AI-Driven Sensor System for Smart Irrigation and Water Waste Minimization

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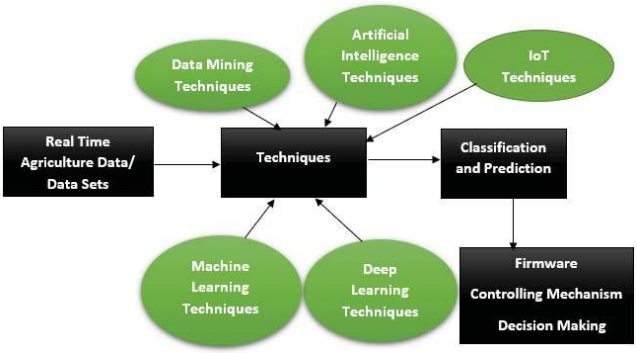
ABSTRACT- The smart irrigation system is the combination of software, hardware, and firmware with the help of various computational techniques such as IoT, artificial intelligence, and Machine learning. It is important and needed to society because of the effective production of yields and effective usage of resources. Effective techniques are needed to optimize the water, monitor the moisture, and increase the yields. This article presents different recent techniques related to the smart irrigation systems in agriculture using IoT and artificial intelligence system. The various components, Modern irrigation system, various comparison parameters, and its requirements are presented in this article. Finally, presented various issues, challenges, and future direction of the research in the smart irrigation system.

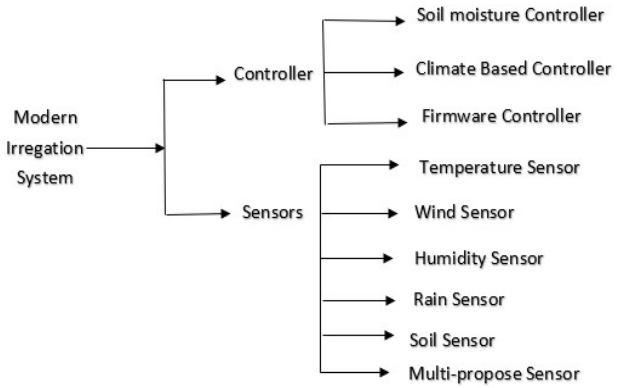
I.INTRODUCTION

In smart agriculture effective utilization of resources is important and needed for irrigations. As per the world bank data around 70%of freshwater needed for agriculture in the future [1]. So, agriculture water optimization and effective usage of water is an important one to consider the research using different techniques. Currently, the smart system is an effective concept to utilize the resources in a different field and especially in agriculture smart system plays an important role in different areas such as irrigation



system, decision making, disease prediction, control system, and energy efficiency, etc. The smart system is the combination of sensing, control, activate, analyze and make decisions based on the various automation operations [2]. The automation operations based on the various emerging techniques, networking capabilities , sensing, and intelligence computations. So, with the help of a smart system, effectively usage the water and increase the yields. The advanced technologies-based agriculture and smart irrigations decrease freshwater usage. The smart system with IoT and machine learning concepts produce the centralized storage, processing, and analyzing the data from different ubiquitous sensors with the decision process[3]. Using this process, the artificial way of distributing resources or water in the agriculture process is called an irrigation system. Mainly this irrigation system used in fewer rainfall areas to maintain the soil moistu re and temperature. Another main important usage of artificial irrigation system helps to stop the unwanted plant growth or weeds in the agriculture field. The irrigation system has two
types such as conventional irrigation system and Modern irrigation system. The conventional irrigation system uses watering buckets, cans, and canals. The main methods of conventional methods are basin, furrow irrigations, strip irrigations, and basin irrigation and it is not applied knowledge. The expenditure of the conventional irrigation system is very high. The expanded conventional irrigation system with the help of modern technologies is called the modern irrigation system. The modern irrigation system has three types such as sprinkler irrigation system, pot irrigation system and drip irrigation system, etc. [4]. The

modern irrigation system also classified into different other usage also. As per weather evapotranspiration controller- based, it is classified into the signal-based controller, Historic controller, and On-site weather measurement controller's irrigation system, etc. As per the soil moisture sensor controller, it is classified into Suspended cycle irrigation systems and water on-demand irrigation. Those are some of the main classifications based on the usage of components and properties. The various controlling and sensing of modern smart irrigation technology shown in figure 1.



The main outcome of the modern smart irrigation system is reducing the water usage, money and increase the yields. The automated smart irrigation system used different recent technologies such as artificial intelligence and machine learning [5], big data [7], IoT [9], wireless sensor network [6], and cloud computing [8] etc. The main components of smart irrigation systems are computation techniques, sensors, automatic controllers, satellite data, flow meters and valves, WSN and battery, etc. The general representation of the modern irrigation system shown in figure 2. The modern irrigation system having different steps such as i. Real-time

Modern irrigation system data collection ii. Applying techniques iii. Class ification and prediction iv. Controlling and decision making.

The organization of the paper is consisting of section 2 having various comparison parameters, section 3 has various smart irrigation techniques using artificial intelligence and IoT, section 4 having issues, challenges, and future direction, and finally the conclusion.

III. VARIOUS PARAMETERS OF SMART IRRIGAT ION

Various parameters are used to measure the effectiveness of the smart irrigation system. The smart irrigation system consists of soil management and water management. Soil management having different parameters such as soil moisture, soil temperature, conditions of soil and dryness of the soil, etc. The water management having different parameters such as dew point temperature, Evapotranspiration, air temperature, wind temperature, and humidity. Apart from those parameters the accuracy of prediction, rate of data transfer, effective usage is the other parameters to consider in the smart irrigation model. The trending formula for measuring soil management and water management are as follows [10].

Gravimetric contents of soil = (Volume of soil moisture – Volume of oven-dried soil) / (Volume of oven-dried soil-dried soil) Volumetric contents of soil water = Volume of Water/ Volume of Soil.

Moisture of the Soil = weight of the moisture of the soil – Weight of the dried Soil/weight of the dried Soil.Beyond these, different formula and equations are used for getting aggregate, mean, and prediction of present and future values.

Various techniques and methods are used to manage smart irrigation. The recent smart irrigation techniques based on IoT, Artificial Intelligence, Deep Learning, and machine learning. With the help of these techniques can manage the weather, s oil management, water management, and multi-parameters. This section gives a brief summary of information about various prediction and management techniques of irrigation systems. The authors of [11] proposed IoT based sprinkling irrigation system. In this system solar panel is connected to the water tank and which is incorporated with a level indicator. The authors of [12] proposed a statistical analysis method for managing water using temperature, moisture, and PH. This application is used in a small farm and small size land. The authors of [13 proposed an automated model to manage water irrigation with the help of IoT components. Using this system, water is pooled to the soil but different parameters are considered for water management. The authors of [14] proposed an IoT based autonomous system to manage irrigation system using different components such as Raspberry pi 3, WIFI

node, and microcontroller. If water shortage raised, immediately supplied to the ground. The authors of [15] proposed an IoT model for monitoring soil moisture using losant platform. The authors of [16] proposed a model for a low-cost smart irrigation system using MQTT protocol to transfer predicted data using sensors. Depending on the soil moisture, the node MCU-12E controller controls the water pump action.

The authors of [21] proposed an application for implementing a mobile boat robot for sensing soil moisture and other various parameters of the environment. The authors of [22] proposed an IoT and wireless sensor network application to improve the efficiency of irrigation. In this method, the software and hardware used to expand the operation using Zigbee node, sensor, and green land. The authors of [23] proposed a model for automatic irrigation and soil PH using a sensor and microcontroller. The authors of [24] proposed a system for an intelligent sensor network for sensing soil moisture and finding nutrients deficiency of soil. using this method deficiency alerts are sent to farmers. The authors [24] proposed a system using IoT, checked the nitrogen, phosphor, and potassium. using these parameters saved money, time, and power. The authors of [26] proposed a model for data acquisition and task management for the decision making of the smart farmer. using this method, task management, planning, and environmental factors are measured. The authors of [27] proposed a model for optimizing water using various components such as wireless sensor unit, wireless information unit, and web application. The authors of [28] presented various protocols and hardware unit to manage the farm. The authors of [29,30] proposed a model for managing farms and a smart decision system for water management. The authors [30] proposed open source technologies for smart irrigation using machine learning. In this method, various irrigation events are monitored.

IV. Challenges and Future direction of research

A. Challenges

Smart irrigation system facing different issues and challenges in different situations such as building the smart system, communication of data transformation, integration of the hardware, decision making, and data analysis etc. In this section presented various challenges in different situations are as follows.

i. The integration of sensors is very challenging task because the different sensors are used for different purpose. For example, in the figure 1 mentioned the different sensor for different purpose. The integration of data from the collected nodes is difficult task.
ii. An IoT based smart system having different layers to data observation, transformation, and integration of the hardware and software. The integration of layers facing problems in cost and implementation.
iii. Improve the smart irrigation automation system in the following way such as irrigation time, wastage of water, prediction of moisture level in the soil, and the finding the requirements of water and nutrients of soil.
iv. The IoT based irrigation system needed smart automated microcontroller, so smart irrigation effective infrastructure, automated switches, automated pump are need for better automations.
v. Multi- events such as climate parameters (Soil parameters, moisture, humidity, rain fall timing andfuture time fall prediction) are important to consider in implementation of smart irrigations.
vi. The role of LED indication, smart mobile based indication and connectivity to consider in implementation.
vii. The decision making based on the past data and future data prediction is important to consider in implementation.

Those are the some of the general challenges are faced in the implementation of smart irrigation system. The main research gap of various existing works is shown below.

i. The authors of [11-20] presented optimization methods in either managing soil moisture or water.
ii. For Water optimization, multi-nodes are not introduced in the various existing methods [31].

V. Future direction of Research

The current research in smart irrigation system needed further improvement because new automatic decision-making systems are introduced using IoT, Big Data, artificial intelligence and machine learning etc.

viii. Future Data Prediction**:** In smart irrigation, future data prediction is an important task. But the most of the previous works summarized in the survey work [32] not present future data management in smart irrigation system.
ix. Infrastructure and integration of weather prediction in smart irrigation not presented and implemented.
x. Past, present and future data analysis and predictions in the smart irrigation using IoT, Big data

and artificial intelligence techniques are help to take decision making.

xi. Need to improve the Sustainable smart irrigation Systems.

xii. Frequency and new form of the Data Acquisition.

xiii. The common architecture for designs and implementation for IoT Irrigation Systems for different crops are needed.

xiv. Best Recommunication system using machine learning and deep learning methods.

VI. CONCLUSION

The smart irrigation system is an important research area because future of the world facing different short coming in water and energy. In the world, 70% of fresh water is consumed for agriculture. So, water optimization, reducing energy, saving money and increase the yields is an important task in smart irrigation system. In this article presented various components of smart irrigation, functions of each layers in smart irrigation and modern irrigation system is presented. In the section 3 presented various techniques and summarized for further research. The end of the section various challenges and future direction of the research are presented.

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