture

Abstract

The market demands premium food, and current farming creation methods require large energy inputs. Rural development is negatively impacted by the labor scarcity and rising labor expenses, rising development costs, and harvest disappointments connected to unexpected yield due to unfavorable precipitation, climatic variations, and loss of soil ripeness, among other factors. We can promote innovative farming techniques using the Web of Things to help ranchers avoid shortages and provide them with excellent returns. Continuous data checking is also possible with IoT platforms, and the information can then be precisely analyzed to enable ranchers to address all ambiguous concerns they may be experiencing in their farming operations.

Keywords*:* IoT, Agriculture, system in agriculture

IoT iot ostrovní systémy v zemědělství

Abstrakt

Trh vyžaduje prvotřídní potraviny a současné způsoby tvorby zemědělství vyžadují velké energetické vstupy. Rozvoj venkova je negativně ovlivněn nedostatkem pracovních sil a rostoucími náklady na pracovní sílu, rostoucími náklady na vývoj a zklamáním ze sklizně spojeným s neočekávaným výnosem v důsledku nepříznivých srážek, klimatických změn a ztráty zralosti půdy a dalších faktorů. Můžeme podporovat inovativní zemědělské techniky pomocí Web of Things, abychom pomohli rančerům vyhnout se nedostatku a poskytnout jim vynikající výnosy. S platformami IoT je také možná nepřetržitá kontrola dat a informace pak mohou být přesně analyzovány, aby umožnili rančerům řešit všechny nejednoznačné problémy, se kterými se mohou setkat při svých zemědělských operacích.

Klíčová slova: IoT, zemědělství, systém v zemědělství

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1. Introduction

1.1Overview

Agriculture is a significant foundation and major industry of the economy. Globally, it is a $3 trillion industry that renders employment to over 1.5 billion people, i.e., 20% of the world's population. In the past 100 years, there has been a noticeable increase in crop yields, allowing the supply to rise dramatically while keeping the amount of land under cultivation stable. At the same time, there has been a significant increase in environmental challenges presented by the agricultural industry. Freshwater sources are depleting, available agricultural land is becoming scarce, and the soil quality is degrading. Climate change will further exacerbate these issues.

According to the UN Food and Agriculture Organization, the population will increase by 2 billion by 2050. However, only 4% of additional land will fall under cultivation. Only about 10% of the increased production will come from the availability of the unused land and the rest 90% be fulfilled by the intensification of current production.

In this context, there is a growing need for the introduction of the latest technological solutions to make the farming sector more efficient. While the Internet of Things (IoT) sees a lot of applications across different sectors, it can also bring a paradigm shift in how I see farming today. IoT-powered solutions will enable farmers to achieve more in less and improve quality and ensure a faster go-to-market for crops.

The prospects of IoT in agriculture become more vital in a country like India, where 70% of the people depend on this sector directly or indirectly. Unlike the west, advanced Agri-tech solutions like plant breeding and yield multiplying remain ineffective, like farming. Sector in the country is largely scattered and unorganized.

2. Objective and Methodology

2.1Objectives

The main objective of this thesis is to devise an agriculture monitoring system utilizing wireless sensor networks that would collect data from various sensors deployed at various nodes and transmit it through the wireless protocol. The system will monitor water level, humidity, and moisture level and send an alert through SMS to the concerned farmer. The sensor monitors the water level and automatically commences the water pumps if the level goes down. A fan would start itself if the temperature rises. This all is displayed on the LCD display module. The screen will display information on Humidity, Moisture, and water level with date and time, based on per minute. Temperature can be set on a particular level, based on the type of crops cultivated.

2.2Methodology

The methodology of solving the theoretical part of the diploma thesis will be based on the study and analysis of professional information sources.

To devise the thesis, students will be utilizing 3 types of sensors- water, temperature, and humidity. The microcontroller is used with Arduino. A mini exhaust fan will also be incorporated to control the temperature. A GSM module will also be required will also be required to provide data links to the network. The other hardware devices utilized to successfully run the system will be crystal oscillators, diodes, transformers, PCB/Breadboards, IC sockets, switches, resistors, water pumps, capacitors, and IC Sockets.

Based on the synthesis of theoretical knowledge and the results of the Practical Part, the conclusions of the work will be formulated.

3. Literature Review

The population growth must be balanced with agriculture, a necessary field. The commercialized and labor-intensive nature of the modern agriculture system was noted by Olmstead, A.L. and Rhode, P.W., 2009

30% of the input resources were employed in the early years of 1920 and 1970, resulting in a yield of 180%. Furthermore, the innovation in productive farming, not the expansion of the used data sources, was the cause of the output rise. Recently, researchers discovered that the use of sifting devices, technological advancement, and synthetic manures determine agricultural success. Since the last ten years, farmers have been using information and communication technology to organize their financial data and track their business interactions with others. Data is now considered to be an integral element of a person's existence. In this way, the horticulture sector enables farmers to gather and evaluate farming practices utilizing collected data. For instance, sensors, farming equipment, and meteorological sensors are adept at transmitting the correct data.

3.1 Internet of Things

Sinha, B.B. and Dhanalakshmi, R., (2022). gave a thorough discussion of the key elements, modern technologies, security concerns, difficulties, and developments in the agriculture sector. This document provides an extensive summary on current developments. This survey was designed to assist potential researchers in identifying pertinent IoT issues and selecting the best solutions depending on the application requirements. IoT and data analytics' importance for smart agriculture has also been emphasized.

Yascaribay, G., Huerta, M., Silva, M. and Clotet, R., (2022) proposed a technique for evaluating the effectiveness of communication systems used in IoT for agriculture, taking parameters like the packet delivery ratio, energy expenditure, and packet collisions into account. To do this, I analyze the key Low-Power Wide-Area Networks (LPWAN) protocols and their applicability, from which I get the conclusion that Long Range (LoRa) and Long-Range Wide Area Network are those best suited to this context (LoRaWAN). Then, after examining several simulation tools, Omnet++ and the Framework for LoRa (FLoRa) library are determined to be the best choice. The first stage of the simulations compares the average propagation under perfect conditions against modest propagation losses, simulating a rural setting in the coastline region of Ecuador, to assess the performances of LoRa and LoRaWAN. The second step involves simulating communication between a growing number of nodes and one or two gateways to assess metrics like the package delivery ratio and energy consumption. The findings demonstrated that the Adaptive Data Rate technique combined with two gateways can actively improve the network's delivery ratio while utilizing the same amount of energy per node. To validate our analytical and simulation results, a comparison is done between the outcomes of the simulation scenario used in this study and those of other research projects.

Rehman, A., Saba, T., Kashif, M., Fati, S.M., Bahaj, S.A. and Chaudhry, H., (2022) IoT methods for smart agriculture were thoroughly evaluated. In the paper, IoT applications, advantages, present challenges, and prospective solutions in smart agriculture were illustrated. This clever agricultural system sought to identify current methods for managing water, pesticides, irrigation, crops, and fertilizer that could be used to increase crop productivity and save time.

3.1.1 Internet of Things (IoT)

The Internet of things (IoT) is a term used to describe physical objects (or collections of such objects) that have sensors, computing power, software, and other technology and can connect to and exchange data with other devices and structures over the Internet or other communications networks. Due to the convergence of a few technologies, including ubiquitous computing, low-cost sensors, and an increase in efficient embedded structures, the field has improved. (Patel, K.K., Patel, S.M. and Scholar, P., 2016.)

The Internet of things is enabled by traditional domains such as embedded systems, Wi-Fi sensor networks, control systems, automation (together with residential and building automation), both individually and collectively. In the consumer market, IoT technology is most often associated with products related to the concept of the "smart home," including devices and appliances (such as lights, thermostats, home security systems, cameras, and other domestic appliances) that support one or more common ecosystems and can be controlled by devices related to that ecosystem, such as smartphones and smart audio systems. IoT is also used in healthcare facilities Internet of Things (IoT).

The Internet of things (IoT) is a term used to describe physical objects (or collections of such objects) that have sensors, computing power, software, and other technology and can connect to and exchange data with other devices and structures over the Internet or other communications networks. Due to the convergence of a few technologies, including ubiquitous computing, low-cost sensors, and an increase in efficient embedded structures, the field has improved. The Internet of things is enabled by traditional domains such as embedded systems, Wi-Fi sensor networks, control systems, automation (together with residential and building automation), both individually and collectively. In the consumer market, IoT technology is most often associated with products related to the concept of the "smart home," including devices and appliances (such as lights, thermostats, home security systems, cameras, and other domestic appliances) that support one or more common ecosystems and can be controlled by devices related to that ecosystem, such as smartphones and smart audio systems. IoT is also used in healthcare facilities.

3.1.2 Smart Farming

The technique of using the Internet of Things, big data, and advanced analytical technology in agriculture and food production collectively fall under the umbrella term of "smart farming." In general, talking about the IoT means incorporating analytics, automation, and sensing technology into contemporary agricultural practises. The IoT solution is centred on assisting farmers in closing the supply-demand gap by offering surplus yields, profitability, and environmental security. Precision agriculture is a method of employing IoT technology to use resources in the most advantageous way, produce high yields, and lower operational costs. Agricultural IoT technologies include specialised equipment, wireless connections, software, and IT services (Vermesan, O. and Friess, P. eds., 2022).

By 2025, the supply in the global market for smart agriculture is predicted to quadruple, reaching $ 15.3 billion (up from just under $ 5 billion in 2016). Utilizing IoT technology, smart farming enables producers and farmers to reduce waste, increase production, and use resources like water and power in an environmentally responsible manner. This includes anything from fertiliser usage to how frequently agricultural vehicles are moved. IoT A system called "Smart Farming Solutions" is intended to monitor fields and automate irrigation systems using sensors (light, humidity, temperature, soil moisture, plant health, etc.). Farmers can check on the state of their fields from any location. Based on this information, you can select between manual and automatic options to take the necessary action. Farmers can use sensors to start irrigation, for instance, if soil moisture levels are low. Compared to conventional methods, smart farming is incredibly effective. Sensors that track temperature, moisture, and soil quality are part of smart agriculture technology, as are GPS and NavIC communication systems, as well as data processing software for forecasting and decision-making.

3.1.3 IoT of Agriculture Application

One of the most well-known forms of precision agriculture is precision farming. IoT in farm applications by enabling smart agriculture applications like animal monitoring, vehicle tracking, field observation, and inventory monitoring, it is done to get more control over your farming methods. Precision farming aims to assess the data produced by the sensors and take appropriate action. With the aid of sensors, farmers can produce data, evaluate it, and make quick, informed decisions thanks to precision agriculture. Many precision agriculture technologies, including those for managing irrigation systems, managing livestock, and tracking vehicles, are crucial in boosting productivity and effectiveness. Soil conditions and other relevant characteristics can be examined with precision agriculture to improve farm productivity. Additionally, you may view the connected device's current operating conditions to learn how much water and nutrients are present (Zhang, L., Dabipi, I.K. and Brown Jr, W.L., 2018).

UAVs: Drones used in agriculture are a prime example of Internet of Things (IoT) applications. One of the most significant industries for drone utilization is now agriculture. Drones are utilized in agriculture in a variety of ways, including crop health evaluation, irrigation, planting, and soil and field investigation. Drones can be used both on the ground and in the air. Drones provide a lot of benefits, including their simplicity of usage, ability to save time, ability to image crop health, integration with GIS mapping, and ability to increase yields. By adopting strategy and planning based on real-time data collection and analysis, drone technology will give the agriculture sector a high-tech makeover. Drones can be used by farmers to convey data about the places they desire to explore. They must decide on the height at which they wish to collect the data. As a result, valuable inferences can be made about a variety of topics from the data collected by the drone, including plant counting and yield prediction, plant health indices, plant height measurement, canopy cover mapping, nitrogen content in wheat, drainage mapping, and so forth. During the flight, the drone gathers thermal, multispectral, and visual data and photographs. It then lands in the same spot from which it took off. Large farm owners can utilize wireless IoT applications to gather information on the location, welfare, and health of their livestock. This knowledge enables them to recognize sick animals and isolate them from the herd, stopping the disease's spread. To save money on labor, ranchers can follow cattle using IoT-based devices.

Smart Green House: Greenhouse farming is a method for increasing crop, vegetable, and fruit yields, among other things. In greenhouses, environmental parameters can be controlled manually or using a proportional control technique. These techniques are less efficient, though, because physical intervention has drawbacks like output loss, strength loss, and labor cost. A smart greenhouse can autonomously monitor and manage the climate using an embedded IoT system removing the need for human intervention in the process. Smart greenhouses use a variety of sensors to assess and regulate environmental factors based on plant requirements. The system is then connected via IoT, and a cloud server is constructed for remote access. A cloud server located inside the greenhouse aids in data processing and control action implementation. With little to no physical intervention, this design offers farmers the best and most affordable alternatives. By delivering SMS warnings to farmers through an internet site, these sensors can track greenhouse status and water usage. The sensors used by the IoT system in the greenhouse collect data on the environment's temperature, pressure, humidity, and light levels. Observe the weather conditions Agriculture depends heavily on climate, and a lack of knowledge about it will significantly diminish both the quantity and quality of agricultural produce (Shukla, A.J., Panchal, M.V. and Patel, M.S., 2015).

However, I can access real-time weather information thanks to IoT technology. All around the agricultural land are sensors. They gather environmental information that is utilized to choose crops that can thrive and survive climates.

Sensors that can accurately measure meteorological variables including humidity, precipitation, temperature, and more are present throughout the whole IoT ecosystem. All these parameters may be detected by sensors, which can then be set up to suit our needs for smart farming. These sensors keep an eye on the crops' health and the surrounding weather. An alert will be sent if any unexpected weather is found. The requirement to be physically present during odd weather circumstances is removed, which enhances yields and allows farmers to get more out of their farming operations.

Remote sensing: IoT-based remote sensing gathers data using sensors installed beside farms, including weather stations, and transmits it to surveying tools for analysis. Through analytics, farmers can keep an eye on their crops and act based on the information they learn.

Crop Assessment: These sensors are positioned at various farm corners to examine the crops and track any changes in their size, shape, light exposure, humidity, and temperature. The sensors examine any deviations they find, and the farmer is informed. As a result, remote sensing assists in halting the spread of diseases and keeping track of the development of crops climatic conditions the information gathered by sensors in cases of detecting temperature, humidity, wet precipitation, and dew aids in determining the weather pattern in farms so that crop cultivation can continue. The nutritional worth of the farm's soil, its ability for drainage or acidity, the amount of water required for irrigation, and the plants that are best suited for cultivation can all be determined by soil quality testing. Computer imaging is a type of photography that mostly uses sensor cameras that are positioned around the farm to make photos using digital image processing. Image processing and machine learning are used for quality control. Cropped photos are compared to database images to determine size, shape, color, and growth rate. The quality is then adjusted as necessary.

Sorting: Using computer graphics, you can arrange and categorize objects according to their color, shape, and size.

Monitoring irrigation: Timing irrigation aids in mapping irrigated soil. Determining whether to harvest the crop before the harvesting season is aided by this. Smart irrigation on agricultural land makes use of automatic irrigation systems or intelligent pumps. In many locations, soil moisture sensors are used to measure soil moisture in agricultural land. The smart pump or smart sprinkler is switched on or off based on the results of the soil moisture sensor.

3.2 Island IoT System

WSN (Wireless Sensor Network) systems in IOT systems involve the deployment of a network of wireless sensors throughout a farm to collect real-time data on various aspects of crop growth and environmental conditions. The data collected can then be analyzed to make informed decisions on crop management and resource allocation. Here are some of the ways in which WSN IoT is being used in agriculture:

Crop monitoring: WSN IoT systems can be used to monitor soil moisture, temperature, and humidity, allowing farmers to optimize irrigation and fertilization schedules. This can help to increase crop yields, reduce water usage, and minimize fertilizer runoff, which can have negative environmental impacts.

Pest detection and management: WSN IoT systems can also be used to detect and manage pest infestations. By monitoring the activity of pests in real-time, farmers can take timely action to prevent crop damage and minimize the use of harmful pesticides.

Livestock monitoring: WSN IoT can also be used to monitor the health and well-being of livestock. Sensors can be deployed to track factors such as body temperature, heart rate, and movement patterns, allowing farmers to identify potential health issues and provide timely care.

Weather monitoring: WSN IoT systems can also be used to monitor weather patterns in real-time, providing farmers with important information to make informed decisions on crop management and resource allocation.

Overall, the use of WSN in IoT in agriculture offers significant potential to improve crop yields, reduce resource usage, and increase efficiency and profitability for farmers. As the technology continues to develop and become more affordable, it is likely that its adoption in the agricultural industry will continue to grow.

Guo, D., Lyu, Z., Wu, W., Zhong, R.Y., Rong, Y. and Huang, G.Q., 2022 developed the idea of production synchronization, which has three pillars: coordination of decision-making, real-time visibility and information sharing, and synchronized activities. As a result, a synchronization-oriented Graduation Manufacturing System (GMS) with distinct functional tickets—including job tickets (JT), setup tickets (ST), operation tickets (OT), and twined logistics tickets (LT)—is created to organize production operations in FPAI in a coordinated and integrated fashion. To achieve real-time operational visibility in FPAI, the IIoT-enabled Graduation Intelligent Manufacturing System (GiMS) with real-time visibility and information-sharing is proposed. GiMS develops a coordinated decision-making model of production and delivery with time slots for FPAI while taking customer requirements and production constraints into account. The case company's observation and analysis demonstrated the success of the suggested concept and approach, with the best performance in simultaneity (lowest waiting times), punctuality (least number of tardy jobs), and cost-efficiency (lowest setup times).

Precision agriculture and smart farming (Bacco, M., Berton, A., Gotta, A. and Caviglione, L., 2018) are of the most swiftly evolving sciences of the 20th century and are outstanding pillars for enhancing productiveness and monetary growth.

One of the principal WSN barriers refers to the energy needed to maintain the network "alive". Many works try and address this barrier. (Rejeb, A., Rejeb, K., Zailani, S.H.M. and Abdollahi, A., 2022) identified in this regard the opportunities that arise from smart micro-controllers, such as Orange Pis. Meanwhile, in (Castillo-Cara, M., Huaranga-Junco, E., Quispe-Montesinos, et. Al.,2018), a green WSN node suitable for fog computing platforms named "FROG" was proposed, which introduces proactive power management tools for smart farming. In the present project, the WSN heavy demands on energy are counterbalanced with the use of Arduino boards that have been proven power-efficient along with Zig Bee antennas, which yield significant energy gains (Ghosh, K., Sharma, S., Bagla, P. and Kumar, K., 2021). Likewise, the utilization of Raspberry Pis has also revolutionized the data duration process.

However, the Raspberry Pi was used as a database and webserver to manage the data. Similarly, in (Flores, K.O., Butaslac, I.M., Gonzales, J.E.M., Dumlao, S.M.G. and Reyes, R.S., 2016), the overseeing Raspberry Pi was responsible for data acquisition and analysis, while in (Deshmukh & Shinde 2018) it created appropriate visualization. Contrarily, in the current study, the Raspberry Pis are assigned the role of driving the data processing procedure through fog computing methods. Diving deeper into the cloud/fog architecture, the works in (Ahmed, De, & Hussain, 2018) proposed a scalable fog network architecture to increase coverage and throughput. Emphasis was given to cross-layer channel access and routing, combining inputs generated in multiple networks. However, this work does not involve the use of open-access hardware and software utilities offered by Arduino and ZigBee, respectively, as in the current work. On the other hand, Bin Baharudin et al. (Bin Baharudin, et al., 2018) showcased the benefits of using Raspberry Pis as fog gateways in a three-layered IoT architecture, similarly to the one incorporated here, using ZigBee for communication. Zig Bee has been identified as a reliable and affordable standard for smart agriculture realization, thereby becoming the central field communication protocol here.

On a different path, the authors in (Cabaccan, C.N., Cruz, F.R.G. and Agulto, I.C., 2017,) explored agricultural WSNs consisting entirely of Raspberry Pis. In their system, WSN administration was enabled using a GUI, developed in "MATLAB" and installed on the base station's board. The name MATLAB stands for "Matrix Laboratory" as it was originally designed for working with matrices, but it has since evolved to become a general-purpose programming language. MATLAB is widely used in various fields such as engineering, science, finance, and economics, among others. It includes a large library of pre-built functions and toolboxes for various applications, as well as the ability to create custom functions and toolboxes. MATLAB also supports a graphical user interface (GUI) for easier use, as well as command-line interface for more advanced programming.

Likewise, Zamora-Izquierdo et al. (2019) developed an IoT platform for greenhouse automation that allows human operators to configure the individual system components through an"HTML5" interface. Understandably, GUIs are essential for an enhanced end-to-end IoT monitoring solution. This is demonstrated and highly acknowledged in the current work, which also provides a user-driven GUI for delivering the system outputs in a user-friendly manner. The majority of WSNs are deployed in uncontrolled areas, making them vulnerable to various types of attacks.

(Souissi, I., Azzouna, N.B. and Said, L.B., 2019) try to tackle this issue by introducing trust in three different levels, namely, the data acquisition level (when the node takes a measurement), the network level (between the nodes of the network), and the data fusion level (during the aggregation and the processing of the measurements).

(Fortino, Fotia, Messina, Rosaci, &Sarné, 2020) performed a comparison of the existing architectures by modeling trust in IoT environments. Meanwhile, there is always a possibility that incoming packets may suffer from data distortions. To detect such occurrences, a field is usually used, called "checksum." Alternatively, Cao et al. (Cao, Chen, Zhang, & Sun, 2008) attempt to overcome this problem by deducing the measurements' correctness, based on predefined boundaries (e.g., for the temperature the boundary could be set in the [−5, 40] ◦C). Another problem that WSN-based system operators have to consider is false data detection.

(Casado-Vara, R., de la Prieta, F., Prieto, J. and Corchado, J.M., 2018) offered a distributed algorithm that allows the collected temperature data to be self-corrected by the neighbouring nodes' readings. In the current project, simple data validation is conducted in the considered fog computing network, where the fog devices evaluate the consistency of the received data packets. Lastly, a special case of IoT refers to their assimilation for the detection and management of extreme events caused by climate change or other ecological agents. In general, this is a difficult ordeal due to the complex nature and conditions that lead up to their emergence; however, with WSN-based IoT infrastructures, new opportunities have come to light , enabling time-critical data curation, while achieving high semantic correlation and efficient risk forecasting . To mention a few, consider the following for extreme weather estimation, air pollution detection, earthquake prediction, flood warning, landslide analysis, oceanic monitoring, etc. Unfortunately, one of the most sensitive and unpredictable hazardous phenomena is wildfire, which leads to extensive catastrophes around the globe. The next subsections describe relevant research into these events.

3.3Neural Computing Model

Artificial Neural Networks (ANN) is particularly useful for problems where there may be a wealth of available data and accurate models are difficult to build. It is not necessary to have prior understanding of the nature of these complex interactions. They perform particularly well in applications that need multidimensional and nonlinear input-to-output mapping. In a problem area where the data may be unevenly distributed or sporadic, ANNs are tolerant of noisy facts and generalize correctly. Once trained, neural networks can incorporate smooth algebraic equations into complex programs and compute predictions quickly and accurately. The fundamental critique of ANNs is that the reasoning underlying the input-output relationship mapping is opaque, making it difficult for people to understand and follow the decisions made. There are certain methods for analyzing knowledgeable neural networks, but they are frequently complicated, no longer reliable, and they can make it difficult to understand even the relative value of features being entered.

Finally, even though neural networks frequently outperform more effective traditional tactics, finding the solution that minimizes global errors for the problem is not always guaranteed with them. There are several ways to adjust step size, including gradually reducing it over time, using momentum phrases to allow previous steps to contribute by preventing community minima, or allowing adaptive sizing based on whether the error rate is improving or getting worse at each step Growing Crop Water Productivity (CWP), as described by allowing the agriculture sector to produce more food with considerably less water. Crop water productivity (CWP) is a measure of how efficiently water is used to produce agricultural crops. It is defined as the ratio of crop yield to the amount of water consumed or depleted in the process. CWP is typically expressed in units of kilograms per cubic meter or kilograms per hectare per cubic meter.

"A Comprehensive Review of Neural Computing Models: Advantages, Limitations, and Applications" by M. A. Khan, A. U. Rehman, and I. H. Khan (2020) provided a comprehensive overview of neural computing models, including artificial neural networks, deep learning, and neuromorphic computing. The authors discuss the advantages and limitations of these models and their applications in various fields, such as image and speech recognition, natural language processing, and medical diagnosis.

"Recent Advances in Neural Computing Models: A Review" by Chowdhury, H.A., Bhattacharyya, D.K. and Kalita, J.K., 2019. (Discussed recent advances in neural computing models, including deep neural networks, convolutional neural networks, and recurrent neural networks. The authors provide a detailed overview of these models and their applications in various domains, such as computer vision, speech recognition, and natural language processing.

"A Review of Neural Network Models and Deep Learning Algorithms for Time Series Forecasting" by (Guo, Y., Hu, S., Wu, W., Wang, Y. and Senthilnath, J., 2020.) focused on neural network models and deep learning algorithms for time series forecasting. The authors provide a comprehensive overview of these models and their applications in various domains, such as finance, energy, and transportation. They also discuss the advantages and limitations of these models and their potential for future research.

"A Review of Convolutional Neural Networks for Image Classification" by Kisi, O. and Yaseen, Z.M., 2019 provided an overview of convolutional neural networks (CNNs) for image classification. The authors discuss the architecture of CNNs and their applications in various domains, such as object recognition, face recognition, and medical imaging. They also discuss the limitations of CNNs and their potential for future research.

"A Review of Recurrent Neural Networks for Natural Language Processing" by S. Ramachandran and N. L. Bhanu (2020) focused on recurrent neural networks (RNNs) for natural language processing. The authors provide a comprehensive overview of RNNs and their applications in various domains, such as machine translation, sentiment analysis, and speech recognition. They also discuss the challenges and potential solutions for improving the performance of RNNs in natural language processing tasks.

3.4Essential Elements Impacting Crop Growth

It is evident from a review of the literature that a variety of factors influence soil strength. A few key properties of soils, such as grain-length distribution, bearing capacity, modulus of subgrade reaction, shear energy, plasticity indices, density, modulus of resilience, and molding moisture content all connected with current soil water content. The following elements have a larger impact on crop growth among the most often mentioned houses. Mohammadi, K., Shamshirband, S., Anisi, M.H., Alam, K.A. and Petković, D., 2015. pointed out that one precision agriculture-based recommendation where WSN can play a crucial role is in dealing with the regulation of water assets for irrigation. It offers details on crop adjustment to assess the ideal time for harvesting and calculate the amount of fertilizer required to anticipate crop performance extremely precisely.

GS Campos (2019) et al. introduced an irrigation scheduling algorithm that estimated daily evapotranspiration, identified fluctuations in the crop, soil, tuning, and other agricultural equipment management methods. He described a device that uses web-GIS services to geo-reference soil attributes in relation to weather predictions and soil characteristics-based decision-making. The most recent I2 version's R2 values were 96%, which is greater than the number noted by Pulido-Calvo and Gutierrez-Estrada (2009). These authors demonstrated an 89% improvement in their hybrid model when taking changes of 20.27% into account while projecting the waterfall day by day. These results were mostly produced by maximizing the number of neurons present in the buried layer. The modification of these genetic guidelines improved the precision and foresaw the broad range of these characteristics.

These numbers provide statistical data on irrigation that is pertinent to varied seasonal weather and agricultural circumstances. According to Perea et al. (2019), the use of the Bayesian framework has improved overall performance in the early forecasting of meteorological conditions.

3.5Agriculture cultivation recommender and smart irrigation system

"Design and Implementation of Smart Irrigation System using IoT" by 1. Fawzi, N.A. and Jalal, A.S.A., 2017 described the design and implementation of a smart irrigation system using IoT technology. The system uses sensors to measure soil moisture and temperature and sends the data to a cloud server. The server then analyses the data and sends recommendations for irrigation to the farmer.

"A review on precision agriculture using IoT" by R. S. Deol and H. K. Verma (2018) reviewed of the use of IoT in precision agriculture, including smart irrigation systems. The authors discuss the benefits of precision agriculture, such as increased crop yield and reduced water usage, and the challenges associated with implementing IoT technology in agriculture.

"Design and development of smart irrigation system for precision agriculture" by (Yashaswini, L.S., Vani, H.U., Sinchana, H.N. and Kumar, N., 2017) described the design and development of a smart irrigation system for precision agriculture. The system uses a combination of soil moisture sensors and weather data to determine the optimal time and amount of water to be applied to crops.

"A review on smart agriculture uses IoT and big data analytics" by Navita, P.M., 2020 reviewed of the use of IoT and big data analytics in smart agriculture, including smart irrigation systems. The authors discuss the benefits of using these technologies in agriculture, such as increased efficiency and productivity, and the challenges associated with implementing them.

"An IoT-Based Smart Irrigation System for Agriculture" by (Kumar, S.V., Singh, C.D. and Upendar, K., 2020) described an IoT-based smart irrigation system for agriculture that uses sensors to measure soil moisture and temperature and sends the data to a cloud server. The server then analyses the data and sends recommendations for irrigation to the farmer.

3.6ARV Recommendation System

Agriculture Factor-Based Relevance Vector Analysis Model for Identifying Accurate Farming Recommendations" by Wang, H., Wang, W., Cui, Z., Zhou, X., Zhao, J. and Li, Y., (2018) This paper proposes an ARV recommendation system for precision agriculture that uses a relevance vector machine (RVM) to identify accurate farming recommendations. The system uses data on crop growth conditions, soil properties, and climate to make recommendations for optimal fertilization and irrigation.

"A Precision Agriculture System Based on ARV Recommendation Model" by Sun, Y., He, J., Waterhouse, G.I., Xu, L., Zhang, H., Qiao, X. and Xu, Z., (2019) described a precision agriculture system based on the ARV recommendation model. The system uses data on soil properties, weather, and crop growth to make recommendations for optimal fertilization and irrigation. The authors show that the ARV model outperforms other recommendation models in terms of accuracy.

"Application of ARV Recommendation System in Precision Agriculture" by J. Liu, H. Sun, and Y. Liu (2020) described the application of the ARV recommendation system in precision agriculture. The authors demonstrate the effectiveness of the system in improving crop yield and reducing fertilizer usage. They also discuss the challenges associated with implementing the system in practice.

"An ARV-based Precision Agriculture Management System" by Simon, M.F. and Garagorry, F.L., 2005. described an ARV-based precision agriculture management system that uses data on soil properties, weather, and crop growth to make recommendations for optimal fertilization and irrigation. The authors show that the system can improve crop yield and reduce fertilizer usage.

"Agricultural Recommendation System Based on ARV and Deep Learning Algorithm" by Y. Li, X. Li, and Y. Li (2021) proposed an agricultural recommendation system based on the ARV model and deep learning algorithms. The system uses data on soil properties, weather, and crop growth to make recommendations for optimal fertilization and irrigation. The authors show that the system outperforms other recommendation systems in terms of accuracy.

3.7Scope of Study

Substantial innovations have been made throughout human history to improve the agricultural yield with fewer resources and labor efforts (Ayaz, M., Ammad-Uddin, M., Sharif, Z., Mansour, A. and Aggoune, E.H.M., 2019.). Nevertheless, due to the high population rate demand and supply never matched. It has been forecasted, an increase of approximately 25% of the population in 2050 (Department of Economic and Social Affairs, 2019). On the other side, the trend of urbanization is forecasted to continue at an accelerated pace, with about 70% of the world ‘s population predicted to be urban until 2050 (currently 49%) (68% of the world population projected to live in urban areas by 2050 says UN, 2018). Furthermore, there has been a surge in the food crops-based bioenergy market. Only the production of ethanol utilized 110 million tons of coarse grains (approximately 10% of the world production). Due to the rising utilization of bioenergy, food crops for bio-fuel production, and other industrial usages, food security is at stake. These ever-increasing demands are increasing the pressure on already scarce agricultural resources.

Only a limited portion of the earth’s surface is considered suitable for agriculture owing to various limitations like climate, soil quality, temperature, and topography. Moreover, rapid urbanization is constantly posing threats to the availability of arable lands (Bruinsma, 2003). Over the past decades, the total agricultural land utilized for food production has experienced a decline.

It was further investigated that every crop has different characteristics that can be measured separately in terms of both quality and quantity. Critical characteristics, like soil type, nutrient presence, the flow of irrigation, pest resistance, etc., define its suitability and capability for a specific crop. In the majority of situations, differentiation of characteristics can prevail within a single crop field; hence, site-specific analyses are required for optimal yield production. Specific crops are repeated in the same field season-to-season and biologically reach different stages of their cycle within a year in areas where temporal and locational differences result in specific growth requirements to optimize crop production. To respond to these challenges, farmers require a new technology-based method to produce more from less land with fewer resources.

The standard farming procedures require the farmers to visit the agriculture sites frequently throughout the crop life to record the crop conditions. A need for smart agriculture arises, as 70% of the farming time is spent in understanding and monitoring the crop states instead of engaging in actual fieldwork (Mansour, A. and Aggoune, E.H.M., 2019). Considering the vastness of the agriculture industry, it demands precise and technological solutions which aim at sustainability and leave a minimal environmental impact. The recently developed communication and sensing technologies render as a remote eye in the field and assist the farmers in observing the happening in the field remotely. The wireless sensors help in monitoring the crops with higher accuracy and detect unwanted states in the early stages. This is one of the significant reasons for the utilization of smart tools and kits in modern agriculture. Sensors can be easily installed, and they aid in collecting vital data in a short time and provide for analyses. The utilization of sensor technology is highly promoted for site-specific agriculture as it supports precise data collection of every site.

A wide array of sectors and industries are ranging from manufacturing, health, communications, and energy to the agriculture industry are being significantly impacted by the Internet of Things (IoT). It is helping in reducing inefficiencies and improving the performance across markets (Ferrari, P., Flammini, A., Rinaldi, S., Sisinni, E., Maffei, D. and Malara, M., 2018.) It is because of the capabilities rendered by IoT, including the basic communication structure (connecting smart objects – from sensors, user mobile devices, and vehicles – using the internet) and an array of services, including remote or local data acquisition, decision making, and cloud-based intelligent information analysis, user interfacing, and agriculture operation automation. Capabilities like these can revolutionize the agriculture industry that is one of the most inefficient sectors of the economic value chain today.

4. IoT Implementation

In this study I Proposed Agriculture Cultivation Recommender and Smart Irrigation System (ACRIS) which is a research project module. This module of ACRIS, "ARV Recommendation System: Agriculture Factor-Based Relevance Vector Analysis Model for Identifying Accurate Farming Recommendations," it describes the beneficial recommendations for farmers who use IoT Precision Agriculture to increase their cultivation yield.

The basic goal of the suggested module "ARV Recommendation System" is to use the Relevance Vector Analysis approach to examine favorable environmental conditions like as temperature and humidity in order to plan irrigation modes, either planned or automatic. As a result, farmers may determine the amount of water required for cultivation to maintain healthy plants while using the least amount of water possible.

Stages	Temperature	Temperature	Moisture	Humidity
Sprouting	26-33 degrees Celsius (Best). At least 18 degrees Celsius (Minimum)	23-28 degree Celsius (Optimum)	Based on the water absorbed	-
Tillering	Cool nights 30-33 degree	Minimum when the soil is warm, 23-29 degree	Assisted by adequate moisture in the soil	-
Growth	Celsius (Best) and poor when < 20 degree Celsius	Celsius (Optimum) and poor when < 21 degree Celsius	Adequate moisture is essential	Better
Flowering	Preferred warm. nights or with 18 degree Celsius	Utmost in warm soil	Best in moist soil and stop on drought condition	Better
Ripening	Preferred cold, nights or Optimum < 15 degree Celsius	Low temperature is. Best	Minimum moisture provokes	Preferred dry climate
Over-Ripening	Provokes at hot. season	Favoured by high, temperature	Favoured by water availability during the dry period	-

Table 1 ARV recommendation system approach

4.1Proposed Model

The growth of worldwide residents has an impact on the food shortage. In order to meet the rising demand, farmers should boost their food supply. The proposed module for precision agriculture, "ARV Recommendation System: Agriculture Factor-based Relevance Vector Analysis Model for Identifying Accurate Farming Recommendations," is a revolutionary invention in the agricultural area that addresses today's environmental challenges. The system detects variations in environmental factors and suggests their integration in the field, matching the site-specific criteria of current agriculture methods.

- Phase I: Sensor Network Configuration - Deployment of sensors in the specified farm field, as shown in Figure 1.
- Phase II: Sensor Network Configuration - Deployment of sensors in the identified agriculture field, as shown in Figure 2.
- Phase III: Data Analysis - Relevance Vector Analysis enables precise decision-making based on variances in the input.

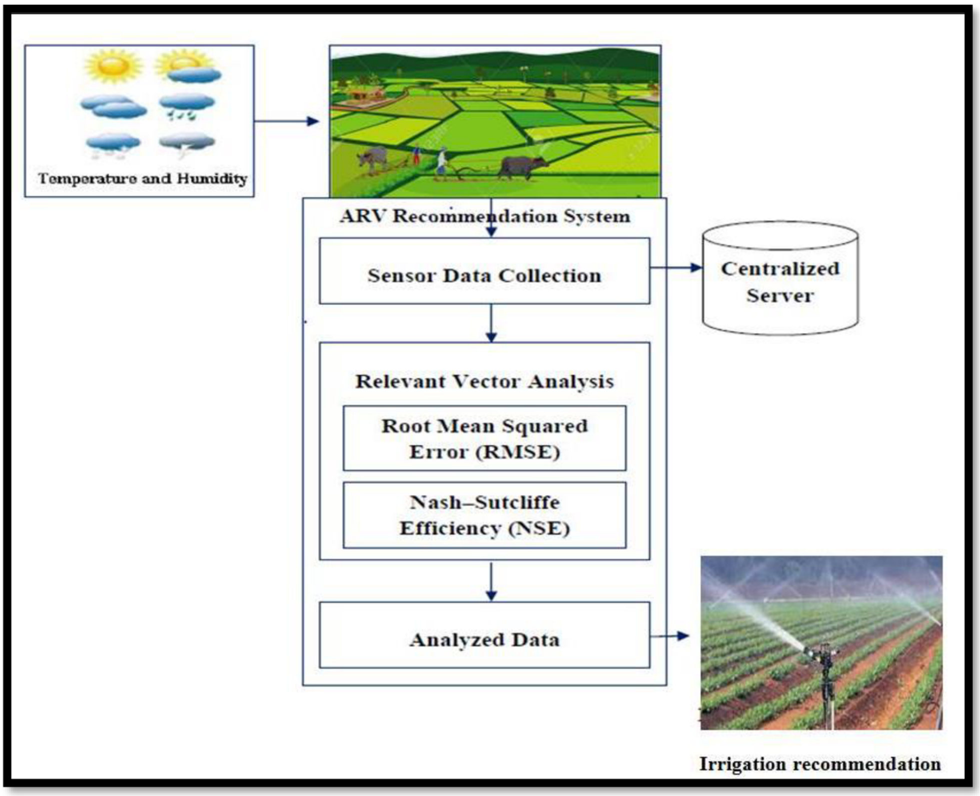

Figure 1 Framework of the Proposed ARV Recommendation (own source)

Algorithm – ARV Recommendation Algorithm

```
Input: Sensor Data (Soil Temperature (Degree Celsius) and Relative (Humidity)
Output: Cultivation Recommendation
Begin
        Train ARV
        Build trained ARV model {
                Get the current sensor data
                Perform the relevant vector analysis {
                        y x, w = ωmφm
                        n
                        i=0 (x) +ω0 =
                        ω.
                        φ
                }
        if (Predicted value==Estimated value)
        Provide irrigation recommendations
        else
        GOTO ARV
}
Display (Analyzed Data);
Display (Recommendation for Farmer);
End
```

Prog 1 ARV Recommendation Algorithm

4.2Data Collection from Sensor

Data collection is critical in precision agriculture since it assists the farmer in achieving real-time crop productivity gains. Environmental influences can now be assessed via sensors thanks to technological improvements. The sensors in the field kept track of time and sent the data to a centralised server. The sensor nodes are exposed to changes owing to severe rainfall and high-temperature oscillations, and environmental conditions have a significant impact on wireless sensor networks.

The basic goal of any cultivation is for the seed to germinate quickly from a weed-free seedbed. This necessitates the preparation and loosening of the soil, which takes time. Many researchers have developed the best sensor design for acquiring field data that is low power and low cost. The author Nabi, F., Jamwal, S. and Padmanbh, K., 2022 suggested that the

(VH400) Soil Moisture sensor and (DS1822) Soil Temperature sensor showed the best achievements in the single-tier heterogeneous network with (XBee-PRO S2) ZigBee module and (MTSMC-G2-SP) GPRS module working on solar-powered in the agriculture field irrigation attracted as one of the primary considerations in this research. Soil temperature, soil humidity, and water level were monitored as environmental parameters.

The data gathered was analysed and stored in a centralised database. Initially, high radiation levels may be required by the crops. As the stages progress, excessive temperatures may have an adverse effect on the yield. Farmers use a ventilation system to control the temperature during these times. The sickness will worsen if the humidity is high. Similarly, soil water has an impact on yield. As a result of the foregoing motivation regarding the impact of temperature, humidity, and water level on cultivation, these elements were considered as key data information in this study. Farmers receive real-time decision help from the data collected over wireless channels for examination by agriculturalists.

4.3Relevant Vector Analysis

The new ARV Recommendation algorithm was used for all data analytics for the ARV Recommendation System. The technique is a mixture of two well-known precision agriculture assessment methods: Root Mean Squared Error (RMSE) and Nash–Sutcliffe Efficiency (NSE). The implemented innovative algorithm predicts significant factors based on observed sensor values and delivers high yield farming recommendations, with the accuracy of observed sensor data determined using RMSE and NSE analysis.

The RMSE is a statistic that compares the observed and anticipated values. The residuals are the RMSE's deviations. Assume that the data samples used for estimation are calculated incorrectly. The root mean square error (RMSE) is a crucial accuracy statistic used in many of the best models for forecasting a certain dataset. Table 1 shows the RMSE and NSE value ranges. The amount of water in a sample ranges from 0 to 1.

RMSE (0-1)	Range Particulars
0	Perfect Fit
Non- negative lower	Better
Negative	Invalid

Table 2 RMSE Range Particulars (own source)

Mean Square Error assesses the quality of the Predictor. For N, the prediction vector, yp the observed vector, andyˆ pdenotes the predicted value. The MSE calculation expressed in Equation (1).

$$MSE = \frac{\sum_{p=1}^{N}(Yp-Yp)^2}{N} \ldots\ldots\ldots\ldots\ldots \; (1)$$

Equation 1 Mean square Error (Allen, D.M., 1971)

Where $\frac{1}{N}\sum_{p=1}^{N}$ is the error calculation for the observed and predicted vector?

Taking the square root for Equation (1), we calculate the RMSE, expressed in Equation (2)

$$RMSE = \sqrt{\frac{\sum_{p=1}^{N}(Yp-Yp)^2}{N}} \ldots\ldots\ldots\ldots\ldots\ldots \; (2)$$

Equation (3) represents the calculation of NSE. (Wilk Sampaio de Almeida et al. 2018)

$$NSE = 1 - \frac{\sum_{p=1}^{N}(y_p - \overbrace{y_p})}{\sum_{p=1}^{N}(y_p - \overbrace{y_p})} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (3)$$

Were,

$\widehat{y_p}$**, The forecasted agricultural parameter**

$\widehat{y_p}$ **, the calculated agricultural parameter**

$\bar{y}$ **, the mean of the observed agricultural parameter**

$\hat{y}$ **, the mean of the estimated observed agricultural parameter**

N **, the total number observations**

NSE (-α-1)	Range Particulars
1	Perfect fit
0	Accurately based on the mean of the observed data
< 0 (close to 1)	More accurate

Table 3 NSE Range Particulars (own source)

The ARV Recommendation is used to locate a land position where all the meteorological conditions are favourable for cultivation. For comparison, the assessed parameter prediction is reviewed and compared to APAL (Australian Precision Agricultural Laboratory), a well-known precision agriculture level predictor. APAL provides unbiased, high-quality soil, plant, and water analytical service benchmarks to help farmers make better agronomic decisions. The APAL level was chosen as a benchmark in evaluating the performance of the algorithm ARV Recommendation based on the successes of the applications benchmarked by the APAL parametric values. The suggested technique was validated by comparing the RMSE to the existing ANN RMSE in terms of data dependability and accuracy.

4.4Hardware Specification

GSM Modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone.

When a GSM modem is connected to a computer, this allows the computer to use the GSM modem to communicate over the mobile network. While these GSM modems are most frequently used to provide mobile internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages.

Figure 2 GSM Based Wireless Notice Board Using ARDUINO (Mary, M.A., Pavithra, B., Sangeetha, R. and Lakshmi, T.S.,)

A GSM modem can be a dedicated modem device with a serial, USB or Bluetooth connection, or it can be a mobile phone that provides GSM modem capabilities.

For this document, the term GSM modem is used as a generic term to refer to any modem that supports one or more of the protocols in the GSM evolutionary family, including the 2.5G technologies GPRS and EDGE, as well as the 3G technologies WCDMA, UMTS, HSDPA and HSUPA.

A GSM modem exposes an interface that allows applications such as Now SMS to send and receive messages over the modem interface. The mobile operator charges for this message sending and receiving as if it was performed directly on a mobile phone. To perform these tasks, a GSM modem must support an “extended AT command set” for sending/receiving SMS messages, as defined in the ETSI GSM 07.05 and 3GPP TS 27.005 specifications.

GSM modems can be a quick and efficient way to get started with SMS, because a special subscription to an SMS service provider is not required. In most parts of the world, GSM modems are a cost-effective solution for receiving SMS messages, because the sender is paying for the message delivery.

A GSM modem can be a dedicated modem device with a serial, USB or Bluetooth connection, such as the Falcon Samba 75. To begin, insert a GSM SIM card into the modem and connect it to an available USB port on your computer.

A GSM modem could also be a standard GSM mobile phone with the appropriate cable and software driver to connect to a serial port or USB port on your computer. Any phone that supports the "extended AT command set" for sending/receiving SMS messages, as defined in ETSI GSM 07.05 and/or 3GPP TS 27.005, can be supported by the Now SMS & MMS Gateway. Note that not all mobile phones support this modem interface.

Due to some compatibility issues that can exist with mobile phones, using a dedicated GSM modem is usually preferable to a GSM mobile phone. This is more of an issue with MMS messaging, where if you wish to be able to receive inbound MMS messages with the gateway, the modem interface on most GSM phones will only allow you to send MMS messages. This is because the mobile phone automatically processes received MMS message notifications without forwarding them via the modem interface.

It should also be noted that not all phones support the modem interface for sending and receiving SMS messages. Most smart phones, including Blackberries, iPhone, and Windows Mobile devices, do not support this GSM modem interface for sending and receiving SMS messages at all at all. Additionally, Nokia phones that use the S60 (Series 60) interface, which is Symbian based, only support sending SMS messages via the modem interface, and do not support receiving SMS via the modem interface.

Temperature Sensor in Arduino

The Temperature Sensor LM35 series are precision integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature.

The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°Cover a full −55°C to 150°C temperature range.

Technical Specifications

- Calibrated directly in Celsius (Centigrade)
- Linear + 10-mV/°C scale factor
- 0.5°C ensured accuracy (at 25°C)
- Rated for full −55°C to 150°C range.
- Suitable for remote applications

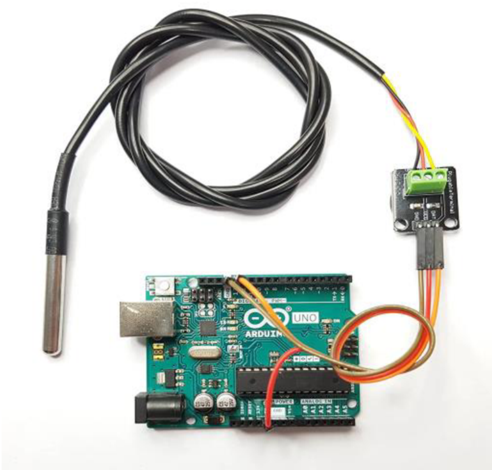

Figure 3 Arduino-based smart irrigation using water flow sensor, soil moisture sensor, temperature sensor and ESP8266 Wi-Fi module. Singh, P. and Saikia, S., 2016, December

```
float temp.
int tempPin = 0;
void setup () {
        Serial.begin(9600);
}
void loop () {
        temp = analogRead(tempPin); // read analog volt sensor & save to variable temp
        temp = temp * 0.48828125.
        // convert the analog volt to its temperature equivalent
        Serial.print ("TEMPERATURE = ", temp, "*C"); // display temperature value
        delay (1000); // update sensor reading each one second.
}
```

Prog 2 Arduino Code for Temperature sensor

Water Sensor

Connecting a water sensor to an Arduino is a great way to detect a leak, spill, flood, rain, etc. It can be used to detect the presence, the level, the volume and/or the absence of water. While this could be used to remind you to water your plants, there is a better Grove sensor for that. The sensor has an array of exposed traces, which read LOW when water is detected.

The sensor has a series of ten exposed copper traces. Five are power traces and five are sense traces. These traces are interlaced in parallel so that there is one sense trace between every two power traces. These traces are not connected unless they are bridged by water when submerged.

The traces act as a variable resistor (just like a potentiometer) whose resistance varies according to the water level.

- The change in resistance corresponds to the distance from the top of the sensor to the surface of the water.
- The resistance is inversely proportional to the height of the water:
- The more water the sensor is immersed in, the better the conductivity is, the lower the resistance is.
- The less water the sensor is immersed in, the worse the conductivity is, the higher the resistance is.
- The sensor produces an output voltage according to the resistance.

By measuring the voltage, we can determine the water level.

In theory, to supply power to the sensor, we can connect the sensor's VCC and GND pins to Arduino's 5v and GND pins, respectively.

Water Pump

As for the characteristics the ones we should look at are:

- **Capacity**: measured in liters per hour (l / h), liters per minute (l / min), etc. It is the amount of water it can extract per unit of time.

- **Hours of useful life**- Measures the amount of time it can be running continuously without problems. The older it is, the better. They are usually 500 hours, 3000 hours, 30.000 hours, etc.
- **Noise**: Measured in dB, it is the amount of noise it makes in operation. This is not too important unless you want it to be very quiet. In such a case, look for one with <30dB.
- **Protection**: many have IP68 protection (the electronics are waterproofed), which means that they can be submerged (amphibious type), so they can be under the liquid without problem. Others, on the other hand, are surface and only the inlet tube can be submerged through which it absorbs the water. If they are not submersible and you put it under the liquid it will be damaged or short circuit, so pay attention to this.
- **Static lift**: it is usually measured in meters; it is the height to which the liquid could propel. This is especially important if you are going to use it to raise liquids to a greater height or extract water from wells, etc. It can be 2 meters, 3m, 5m, etc.
- **Consumption**- It is measured in watts (w) and will indicate the amount of power they need to function. In many cases they are quite efficient, they could have consumptions of 3.8W (for the small ones).
- **Accepted liquids**: Like I said, they accept several types of liquids, although not all. If you want to be sure that the pump you buy can work with the liquid you are going to handle, check this manufacturer's specification. They can generally work well with water, oil, acids, alkaline solutions, fuels, etc.
- **Type of motor**: These are usually DC electric motors. The brushless type (without brushes) is especially good and durable. Depending on the engine power you will have a pump with capacity and static elevation.
- **Propeller type**: the motor has a propeller connected to its shaft, which is what generates the centrifugal energy to extract the liquid. These can be of different types, and the speed and flow with which the pump works will depend on it. They can even be printed using 3D printing with different results depending on their shape. I leave you the following interesting video about it:

As you know, you could also use a relay if you need it. But here, to integrate the water pump with Arduino I have chosen a MOSFET. Specifically, a module IRF520N. And for the connection, the truth is that it is quite simple, just follow these recommendations:

- **SIG** of the IRF520N module will be connected to an Arduino pin, for example D9. You already know that if you change it, you must also alter the sketch code to make it work.
- **Vcc and GND** of the IRF520N module you can connect them to 5v and GND of your Arduino board.
- **U + and U-** This is where you will connect the two wires from the water pump. If it is not internally compensated, it is an inductive load, so it would be advisable to use a flyback diode between both cables.
- **Vin and GND** It is where you will connect the rack with the batteries that you are going to use to power the water pump externally, or the battery, power supply or whatever you are going to use to power it ...

Source code to control Arduino.

```
const int pin = 9; //Declarer pin D9
void setup () {
        pin Mode (pin, OUTPUT); //Define pin 9
}
void loop () {
        digitalWrite (pin, HIGH);       // HIGH (activator)
        delay (600000);                 //Delay 10 min
        digitalWrite (pin, LOW);        // Turn Off sensor.
        delay (2000);                   // It will wait 2 seconds and start cycle
}
```

Prog 3 Source code to control Arduino.

Transistors, Resistors and Diode

The basic is simple the signal wire of Arduino will be connected to base of the transistor and output is connected at collector and emitter is grounded and when a current will flow from Arduino pin to base then there will be a current flow proportional to the base current in output which will go through collector to emitter and called as emitter current.

when it comes to driving high power output devices such as 'high power led's' , 'motors' etc. then ARDUINO is not able to drive such outputs directly and to drive such kind of outputs we need a amplifier to amplify the signal and generally we use transistors to amplify the signal of Arduino and drive led's or motors according to the signal of Arduino and generally we use BJT's for those kind of jobs.

Humidity Sensor

The DHT11 detects water vapor by measuring the electrical resistance between two electrodes. The humidity sensing component is a moisture holding substrate with electrodes applied to the surface. When water vapor is absorbed by the substrate, ions are released by the substrate which increases the conductivity between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity. Higher relative humidity decreases the resistance between the electrodes, while lower relative humidity increases the resistance between the electrodes.

The connections are simple. The first pin on the left to 3-5V power, the second pin to the data input pin and the right-most pin to the ground.

Technical Details

- **Power** − 3-5V
- **Max Current** − 2.5mA
- **Humidity** − 0-100%, 2-5% accuracy
- **Temperature** − 40 to 80°C, ±0.5°C accuracy

Components Required

We will need the following components −

- 1 × Breadboard
- 1 × Arduino Uno R3
- 1 × DHT22
- 1 × 10K ohm resistor

Source Code for various DHT humidity/temperature sensors

```
#include "DHT.h"
#define DHTPIN 2 // what digital pin we're connected to
//#define DHTTYPE DHT11 // DHT 11
#define DHTTYPE DHT22 // DHT 22 (AM2302), AM2321
//#define DHTTYPE DHT21 // DHT 21 (AM2301)
// Connect pin 1 (on the left) of the sensor to +5V
// NOTE: If using a board with 3.3V logic like an Arduino Due connect pin 1
// to 3.3V instead of 5V!
// Connect pin 2 of the sensor to whatever your DHTPIN is
// Connect pin 4 (on the right) of the sensor to GROUND
// Connect a 10K resistor from pin 2 (data) to pin 1 (power) of the sensors
// Initialize DHT sensor.
// Note that older versions of this library took an optional third parameter to
// tweak the timings for faster processors. This parameter is no longer needed.
// as the current DHT reading algorithm adjusts itself to work on faster procs.
DHT dht(DHTPIN, DHTTYPE);
void setup () {
        Serial.begin (9600);
        Serial.println ("DHTxx test!");
        dht.begin ();
}
void loop () {
        delay (2000); // Wait a few seconds between measurements.
        float h = dht.readHumidity(); // Reading temperature or humidity takes about
250 milliseconds!
        float t = dht.readTemperature(); // Read temperature as Celsius (the default)
        float f = dht.readTemperature(true); // Read temperature as Fahrenheit
(isFahrenheit = true)
        // Check if any reads failed and exit early (to try again).
        if (isnan(h) || isnan(t) || isnan(f)) {
                Serial.println("Failed to read from DHT sensor!");
        return;
        }// Compute heat index in Fahrenheit (the default)
        float hif = dht.computeHeatIndex(f, h); // Compute heat index in Celsius
(isFahreheit = false)
        float hic = dht.computeHeatIndex(t, h, false);
        Serial.print ("Humidity: ",h, " %\t", h, t, "*C ", "Temperature: ", t, f, " *F\t",
"Heat index: ");
        Serial.print (hic, " *C ", hif, " *F");
}
```

Prog 4 Source Code for various DHT humidity/temperature sensors

Mini Exhaust Fan

Arduino can not only turn on/off the fan but also control the fan's speed.

we are going to turn on/off a fan using Arduino. If 12V fan is powered by 12V power supply, it run with full speed.

- If 12V fan is powered by 12V PWM signal, The fan's speed can be controlled.

The below code repeatedly turns the fan ON in five seconds and OFF in five seconds,

```
// constants won't change
const int RELAY_PIN = A5; // the Arduino pin, which connects to the IN pin of relay
// the setup function runs once when you press reset or power the board
void setup () {
        // initialize digital pin A5 as an output.
        pinMode (RELAY_PIN, OUTPUT);
}       // the loop function runs repeatedly forever
void loop () {
        digitalWrite (RELAY_PIN, HIGH); // turn on fan 5 seconds.
        delay (5000);
        digitalWrite (RELAY_PIN, LOW); // turn off fan 5 seconds.
        delay (5000);
}
```

Prog 5 Source Code to run Fan.

Figure 4 Experimental Setup (Own Source)

5. Experimental Results and Observation

Data Collection, Experimental Setup, and Sensor Deployment Soil temperature, soil humidity, and water level are the environmental parameters that are measured. The ARV Recommendation system considered the training samples and employed a real-time sparse dataset obtained from the farm field. Plants from 100 different types were chosen at random as testing samples. In a tropical climate, the implementation was carried out in the sector of agriculture. Sensor observations were taken every day at 8 a.m., 10 a.m., 12 p.m., 2 p.m., and 4 p.m. for a month. The humidity sensors were used to collect dampness data at a regular interval of every 60 minutes.

The sensors were put at an 8-meter distance in the agricultural field to sense the microclimate during the growth season. One of the key considerations suggested by the author Nabi, F., Jamwal, S. and Padmanbh, K., 2022 is the use of Soil Moisture Sensor (VH400) and Soil Temperature (DS1822) in agriculture field irrigation. Sensors were used to determine the temperature, humidity, and pH value of the soil.

A control device was employed to sense the parameter. As shown in Figure 2, the considered farm field is divided into equal tubs, each tub having a unit area of 8m by 7m.

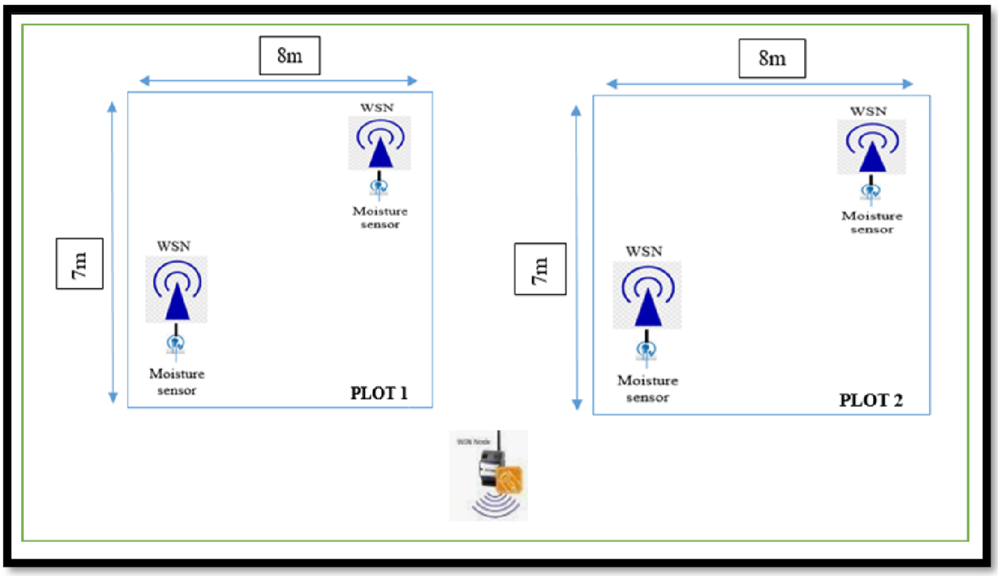

Figure 5 Tub Model-based Sensor Placement (own source)

There are two sensor nodes in each tub. The location of each sensor node will allow the fault nodes to be detected. The procedure employs an IoT technique based on fault tolerance and check pointing. The number of sensors necessary for a given agricultural land is expressed in Equation (3).

$$NS = Nd\,x2$$

$$N_S = N_d \times 2 + [\![(f_w - 1) + ((N_d - f_w) \times \left(\frac{1}{fw} \times 1\right)(n_d - f_w) \times \left(1 - \frac{1}{fw} \times 2\right) \ldots\ldots\ldots\ldots\ldots \quad \textbf{(3)}$$

where Ns is the number of needed sensor nodes, Na is the number of agricultural field divisions, and few is the field width. Sensor nodes are dispersed based on the field width. Figure 3 shows a sample sensor deployment in an agricultural field with a total size of 105.8m X 39.7m.

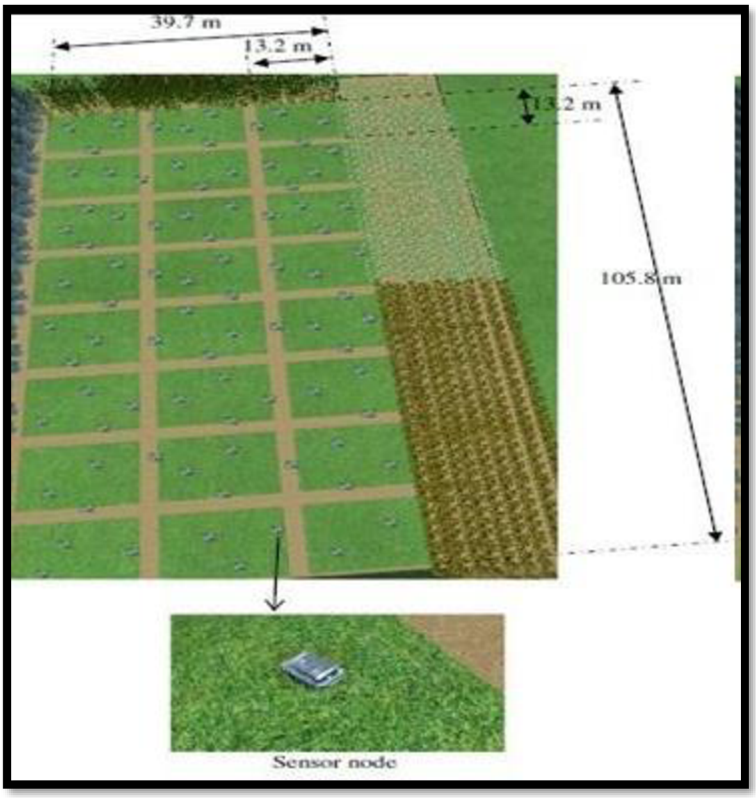

Figure 6 Deployment of the sensors in the field (own source)

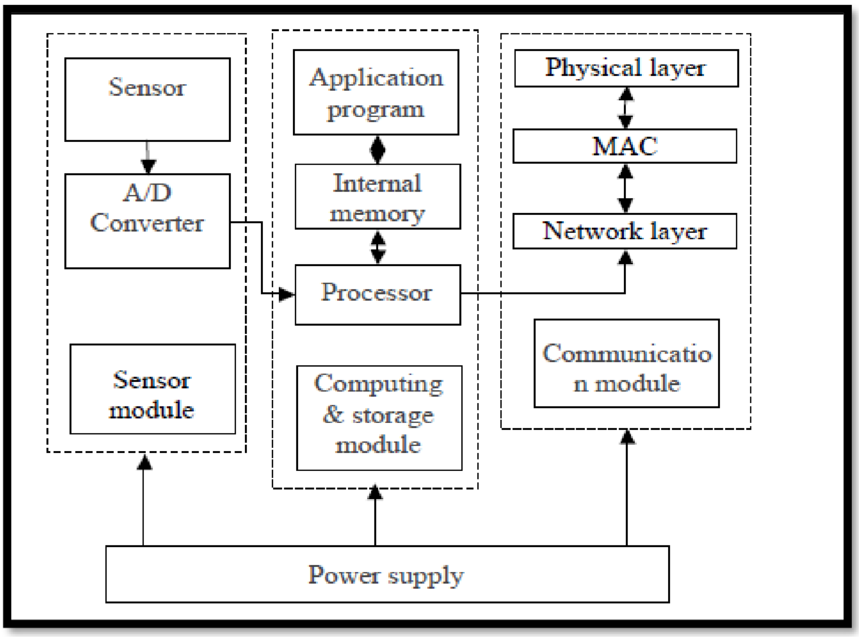

Figure 7 Hardware Components in a Sensor (own source)

Figure 3 shows the data acquisition boards, such as the MDA300, which senses the soil moisture level. These boards are equipped with a processor unit that handles both processing and storage. The hardware components of a single sensor are shown in Figure 4.

The Sensing Unit, the Processing Unit, the Transceiver for communication between the WSN node and the base station, and the Power Unit make up each sensor. The sensor's architecture, as well as its connection module, are shown in Figure 4. Finally, the ARV Recommendation algorithm is implemented in MATLAB (2018), with the training and testing samples evaluated using 5-fold cross-validation. Equation 1 shows the crop yield derived using the grain flow rate and the area covered (4)

$$\textit{Crop Yield} = (\textit{Mass}/\textit{Volume})/\textit{Area} \ldots\ldots\ldots \;(4)$$

5.1 Observations and Results

The following are the assumptions for crop growth observation:

- Crops grow in normal, healthy conditions.
- Crop growth can resist both extremes of sunlight and moisture.

- Cropping below the lowest tolerable sunshine temperature is limited due to a lack of water.
- Irrigation was completed for a total of 5 minutes.
- The primitive conditions for beneficial cultivation, as shown in Table 3.1, were considered.

The ARV Recommendation algorithm analyses the data collected to determine which factors are not in good working order and whether the field should be used for agriculture. Finally, the system's performance was demonstrated following the completion of the crop's growth and yield. This demonstration will be based on the acquired crop growth image that will be saved as evidence in the future.

Figure 5 displays the suggested ARV Recommendation system analysis for 7 days, considering the environmental conditions. The soil humidity and moisture levels are extremely low during this time, necessitating irrigation in the field to keep the produce fresh and survive the sun's heat.

In addition, as illustrated in Figure 5, the performance of the algorithm ARV Recommendation is tested using an existing ANN RMSE predictor parameter for precision agriculture.

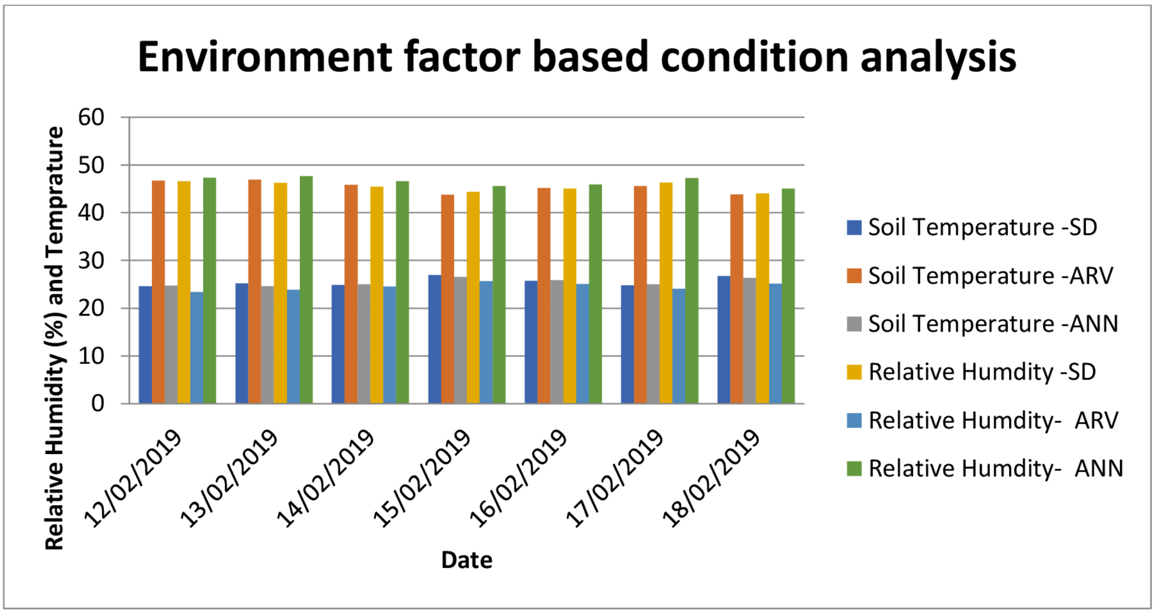

Figure 8 Environmental Factor-based Condition Analysis (Own Source)

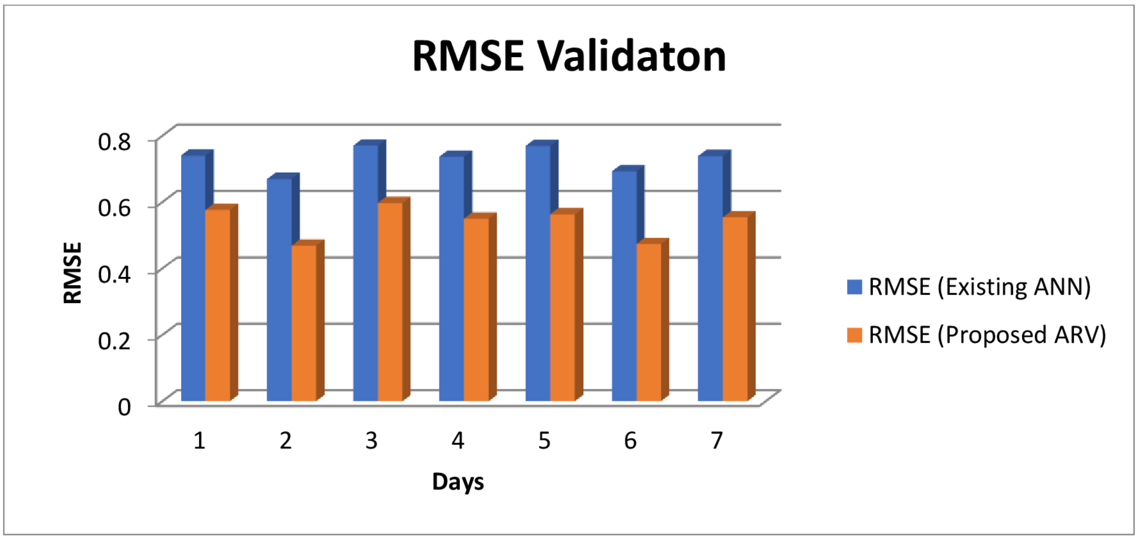

Figure 9 RMSE Validation (Own Source)

The RMSE, or difference between the anticipated and observed value by the environment, is shown in Figure 6. The model's projected value is quite close to the data points that were observed. It, therefore, denotes a better match.

In comparison to the RMSE of the previous ANN model, Figure 6 shows an improved ARV RMSE value of 0.576, 0.469, and 0.57 for the first three days (Balraj Singh et al. 2018). During validation, the NSE values of the models are identical. As a result, the RMSE values are shown in Figure 6. Wilk Sampaio de Almeida et al. (2018) found that the lower the RMSE estimation, the higher the precision and accuracy attained. The low RMSE values show that the ARV Recommendation system is accurate in predicting and recommending farming practices. The analysis of water use during the considered cultivation days is shown in Table 3. In the ARV Recommendation System, the moisture content for cultivation is fixed above 35Volumetric Water Content (threshold value). Once the moisture level exceeds the threshold value, the irrigation pump will activate. Table 3 depicts the use of water for irrigation purposes. For the plants to be healthy, the water level must be maintained. The initial irrigation was done at 12 p.m. in February, as indicated above. For this process, the threshold value is kept constant. The volume of water consumed by the scheduled method of irrigation varies at a rate of 2500ml from the table, but the automatic mode consumes only 100 ml.

Mod of Cultivation	Cultivation (No. of Days Considered)	Water Consumption (In ml/ Day)	Total water consumption (ml)
Scheduled	4	500	2000
Automatic	4	200	800

Table 4 Analysis of Water Consumption during Cultivation (Own Source)

Thus, the ARV Recommendation System can support both the farmers and plant pathologists. These include:

- Provide accurate information on temperature, humidity, and water factors.
- Save water resources during drought.
- Provide timely, accurate, reliable, and useful information.
- To farmers to increase productivity.

6. Conclusion

An improved ARV RMSE value of 0.576, 0.469, and 0.57 during the first three days was the study's main conclusion. The models' NSE values are equal during validation. As a result, Figure 9 displays the RMSE values. Wilk Sampaio de Almeida et al. (2018) discovered that the precision and accuracy gained increased with decreasing RMSE estimation. The low RMSE values demonstrate the accuracy of the ARV Recommendation system's predictions and recommendations for agricultural practises. The moisture concentration for agriculture is regulated above 35Volumetric Water Content in the ARV Recommendation System (threshold value). When the moisture level reaches a certain level, the irrigation pump will turn on. The proposed module for precision agriculture, "ARV Recommendation System: Agriculture Factor-Based Relevance Vector Analysis Model for Identifying Accurate Farming Recommendations," implements a novel algorithm, "ARV Recommendation," that identifies environmental factor variations and makes precision farming recommendations to farmers. During the experimental period, data on humidity and temperature show high temperatures and low humidity during the day. Furthermore, evaporation of water occurs at a rapid rate during the day. As a result, the daytime moisture level will be lower than the nocturnal moisture level to meet the threshold value. As a result, the farming advice should be able to estimate the crop and maximise production in a specific location.

7. Summary

The "ARV Recommendation System: Agriculture Factor-Based Relevance Vector Analysis Model for Identifying Accurate Farming Recommendations" module's framework and experimental outcomes were discussed in this chapter. The parameter with the lowest RMSE is regarded as having sufficient parametric conditions for cultivation.

In comparison to the RMSE of the previous ANN model, Figure 3.6 shows an improved ARV RMSE value of 0.042, 0.038, and 0.0.35 for the first three days.

The ARV Recommendation System is an algorithm designed to analyse data collected from crop growth observations and provide recommendations for agricultural practices. The system considers factors such as soil humidity, moisture levels, and environmental conditions to determine which factors are not in good working order and whether the field should be used for agriculture. The system's performance is demonstrated using an existing ANN RMSE predictor parameter, which shows that the ARV Recommendation System is accurate in predicting and recommending farming practices. The system is also designed to save water resources during drought and provide accurate information on temperature, humidity, and water factors to farmers to increase productivity. Overall, the ARV Recommendation System has the potential to support both farmers and plant pathologists by providing timely, accurate, reliable, and useful information for agricultural practices.

8. Future Scope

The future scope of the ARV Recommendation System is promising. As technology continues to advance, there is an opportunity to integrate new features and capabilities into the system to further enhance its effectiveness. One potential area for improvement is the integration of remote sensing technology. Remote sensing technology can provide real-time data on soil moisture, plant health, and other important agricultural factors, which can be used to further refine the recommendations provided by the ARV Recommendation System.

Another area for improvement is the integration of artificial intelligence and machine learning algorithms. By analyzing large amounts of data, machine learning algorithms can identify patterns and trends that may not be immediately apparent to humans. This can help to improve the accuracy and effectiveness of the ARV Recommendation System. In addition, there is an opportunity to expand the scope of the system beyond crop growth observations. The ARV Recommendation System could potentially be used to provide recommendations for other agricultural practices, such as soil management, pest control, and fertilization.

Overall, the future scope of the ARV Recommendation System is wide-ranging, and there are many opportunities to further enhance its capabilities and effectiveness in supporting farmers and plant pathologists.

Developed predictive models can be customized for both field irrigation and urbanization area. The development of a smart irrigation system turns the life of a farmer. This research proposes an IoT based intelligent irrigation architecture and a hybrid machine learning-based approach to predict soil moisture. Based on the previous observations made on the weather forecast data, the proposed algorithms make predictions for the future requirement and the soil moisture level analysis. Thus, research focus brings an auto and effective mode of water utilization and helps in bringing water-saving systems based on the proposed algorithm with cost-effective analysis. By increasing the model strength and quality of performance, some more advancement in the agricultural field for lifetime usage enhanced for promoting agriculture.

8.1Future Enhancement

The recommender system can relate to farmers on the desktop application or mobile phones to exchange information in the future. Furthermore, intelligent decisions for planting, fertilizing, and harvesting crops can be considered future research directions to effectively use the information to achieve higher yields and earn higher profits. Further, the system developed considering the soil characteristics as parameters for precision agriculture. The system can utilize various other algorithms such as random forest, K-nearest neighbor and Naive Bayes with an improved and extensive data set regarding yield prediction.

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