DEPARTMENT OF COMPUTER SCIENCE
AHMADU BELLO UNIVERSITY
ZARIA - NIGERIA

PROCEEDINGS

OF THE

INTERNATIONAL CONFERENCE ON COMPUTING & ADVANCES IN INFORMATION TECHNOLOGY (ICCAIT 2021)

THEME

FOSTERING DIGITAL ECONOMY THROUGH RECENT TRENDS IN INFORMATION TECHNOLOGY

NOVEMBER 15 - 17, 2021

VENUE: CBN Centre of Excellence, Ahmadu Bello University, Zaria, Nigeria

EDITORS

M. A. Bagiwa, M. A. Umar, M. Abdullahi,
A. Abdulrahim, S. I. Dishing, A. M. Shaheed

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FORWARD

The International Conference on Computing and Advances in Information Technology (ICCAIT 2021) has been successfully orchestrated from 15th – 17th November, 2021. The biennial conference which was well attended as it was conducted in a blended (Physical and Virtual) attracted people and paper presentations from a cross section of participants as well as speakers from industry and academia internationally. This edition's (2021) theme: "Fostering Digital Economy Through Recent Trends in Information Technology" witnessed a collection of papers presented on various facets of Computer Science, Information Technology, Software Engineering, Information Systems, emerging Technologies, etc., under the following sub-themes:

- Computer and Intelligent Systems
- Communication, Network and Security
- Emerging Technologies
- Applied Computing and Information Systems
- Ethical, Legal and Social Issues in Computing
- Information Technology and Covid-19

This document features the collection of papers presented thus far at the conference.

We wish to sincerely thank and appreciate everyone who participated in this year's edition for making the conference a success. Special thank you to all technical programme committee as well as the numerous reviewers. Looking forward to seeing you in next and subsequent editions.

Dr. Mohammed Abdullahi
Chairman, Conference Organizing Committee.

PROFILE OF THE INVITED SPEAKERS

Prof. Isa Ali Ibrahim Pantami

Honourable Minister of Communications and Digital Economy

Isa Ali Ibrahim, PhD (Pantami) is the Minister of Communications and Digital Economy of the Federal Republic of Nigeria. Dr Ibrahim obtained a Bachelor of Technology in Computer Science (B.Tech), from the Federal University of Technology, known as the Abubakar Tafawa Balewa University (ATBU), Bauchi, and proceeded to acquire two Masters Degrees from the same institution in quick succession. One in Computer Science (MSc) and the other, an MBA in Technology Management. His scholarly pursuits then led him to the Robert Gordon University Aberdeen, Scotland, United Kingdom, where he obtained a Doctorate in Computer Information Systems. He is also a Professor of Cybersecurity.

Prior to his appointment as a Minister, he was the Director General (DG)/Chief Executive Officer (CEO) of the National Information Technology Development Agency (NITDA), which has a strong mandate on Research in Information Technology. Prof. Ibrahim is currently the Chief Digital Officer of the Federation, based on the National Policy for Virtual Engagements in Federal Public Institutions. He has also been a Chairman and member of several Presidential and Inter-Ministerial Committees, including Committee on Citizen Data Management and Harmonisation, National Committee on Export Promotion, Digital Identity Ecosystem Steering Committee, National Action Committee on African Continental Free Trade Area Agreement (AfCFTA). He was also appointed as AfCFTA Champion for Communications and Digital Economy, as well as Chairman, Presidential Steering Committee for National Identity.

Under the leadership of Prof. Ibrahim, as the first Minister of Digital Economy, a National Digital Economy Policy and Strategy (2020 - 2030) and National Broadband Plan (2020 - 2025) were developed, among others, and many unprecedented successes recorded. In fact, within 2 years in office, 16 National Policies have been developed and they are being implemented.
Also, in less than a year, as the Minister of Communications and Digital Economy of the Federal Republic of Nigeria, the lingering issue of excessive Right of Way charges and vandalism of telecommunication infrastructure have been effectively addressed. Under his stewardship, broadband penetration increased by more than 10% in a year, instead of the average annual increase of about 1.7%, and the Information and Communications Technology (ICT) sector contributed an unprecedented 17.83% to the GDP based on the Q2 2020 GDP Report by National Bureau of Statistics (NBS). The ICT sector was also the fastest growing sector of the Nigerian economy in the 4th Quarter of 2020, growing at a rate of 14.70%. He initiated the first Virtual Federal Executive Council and first Virtual National Security Council meeting on the 13th of May 2020 and has been coordinating and supervising the technical aspects of the meetings since then. This saved government money running into billions of Naira monthly.

Recently, his achievements have led to him being recognised and *awarded* with; the *2020 Minister of the Year Award* by the *Blueprint Newspaper; Most Outstanding Minister of the Year 2021* by *Elite Exclusive Magazine;* and *Digital Economy Driver Award* by the *National Body of Nigeria Information Technology Reporters Association (NITRA)*, amongst others. He received a 2020 Person of the Year Award from Thinkers' Magazine in September 2021. In fact, he has received over *150 awards from 2017 to date*. Prof. Ibrahim also holds *certificates in Digital Transformation from Harvard University*, Digital Strategy from both *Massachusetts Institute of Technology (MIT)* and *Institute of Management Development (IMD), Lausanne, Switzerland*, *Strategic Leadership from Oxford University*, and a *University of Cambridge Certification in Management*. The dynamic, inspirational agent of transformation is also a conflict resolution expert with national and international experiences in that regard. Prof. Ibrahim lectured at various universities for almost two decades, teaching ICT courses. He is still engaged with the academia, as a professor. During his early days, Prof. Ibrahim was a lecturer at the Federal University of Technology, Bauchi for over a decade, prior to joining other universities.

Prof. Ibrahim is a recipient of several global awards and is a well sought-after speaker, delivering convocation lectures in a number of public and private universities, including the Federal University of Technology Minna, the Nile University, the Federal University Kashere and the National Defence College, among others. He has also served as a Speaker at leading global events like Mobile World Congress (MWC)

Barcelona, Gulf Information Technology Exhibition (GITEX) in Dubai, the GSMA Africa Policy Leaders Forum, the Consumer Electronics Show (CES), Las Vegas and International Telecommunication Union (ITU) events, amongst others.

Furthermore, as an expert in key fields like the digital economy and cybersecurity, he also eaches and serves as a resource person to several institutions, including the National Defence College, Federal University of Technology Owerri, Imo State, Nigerian Army Resource Centre, National Institute for Policy and Strategic Studies, among others.

He has been the Champion of the Massachusetts Institute of Technology (MIT) Regional Entrepreneurship Acceleration Program (REAP), Abuja since 2018. The MIT-REAP is a global initiative that helps regions accelerate economic growth and promote social progress through Innovation-Driven Entrepreneurship (IDE). He has published several academic articles in high impact journals, presented papers in more than 150 conferences and published several books. These include Datafication of Society to Foster an Internet Economy, Selected Speeches on Developing the Nigerian ICT Sector (Volumes I - III) and Building a Digital Economy for a Digital Africa, among others. He has also visited over 35 countries for academic activities and to foster collaboration towards the development of National Policies.

Isa Ali Ibrahim who is popularly known as the Digital Minister, is a global IT citizen, a revered and highly respected Fellow of the Nigerian and British Computer Societies, as well as a Fellow of Cybersecurity Group of the British Computer Society. Prof. Ibrahim is happily married with children.

Dr. Seyed Mohamed Buhari

Department of Information Technology, King Abdulaziz University, Saudi Arabia.

Seyed M. Buhari is an Associate Professor, Department of Information Technology, Faculty of Computing and Information Technology, King Abdulaziz University, Saudi Arabia. From 2006 to 2012, he worked as Senior Lecturer at Faculty of Science (Computer Science) at Universiti Brunei Darussalam, Brunei Darussalam. From 2000 to 2006, he worked as a Lecturer at the Information and Computer Science department at King Fahd University of Petroleum and Minerals, Dammam, Saudi Arabia. He has also worked at Multimedia University, Malaysia, as a lecturer and Gerhard Mercator University, Duisburg, Germany, as a visiting research fellow.

Dr. Buhari obtained his bachelor's degree in Engineering (Computer Engineering) from Madurai Kamaraj University (Mepco Schlenk Engineering College, Sivakasi) in India, master's degree in Engineering (Computer Science and Engineering) from Bharathiar University (PSG College of Technology) in India and PhD from Multimedia University in Malaysia. Dr. Buhari has published around 30 international journal papers along with many conference papers. His research interests include (1) Optimization of scheduling algorithms, (2) Applied Machine Learning, and (3) Internet of Things (IoT).

He has visited various universities around the globe to collaborate in research and conducted various trainings/courses. Some of those institutes, he has visited are:

- Ahmadu Bello University, Zaria, Nigeria.
- National Institute of Technology, Nagaland, India.
- Indian Statistical Institute, Kolkata, India.
- Gebze Institute of Technology, Turkey

His interest in curriculum development is supported by his involvement in ABET accreditation of the Bachelor of Science in Information Technology program. As head of ABET accreditation committee, he has led faculty members to identify shortcomings and find areas of potential academic improvement.

Prof. Bashir Shehu Galadanci

Department of Sofware Engineering, Beyero University Kano, Nigeria

A Computer Engineer who has very broad experience in the ICT area in general and in the fields of Software Engineering, Telecommunications and Computer Science in particular. He got his B.Sc. degree in Electrical/Computer Engineering with first class honours from King AbdulAziz University, Jeddah, Saudi Arabia in 1984. He thereafter obtained his M.Sc. and Ph.D. degrees from Boston University, Boston, MA, USA in 1987 and 1994 respectively.

He currently a professor in the Department of Software Engineering at Bayero University, Kano where he is also the Director of the Centre for Information Technology (CIT). He has held many administrative positions in the University including Dean, Faculty of Computer Sciences and IT, and Head of Department, Department of Software Engineering. He is a member of the BUK Senate and has served in the BUK Council.

He served as a Special Advisor to the Governor on ICT and Education, and later as a Commissioner for Science and Technology for Kano State. He has chaired many high-level committees at the state and federal levels in Nigeria and participated in several workshops and conferences in Nigeria, Italy, Ghana, Malaysia, Kenya, Egypt, Uganda and the U.S.A. He has many publications including two books.

Prof. (Mrs.) Adenike Oyinlola OSOFISAN (FNIM, FNCS)

Department of Computer Science, University of Ibadan, Nigeria

Adenike Oyinlola OSOFISAN was born on 11th March 1950 in Osogbo, to the late Chief Honourable Josiah Orisabinu Adedipe,the Elemo of Akure and Mayegun of Osogbo and late Chief (Mrs.) Felicia Fehintola Adedipe (nee Ogundare), the Akuwajo of St. Paul Anglican Church Emure Ekiti.

She attended All Saints Primary School Osogbo and St Stephen's Primary School Akure; Fiwasaiye Girls' Grammar School in Akure (1962-67) where she finished in First Division. Prof Osofisan was a pioneer student of the department of Computer Science of University of Ile-Ife (now Obafemi Awolowo University) and graduated with a 2nd Class Upper Division Honours Degree in Computer Science/Economics. She also has a Master's degree in Computer Science in 1979 from Georgia Institute of Technology in Atlanta and PhD Computer Science in OAU to become the first Nigerian woman to hold a PhD degree in Computer Science. She also has an MBA (Finance & Accounts) of University of Ibadan in 1993, where she graduated with unprecedented nine distinctions. She joined the services of The Polytechnic Ibadan in 1979 and rose to the post of Senior Principal Lecturer and Dean of Faculty of Science before joining the services of the University of Ibadan in 1997 as Senior Lecturer and rose to the position of Professor in 2006 as the first female professor of Computer Science in Africa.

She was president of Computer Professional Registration Council of Nigeria 2005-9 as first female to head the Council, Former Member of Nigeria Institute of Management Council, Member Board of Trustees of Nigeria Internet Registration Association (NIRA), former Member of Council of Nigeria Mathematical Centre and its Academic Board and member of SAP African Academic Board just to mention a few. She was Foundation Director of University of Ibadan School of Business (UISB), August 1, 2012- July 31, 2018. She was immediate past Provost, College of Fellows Nigeria Computer Society also as the first Female Provost of the College, 2017 to 2021.

Prof. Osofisan has been the recipient of many national and international prizes, scholarships and fellowship awards to United Kingdom, USA, Australia, India, Ghana and South Africa. She is a Fellow of the Nigeria Institute of Management (NIM) chartered; Fellow Nigeria Computer Society (NCS); Life Member, Nigerian Economic Society, Member, Computer Society of IEEE; and Member Association of Computing Machinery (ACM). She has received numerous awards for the development of Information Technology and Computer Science Education in Africa. She was inducted into Nigerian Women Hall of Fame on June 10, 2019.

Professor Osofisan has attended many conferences, seminars both at national and international level presenting papers of her various research works. She has over 90 publications authored in national and international journals and conference proceedings. She had successfully supervised 20 PhD Theses, over 100 M.Sc. Theses and dissertations and numerous final year projects.

Prof. Adenike Osofisan is a devout Christian, serving the Christian Community in various positions. Prof. Osofisan is married to a literary giant, Emeritus Prof. Femi Osofisan of the Department of Theatres Arts, University of Ibadan and former General Manager, National Theatre Iganmu Lagos. The marriage is blessed with children and grandchildren.

Dr. Bayo Adekanmbi

Data Science Nigeria

Olubayo (Bayo) is driven by a vision to build an AI-first society where Artificial Intelligence is effectively deployed to solve local problems, particularly the sustainable millennial goals. He believes that AI will provide a springboard for Africa's development by enhancing how we live, work and play.

He believes that Nigeria's population of 200million with median age of about 18 years is a huge strategic advantage that can position Nigeria as one of the top 10 AI Knowledge centres in the world, especially the opportunity to raise 1 million AI talents in 10 years with globally relevant skills that can drive increased employability, FOREX inflow, AI-enabled start-ups and enhancement of the general quality of life through solution-oriented AI applications in Health, Agriculture, Financial Inclusion, Smart City etc.

He is a leading expert in Data Science, Advanced Analytics, Business Transformation, Marketing and Strategy, with 19 years of cognate industry experience from two largest economies in Africa (Nigeria & South Africa). The following summerized his Profile:

Industry-level Advanced Analytics and Data Science practitioner

- Previously served as General Manager Business Intelligence and Chief Marketing/Strategy Officer.
- Currently serving Chief Transformation Officer, MTN Nigeria
- Awarded the prestigious MTN Yello Star award for the conceptualisation of a Customer Value/Risk Management framework, which led to multi-billion naira revenue growth.
- Developed many operational analytical models for industry applications

Practising Data Scientist and active on the world's No 1 platform –Kaggle

- Kaggle Competition Bronze
- No 1 on the Data Science Dojo In-class Capstone project Leaderboard
- Top 1% amongst the over 11,000 data scientists competing on the Kaggle Titanic Machine learning survival model

Patent owner (United States Patent Office final approval stage) for a Data Science product

- Social Pricing Recommender algorithm for low income prepaid telecommunication users using uncalled-called numbers modelling (US62400186)

Doctoral-level scholar – combined PhD programme at the University of London (CityU) and TIAS Business School, the Netherlands.

- Research work on application of Data science algorithm to understand the effect of customer social networks on consumption behaviour in luxury and telecoms industry.

Community Builder, Pan-African mentor and Knowledge leader

- Advisory Board member, insight2impact (i2i) – a global resource centre that seeks to improve financial inclusion through the smarter use of data.
- Winner – MIPAD – Most Influential People of Africa Descent (Class of 2018)
- Chairman, Data and Advanced Analytics workstream of the Nigeria Economic Summit Group (NESG)
- Participant, Network of Excellence in Artificial Intelligence for Development (AI4D) in sub-Saharan Africa
- Part-time academic mentor/supervisor

CONFERENCE PROGRAMME

Monday, November 15, 2021 Day 1		
Time	**Activities**	**Venue**
08:00 – 09:30	Registration	Assembly Hall, ABU, Zaria.
10:00 – 10:05	Introduction	
10:10 – 10:15	National Anthem	
10:10 – 10:15	Opening prayer	
10:15 – 10:20	Opening Remark: Prof. S. B. Junaidu (Conference Chair and Dean, Faculty of Physical Sciences, ABU, Zaria.)	
10:20 – 10:30	Goodwill massages	
10:30 – 10:40	Welcome Address: Prof. Kabiru Bala (VC, ABU, Zaria)	
10:40 – 11:10	Guest Speech: Prof. Isa Ali Ibrahim Pantami (Hon. Minister of FMC&DE) Title: *The Role of Emerging Technologies in Accelerating the Development of Nigeria's Digital Economy*	
11:10 – 11:40	**Group Photograph and Tea Break**	**Assembly Hall, ABU, Zaria.**
11:40 – 12:10	Keynote Speech 1: Prof. Osofisan Adenike O., University of Ibadan, Nigeria Title: *Sustaining Digital Economy in Nigeria*	Assembly Hall, ABU, Zaria
12:10 – 12:40	Keynote Speech 2: Prof. Bashir Shehu Galadanci, Beyero University Kano, Nigeria. Title: *Fostering Digital Economy in Nigeria Through Software Engineering*	
12:40 – 13:10	Keynote Speech 3: Dr Seyed Mohamed Buhari, King AbdulAziz University, Saudi Arabia Title: *Challenges of Information and Cyber Security in Developing World*	
13:10 – 13:40	Keynote Speech 4: Dr Bayo Adekanmbi, Data Science Nigeria Title: *Data as the Black Gold of the 21st Century*	
13:40 – 14:00	Interactive Session	
14:00 – 14:05	Presentation of Award to Invited Speakers, Sponsors & Collaborators	
14:05 – 14:10	Vote of thanks/Annoucement: Dr Mohammed Abdullahi (Chairman, LOC, ICCAIT 2021)	
14:10 – 15:00	**Lunch Break**	**Assembly Hall, ABU, Zaria.**

	Tuesday, November 16, 2021 **Day 2**	
Time	**Activities**	**Venue**
08:00 – 09:00	Registration	LH1, LH2 & LH4, Department of Computer Science, (Phase II), ABU, Zaria
09:00 – 10:30	Parallel Session I: Tracks: ▪ Computing and Intelligent Systems ▪ Emerging Technologies ▪ Information Systems and Applied Computing	
10:30 – 11:00	**Tea Break**	**NITDA IT Hub, ABU, Zaria**
11:00 – 13:00	Parallel Session II: Tracks: ▪ Computing and Intelligent Systems ▪ Emerging Technologies ▪ Information Systems and Applied Computing	LH1, LH2 & LH4, Department of Computer Science, (Phase II), ABU, Zaria
13:00 – 14:00	Lunch Break	NITDA IT Hub, ABU, Zaria
14:00 – 16:30	Parallel Session III: Tracks: ▪ Computing and Intelligent Systems ▪ Emerging Technologies ▪ Information Systems and Applied Computing	LH1, LH2 & LH4, Department of Computer Science, (Phase II), ABU, Zaria

Wednesday, November 17, 2021 **Day 3**		
Time	**Activities**	**Venue**
09:30 – 10:30	Closing Ceremony: ▪ Presentation of Certificates ▪ Vote of Thanks: Dr Muhammad Abdulkarim (Head, Computer Science Department, ABU, Zaria.)	Main Hall NITDA IT Hub, ABU, Zaria
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TABLE OF CONTENTS

Design and Implementation of Autonomous Irrigation System using IoT and Artificial Intelligence

Thomas Onimisi Akande, Abubakar Saddiq Mohammed and Henry Ohize
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***Abstract*— Agriculture plays a vital role in Nigeria's economy contributing about 23 percent to the total GDP which makes it a key activity after oil. To improve crop productivity, optimum use of scarce water resources and the ability to predict rainfall is crucial in this era. The adoption of emerging technologies to automate irrigation processes is necessary to improve crop productivity. An intelligent irrigation system can be achieved through the synergy between Internet of Things (IoT) and Machine Learning (ML) algorithms, which support automation and improved efficiency in the agricultural field. In this proposed system, sensors will be deployed to collect air temperature, soil moisture, and air humidity. These raw data will be transmitted to NodeMCU to know if the soil is dry by comparing it to a trained set of data in the NodeMCU. The NodeMCU will then obtain data from the Opensource Google weather API (Application Programming Interface), OpenWeatherMap using JSON (JavaScript Object Notation) data to know if there will be rainfall in less than an hour or not. Base on the data collected from the weather API by the NodeMCU, it will then determine whether to trigger the pump for irrigation or not. If the soil is dry and rain will likely fall in less than an hour, the pump remains OFF and allow the rain to water the field, otherwise, the pump is triggered ON and a calculated amount of water is pumped into the soil. The real-time monitoring report of this process will be sent to the cloud where the farmer can access to monitor the condition of the farmland.**

Keywords—IoT, Machine Learning, Sensors, Rainfall Prediction, Intelligent Irrigation.

I. INTRODUCTION

Agriculture which is as old as man himself has been the most important practice from the beginning of human evolution. It is one of the main aspects of human survival as it is the main source of food [1]. There exists an intricate relationship between agriculture and irrigation as they both go hand in hand. This is essential because water is imperative for the survival of any living organism. Irrigation is the application of controlled amounts of water to plants at the needed interval to grow crops. The plant consists of networks and irrigation is considered as one of the main drivers. The growth of crops greatly depends on the soil moisture content and once the moisture content of the soil is excessive, it could result in the rot of crop roots, wash away a large amount of fertilizer that can result in water pollution, impedes the exchange of gas between the soil and the atmosphere which reduces root respiration and root growth.

The unpredictability and uncertainty of rainfall have resulted in irrigation becoming an important factor in agriculture. In the western part of Africa, the over-dependence of farmers on rainfall has constituted a major setback to sustainable development in agriculture, thus making production systems vulnerable to change and variability in climate [2]. This has also forced some farmers into the adoption of seasonal farming which only functions with cycles of rainfall. In recent years, there has been an unprecedented drive towards improving agricultural productivity in Nigeria. Because agricultural contribution to GDP is on the decline nowadays, there is an urge towards increasing the productivity of crops through effective and efficient use of scarce water resources. [3] believes that there will be improvement in standard of living, increase in GDP, and creation of employment through efficient and strong agricultural sector. Technical knowledge is required to increase the efficiency of irrigation systems[4].

The solution to this age-long problem lies in the adoption of automated irrigation systems [5]. In an IoT-based automated irrigation system, sensors are usually deployed for the real-time monitoring of the farm. This helps the farmers to monitor the conditions of their crops field from anywhere. This results in a highly efficient and economical system of farming when compared with the conventional approach as a result of its ability to conserve water and reduce human labour. Automated irrigation systems can be programmed to discharge more precise amounts of water in a targeted area, which promotes water conservation. The rapid advancement in technology in recent years has made lives simpler and easier. The extension of this development to farmers will result in the reduction of the cost incurred with the use of manual irrigation and monitoring, save time and energy, abate or eliminate the ever-increasing competition for the scarce water resources.

Machine learning is an aspect of computer science that can learn from previous data and experience to make more informed decisions[6]. Fig. 1 shows the process steps for ML applications.

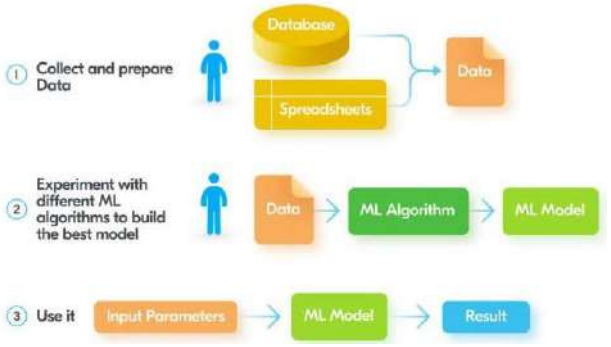

Fig. 1 Machine Learning Algorithm Workflow

II. AIM AND OBJECTIVES

The project aims at designing and implementing cheap and efficient weather adaptive intelligent irrigation systems based on the internet of things and artificial intelligence to maximize water usage and predict future tendencies based on the acquired data. The objectives are further highlighted as shown below.

- To acquire real-time data of the soil using sensors and transmission same to the cloud.
- To analyze and train the data using a suitable machine learning algorithm to effectively predict the condition of the soil and minimize farmers' interaction with the system.
- To predict rainfall using rainfall data obtained online to avoid water wastage and waterlogging.
- To automatically irrigate the soil optimally using the above mechanism.

III. PROBLEM STATEMENT

Irrigation which has become crucial part of agricultural processes is always tedious, time consuming, and requiring a lot of manual labour. The adoption of emerging technologies in recent years have reduced human resource input and time requirement for irrigation processes. In most of these systems, sensors are used to periodically measure the soil parameters to determine its state. Decision is then taken when these data is compared to a set reference without taking into consideration the condition of the weather. Such systems also lack the capability of learning from the data obtained to predict future parameters neither can they work independently without manual input by the farmers. With such technology-enhanced irrigation systems, there is limited control of irrigation processes which results in the massive wastage of scarce water resources since the amount of water available is more than the plants' needs. To avoid poor water management, which could reduce yield and ultimately revenue loss, there is a need to incorporate Artificial Intelligence and weather adaptive technology-enhanced irrigation systems. Farmers in Nigeria have not embraced the concept of Climate Information Systems in the practice of agriculture talk less about adopting the same during the irrigations process for crops.

Thus, this research work intends to develop an autonomous irrigation system that is responsive to all weather conditions and cost-effective. It will also incorporate the ability to learn the pattern and work independently without manual input.

The proposed system will through the help of sensors collect air temperature and humidity, soil moisture content, and transmit the raw data to NodeMCU to know if the soil is dry by comparing it to the trained set of data in the NodeMCU. The NodeMCU will then obtain data from the Opensource Google weather API (Application Programming Interface) called OpenWeatherMap using JSON (JavaScript Object Notation) data to know if there will be rainfall or not. Base on the data collected from the weather API, by the NodeMCU, it will then determine whether to trigger the pump for irrigation or not. The real-time monitoring report of this process will be sent to the cloud where the farmer can access to monitor the condition of the farmland whenever he wishes.

IV. LITERATURE REVIEW

In the proposed system by [7], sensors were deployed to collect the humidity, temperature, and soil moisture content for the monitoring of the crop field. This collected information is sent to ATmega328(Arduino) and can be displayed on an LCD attached to it. The periodic update of these data is sent to a webpage through the help of a Wi-Fi module. The system also incorporates a GSM module through which messages about the condition of the farm are sent to the authorized person. In [1], a system was designed using Arduino and NodeMCU which uses the sensors' information to determine when to switch ON the pump to water the farm, thus enabling the real-time monitoring by the administrator(farmer). The parameters collected are soil moisture content, relative humidity, and temperature. The system uses Thingspeak API as the central node and this is the medium through which information is relayed to the farmer.

The system designed by [8] used Arduino as the microprocessor and NRF24L01 Wi-Fi module for the communication network. The system is designed to operate both manually and automatically. The manual system is operated with an Android Application which enables the farmer to water his farm from anywhere regardless of the distance, while the automatic system periodically checks the condition of the field and water when the soil parameters go below a set reference value. The Authors of [4] developed and implemented a system that used a humidity sensor, soil moisture sensor, temperature sensor, and light sensor to monitor and automate irrigation processes. There is a dedicated web server database where these sensor data are sent using wireless communication. In the server database, the data are encoded in JavaScript Object Notation (JSON) format. The working principle is to periodically check if the temperature or moisture content of the field falls below the brink and automate irrigation by releasing the precise amount

of water to the soil. An update is periodically sent via SMS to the farmer's phone.

The author of [9] designed and implemented a Smart system to monitor and irrigate crop-field using Microsoft Azure machine learning. The system used Arduino and through the help of deployed sensors received data from the farmland. This data coupled with weather forecasting data is processed through ML operation to better informed the farmer on irrigation scheduling. With this process, the farmer is informed of the possibility of rainfall and can decide whether to irrigate or not. The interaction is done with an android application or web page through which the farmer remotely operates the tap. This enables the farmer to make an informed decision, thus maximizing the use of water. The statistical analysis of the sensor values is displayed on a web page using a graph and also for any inquiry purposes about the application.

In [10], an Arduino-based system for watering and roofing was developed. The system used Kalman filtering to obtain accurate values from sensors through the removal of noise. The decision-Tree algorithm of ML was employed in the raining of the data to know when watering should be done. A mobile application was also developed where sensor data from the cultivation field are obtained to control irrigation processes from the phone. Using the Decision Tree Model with the help of the node.js library, the sensors' data is compared with the weather forecast data which enables the administrator (farmer) to know the appropriate time to water the crop. The system developed by [11] interfaced an android app with Arduino to control the irrigation system remotely. The wireless communication is enabled by the connected HC-05 module. Sensors were first deployed to measure important parameters of the soil and the data obtained were sent to the Arduino connected wirelessly through the HC-05 module to an Android smartphone. The farmer can also interact with the sensor data through the smartphone's GUI. This system is cost-effective and efficient as it helps the farmer remotely control the watering of his farm from the comfort of his house or anywhere without heavy demand for manual input. This affords the farmers have better control of their irrigation time.

An automatic plant irrigation system that consists of solar modules, various sensors, etc., was designed by[12]. The adoption of solar in this work is to ensure a constant power supply to the entire system. Sensors that measure water level in real-time are deployed on the paddy field and this information is constantly sent to the farmer to intimate him of the condition of the water level on the field. The farmer can start the irrigation process just by sending text messages remotely from his mobile phone which in turn triggers the motor to water the crop field. The system is also designed such that when the water level reaches a critical state without instruction from the administrator, it can automatically trigger the pump to open on its own and water the field. The effect of the system developed by [12] worked in such a way that all the devices function independently on their own through the help of sensor data obtained as the input which monitors the crop field to determine the state. These results are periodically sent to the farmers to acquaint them on whether things are in order or some critical decisions needs to be made. The entire process was controlled and monitored by the programmable controller with electrical and mechanical parts. The electrical part is powered with solar energy to ensure that there is a constant supply to the entire setup.

V. JUSTIFICATION OF THE RESEARCH

So far, there have been many advancements in precision agriculture. However, almost all the breakthroughs exclude the use of an intelligent machine-to-machine interaction and rainfall prediction in irrigation. Most of the systems fetched the data at a particular time and responded immediately controlling the valves in the field. There has not been any system that takes the decision based on past experiences and analyzing real-time data with also the inclusion of rainfall prediction. With these existing systems, human input is still required for the efficient running of the systems, and the fact that rainfall prediction was not incorporated into these systems often leads it to make unintelligent decisions like watering the field when there is the possibility of rainfall in the next minute. This does not only lead to wastage of scarce water resources but could also result in waterlogging which is harmful to the survival of crops. Till now, machine learning has only succeeded in abating crop disease detection, crop management, and crop yielding problems. There is no or meagre research in the field of machine learning techniques that analyze the soil moisture content based on past data fed and controls the irrigation process without any involvement of human work. The study will develop an autonomous irrigation system that is intelligent, energy-efficient, portable, cost-effective, and can be used at any geographic position and responsive to all weather conditions.

VI. METHODOLOGY

A. Data Collection

In Machine learning projects, data plays an important role. It is a necessary task to collect the data from all the sensors and storing them correctly in a proper file format so that they can be used when needed to design the various machine learning algorithms on the project. We will be deploying sensors to the field in consideration to obtain a dataset containing the following parameters for the training of the model.

- Temperature
- Relative Humidity
- Soil Moisture

B. Machine Learning Models

In the proposed research work, we will utilize the application of Machine Learning in IoT to train sensor data. Several ML algorithm will be tested to ascertain the one that best fit the data based on the percentage accuracy. The one with the highest accuracy and least error will be adopted. The ML algorithms that will be considered are Logistic Regression, Support Vector Machine, k-Nearest Neighbors, and Decision Trees. The main classification of ML algorithms is shown in Fig. 2.

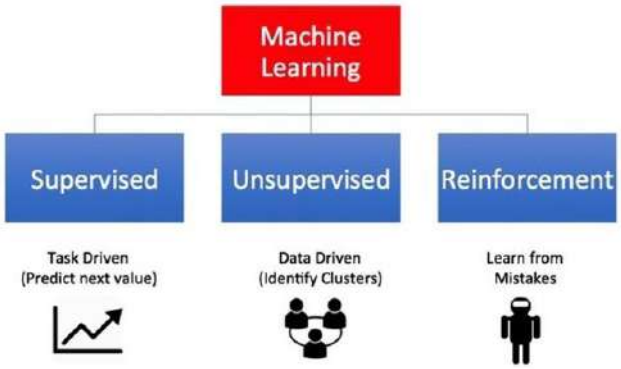

Fig. 2 Machine Learning Classifications

The following are the key factors to consider before adopting any of the following algorithms.

- High performance on both small and large datasets.
- Responds well to noisy data.
- The cost of learning is zero.

C. Rainfall Prediction

OpenWeatherMap is an online weather prediction service that can determine the minute-by-minute forecast of data for any geographical area. It does this via API which takes weather data from numerous weather station, apply convolutional neural network on them to predict precisely the condition of weather for a geographical location.[13].

The required modules will be designed using Arduino IDE, and espressif SDK. The Pseudocode for smart irrigation algorithm will be formulated using a Rule-Based machine learning concept approach.

The system will be implemented using soil moisture, humidity, temperature, and GPS sensors, Arduino microcontroller, ESP8266 NODEMCU, DS1307 clock chip, and Pump relay and Ethernet Module. Arduino IDE will program the NODEMCU and the NODEMCU will be interface with the soil moisture sensor to know when to irrigate the soil through the pump valve. The temperature and humidity sensor will be used to collect the air humidity and air temperature while the soil moisture sensor will be used to measure the water content of the soil. The raw data collected from the sensors will be used to determine if the soil is dry by comparing it to a trained set of data in NODEMCU. The NODEMCU through the GPS module will then obtain data of the field location from the Opensource Google weather API(OpenWeatherMap) using JSON data to know if there will be rainfall or not. Base on the data collected from the weather API, the NODEMCU will then determine whether to trigger the pump for irrigation or not. The system will be connected to the internet using Wi-Fi technology embedded in the NODEMCU. The condition of the farm will be routinely uploaded to the cloud where the farmer can access it anytime.

The system will be evaluated using the performance metric of the system behavior by making a comparison between the expected system output for defined input variables and set of rule bases and the actual system output for real-time input variables with sets of rules. The prototype of the implemented system will be developed and tested to ascertain the accuracy of the entire system. Fig. 3 shows the flowchart for the entire system. The NodeMCU will first be initialized once the system is switched ON. It is then expected to read the input of the sensors and store the readings in a text file that will be readable by the machine learning algorithm. The NodeMCU will then predict the state of the soil using a suitable machine learning algorithm and compare the result with that obtained from the sensors to ascertain whether the soil is wet or dry. If the soil is wet(not dry), the system gets back to read the sensors' data over again and that loop will continue until the soil is dry. If the soil is dry, The NodeMCU through the GPS module will then obtain data of the field location from the Opensource Google weather API(OpenWeatherMap) using JSON data to know whether there is a likelihood of rainfall in less than an hour or not. If there will be rainfall within an hour, the pump remains closed as it is expected that the rain will water the soil. If on the other hand, the rain will not fall within an hour, the pump will be opened and adequate water will be pumped to water the field. The IP address of the NodeMCU will be obtained and the predicted values will be sent to the cloud for farmers' interaction.

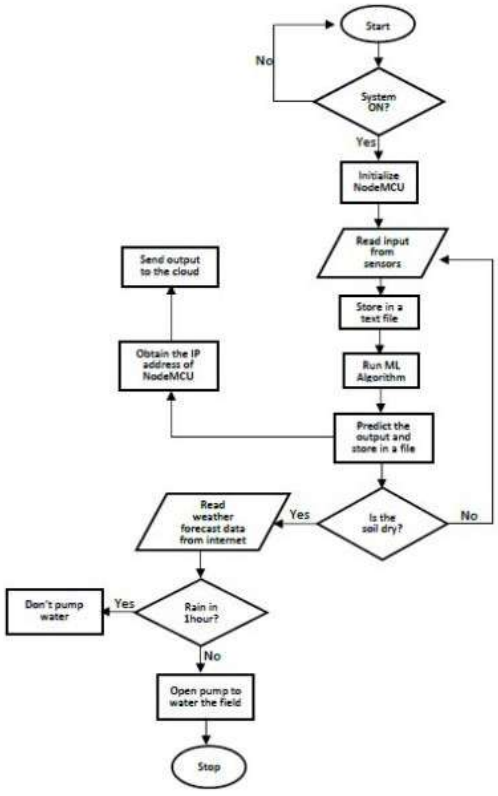

Fig. 3 Flowchart of autonomous irrigation system

The machine learning predicated decision system, when trained with precise data, can provide a precise estimate of the irrigation requisites of the crop in consideration, given the required authentic-time information including the crop and soil condition. Evapotranspiration which refers to the rate at

which moisture leaves the soil to the atmosphere is essential to estimating its irrigation requisites.

VII. Scope of the research

This study will be limited to the development of an autonomous irrigation system that will irrigate farmlands based on the information obtained from soil moisture sensors and weather forecasts. It is not designed for any specific type of crop.

VIII. Expected contribution to knowledge

This research work will produce a weather-adaptive intelligent irrigation system that would use water and electrical energy more efficiently by preventing water loss and waterlog, preserve electrical energy, and minimizing the cost of labour.

IX. Conclusion

This proposal gives a comprehensive overview of the entire steps required for the execution of the research work. Beginning from the introduction, aim, and objectives, problem statement, justification, the method that will be adopted, and the contribution to knowledge, it is clear that when completed, it will herald a breakthrough in the agricultural sector.

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