Logistic Regression and Internet of Things Based Smart Irrigation to Predict Crops Water Need

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Abstract—Irrigation is crucial to agriculture. Due to advancements in technology, when we go outside or whenever crops need to be watered, we no longer need to rely on someone to perform irrigation. Many researchers have attempted to irrigate crops automatically, but accuracy, timeliness, and cost concerns are rarely addressed and given top priority. The proposed approach carries out autonomous watering, which results in smart irrigation, using a wireless sensor network, real-time sensors, and irrigation system control. By using this method, waste is decreased and the necessary water is kept in the container. Instead than just evaluating soil moisture, automated irrigation takes into account the type of crop, the weather, and soil moisture to determine whether the crops need to be watered. By taking into account the aforementioned three factors, a machine learning technique called logistic regression is utilized to estimate the need for water. The logistic regression model, which is based on the values of the three parameters given, forecasts the watering needs of the plants using an arduino-based IoT circuitry. The strategy outlined is advantageous in terms of accuracy, timeliness, and cost. The results of the proposed model has proven its betterment in performance and the amount of automation over the existing irrigation systems. The IoT and machine learning combined model is useful from the point of view of its accuracy, cost and timeliness in predicting water needs for crops as well as full automation is enabled in the irrigation system with this approach.
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Keywords-IoT, Logistic Regression, smart irrigation, accuracy, soil moisture, weather conditions

I. INTRODUCTION

The objective is to develop a wireless, three-level controlled smart irrigation system that can water plants automatically and preserves water and money. The main objective is to use the system to increase the health of the soil, which will benefit the plant as a result. For optimal plant growth, the level of water in the soil must be just right [1]. Water must not be used excessively because it is a necessary component for life support. The main user of water is irrigation. This necessitates controlling the water supply for irrigation. There should be a balance between over- and under-irrigating fields. Here, the parameters for finding the need of water are very important to get the accurate water needs. In addition to being a fairly evident metric that all researchers use, soil moisture level is crucial in determining the need for water.But considering water needs based on soil moisturein all type of weather conditions is important for real time predictions. The water need varies according to weather conditions. In hot weather conditions, the water is needed in excess amount, in cold weather conditions, water needs are less than that of hot weather and in rainy conditions, assessing the water levels is very important, as rain pours water to crops, watering to crops along with rain can harm the crops with excessive amount of water. Fig. 1 shows the limitations of the existing water irrigation system. The major limitation is manual watering adjustments which demands availability and efforts of human resources [2].

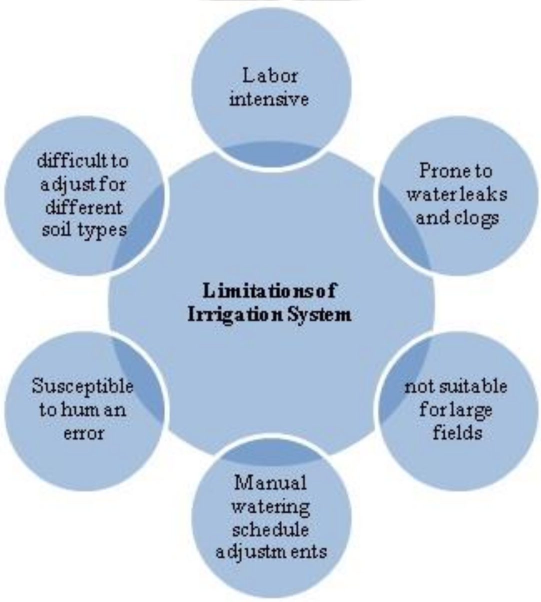

Figure 1. Limitations of Manual water irrigation

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Systems have been put in place over time to accomplish this goal, with automated techniques being the most desired because they allow for the frequent collection of data with minimal labor. Microprocessor-based systems are used by the majority of the current systems. Although these systems have a number of technological advantages, they are expensive, bulky, difficult to maintain, and less well-liked by workers in rural areas who lack technical skills. The Internet of Things (IoT) is revolutionizing the agricultural sector and empowering farmers to overcome the tremendous obstacles they encounter. The sector must deal with growing water limitations, a lack of available land, challenging cost management, and rising consumption needs of a population that is projected to increase by up to 70% by 2050 [3].When irrigation systems for farms or nurseries are automated, producers can use the right amount of water at the right time without having to hire help to turn on and off valves. They lack a highly functional mobile app with a respectable user interface that was created for users. It just enables the user to monitor and maintain the moisture level remotely and at any time. The produced microcontroller-based irrigation system will function permanently for indefinite basic measure, even in specific abnormal conditions, for the goal of reading and performing at remote locations.

Since the Arduino Uno is a reasonably priced microcontroller, it will be utilized in this project to replace pricey controllers in the currently existing systems. The Arduino Uno can be trained to evaluate a variety of sensor signals, such as readings from moisture, temperature, and rainfall sensors. A pump is used to pump water and fertilizer into the irrigation system. Use of easily accessible components lowers manufacturing and maintenance costs. The suggested method is therefore an appropriate, practical, and low-maintenance choice for applications, especially in rural areas and for small-scale farmers. This study project has been improved to aid small-scale farmers and will boost crop yields, which will boost government revenue [3] [4].

Along with IoT circuit, the correct prediction of required water needs, and automated driving of water pump and machinery is important. For predictions, we know that the machine learning techniques are very helpful. A subset of artificial intelligence known as "machine learning" is the practice of teaching a computer to learn from data [5]. For the computer to anticipate future values and occurrences, it achieves this by spotting patterns and correlations in training data. Machine learning is able to learn from any quantity of data, unlike traditional approaches that employ a set of established rules to create predictions. Machine learning may be applied to a number of tasks, including forecasting sales, recognizing market patterns, and even detecting when a computer could fail. In fact, it may be used to any issue involving time-series data and future prediction. One of the useful machine learning techniques is logistic regression for predictions. Classification problems are resolved using the machine learning technique of logistic regression. It is a method of predictive analysis that is founded on the notion of probability. The likelihood of a categorical dependent variable is predicted using the classification method Logistic Regression. In logistic regression, the dependent variable is a binary variable whose values are either 1 (yes, True, normal, success, etc.) or 0 (no, False, abnormal, failure, etc.).Finding a correlation between attributes and the likelihood of a certain result is the aim of logistic regression. A logistic regression model is similar to a linear regression model, but instead of using a linear function as its cost function, it uses a more complex cost function called the "sigmoid function" or "logistic function." [6][7].

In the water need predictions the logistic regression is useful for predicting water is needed for crops or not needed based on soil moisture, type of soil, weather conditions, soil moisture and type of crop in the crop field [8].

The subsequent part of the research article explains the detailed literature insights, proposed methodology for water level predictions, nature of data used for model implementation, results of the model for the testing data, finally the conclusions explain the efficiency and effectiveness of the model as compared to the existing systems.

II. LITERATURE SURVEY

The researchers have done the detailed literature study in the area of smart water irrigation solutions with respect to the methodology, results, advantages and disadvantages of each methodology.

In [9], Aamo IORLIAM et. al. have used machine learning techniques to classify (separate) data generated by IoT-enabled smart irrigation equipment. In order to identify trends and carry out classification tasks, the researchers came to the conclusion that pre-processed IoT-generated datasets from smart irrigation equipment may be used as input data. The RF algorithm, one of the four machine learning algorithms (LR, RF, SVM, and CNN) used in this study, was judged to be the most successful because it accurately identified when the smart irrigation device was "ON" and when it was "OFF" with an accuracy of 99.98%, 0.9998, 0.9996, and 0.9999 for the Accuracy, F1 score, Precision value, and Recall, respectively. The limitation of the work is the amount of data and quality of data used for model development is very less, also the researchers have not mentioned about dependency parameters based on which the water level predictions are calculated. The results are generated for only few samples and all types of attributes with necessary samples showing the water needs in various conditions for various crops is missing.

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According to P. Mercy Nesa Rani et al.'s description of an automated irrigation system in [10], farmers can water crops appropriately to irrigate them without limiting their growth. This irrigation system determines the moisture level of the soil and waters the plant accordingly by measuring the resistance of the soil-inserted electrodes. Using the ADC signals from the moisture sensors, the amount of moisture in the soil is calculated. Depending on how much soil moisture there is, the water pump is turned on to irrigate the crop. The disadvantages of these methods of moisture monitoring include the need for specific calibration and failure in soil that contains salt. By lengthening the electrode, the scientists were able to detect the water content of the soil across a larger region. The work does not make use of wireless sensor networks and does not offer monitoring of vast agricultural fields.

In [11], G.Ravi Kumar et al. presented a state-of-the-art design methodology for controlling soil moisture using LabVIEW, complete with all the tools required to swiftly build any measurement or control application. A rain sensor is also part of the design, which is essential to limit unnecessary power use. The authors claim that farmers are able to boost agricultural yields and quality while using less water overall to grow crops by regulating soil moisture more efficiently throughout crucial plant growth phases. Adoption of an embedded system for computerized irrigation in agriculture is a good substitute for page-accurate irrigation control that aids farmers in increasing yield while saving money. The system's drawback is that it uses a small number of parameters and completely automates the watering system. Additionally, the quality features attained by the study activity are not specifically mentioned in the reports.

In [12], Vishal Saraswat and colleagues describe and test "Smart irrigation system using Arduino based on soil moisture." It came from combining features from all of the hardware used. The mechanical operation of the system has been confirmed. The moisture sensors calculate the various plants' levels of moisture (water content). If the dampness level drops below the desired and specified level, the moisture sensor sends a signal to the Arduino board, which in turn instructs the Water Pump to turn ON and feed water to each individual plant. When the desired moisture level is attained, the system automatically shuts down and the water pump is turned off. The system's operation has therefore undergone extensive testing and is believed to function exactly as anticipated. However, in this instance, the system merely uses the sensor; there is no mechanism in place to assess the data and foretell when water would be needed. Additionally, it is dependent on the quantity of moisture alone; other significant factors are not taken into account.

When the weather system anticipates and modifies the plant watering cycle in accordance with the weather, human contact with plants during irrigation is completely removed [13], according to Aman Bafna et al. Farmers are no longer obliged to fertilize their crops thanks to the introduction of fertilizers that are water soluble. The irrigation system will take care of the rest; just add fertilizer to the water tank. The system's drawbacks in this instance are that it ignores automated watering, only provides plants that can flourish in the available soil types and does not take forecasts of water requirements into account.

In [14] by Ancy Stephen et al. describes how automated irrigation is carried out. Real-time sensors, a wireless sensor network, and irrigation system control are all included in the recommended system, which enables autonomous watering. This method helps to keep water in the container as needed and minimizes waste. The level of soil moisture determines whether or not the pumping motor runs automatically in automated irrigation. To predict how dry the soil is, machine learning techniques like the KNN algorithm and Naive Bayes algorithm are used. The linear method is used to calculate the required amount of water and to predict when the subsequent water cycle will occur. Then, an artificial neural network is used to construct the pumping ON/OFF prediction algorithm. The suggested system uses a linear algorithm, and classification techniques do not accurately anticipate the intended outcomes. The structure and output of the linear algorithm, as well as the data requirements, are not specified by the system. This approach doesn't offer projections for water levels or the amount of water that crops in a field will need.

In [15], YounessTace have discussed about the production needed to satisfy the projected 70% rise in global food demand by 2050 can be increased in part by using intelligent irrigation. It also involves controlling how much water is used for irrigation. In this article, we suggest an irrigation forecast that begins with the development of a database utilizing a data acquisition card with several sensors (Soil humidity sensor, temperature, and humidity sensor, rain sensors), and the Node-RED platform. This made it possible for us to gather a variety of data for use in our machine learning-based decision support models. The findings indicated that k-Nearest Neighbors has a recognition rate of 98.3% when compared to other models, and finally, present a web application to group all functions carried out throughout this course in order to facilitate the visualization and supervision of the environment through a straightforward phone or laptop. The limitation of the work is the quality and amount of the data is low as per the requirement of machine learning techniques accuracy enhancement demands. The accuracy results of the system can be improved with better approach. The complete automation of the system is not achieved in the working mechanism.

In [16], R Aminuddin et. al. in order to keep track of a plant's water usage, have created a smart irrigation system for

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urban gardening. Python and a Raspberry Pi were used to create and develop the system. For real-time irrigation, this study suggested using the Binary Logistic Regression technique. The results demonstrate that by using the information gathered from soil moisture, temperature, and humidity sensors, the system was able to forecast the irrigation condition. 82% of the total data are accurate. In the future, the sensor data can be more visualized over time rather than just being displayed as data numbers. As an illustration, showing the readings of the soil moisture sensor against a time plot enables for better monitoring of how efficiently the system regulates the plant's moisture. The limitation of the system is its automation and the scope unavailability for rural crop fields. The data set details are not discussed by the researchers. Also, the cost of the hardware required for the model building is more than the affordable prices for the rural area farmers [17].

From the literature review following highlights are summarized as limitations of the existing irrigation solutions proposed and available in the current scenario.

- The solutions have been implemented as IoT based designs, the water need predictions are not generated by any.
- The existing solutions consider only soil moisture level as parameter to identify the water needs, whereas weather conditions, type of soil, type of crop are also important parameters which are not considered.
- The accuracy of the systems is not up to the mark, which can damage the crop fields in case of unnecessary and excess watering or under watering.
- The existing solutions are not fully automated and needs the human resource to take care of most of the functionality.
- The working mechanisms are not established in the real agricultural farms.
- The systems are not targeted for the large farms and crop fields, especially for rural areas.

III. CONCEPTS AND DEFINITIONS

In the proposed model building two important things form a complete designing of the irrigation system. The things are:

a. *Arduino*
b. *Logistic Regression*

The arduino circuit is important here to drive the ON and OFF mechanism of the watering pump and logistic regression is important for predicting the water need for crops which makes arduino circuit to decide watering to crops or not. Lets briefly discuss about these concepts to understand their need in the model development.

a. *ARDUINO:*

The circuit board of an Arduino has a variety of elements that interface with one another. The layout has evolved through time and some iteration now incorporate additional components. However, a simple board is likely to have the following components:

- There are other pins that may be utilized to link the Arduino to different components. There are two types of these pins:
  a. *Digital pins that only have two possible states: on and off. Digital I/O pins on Arduinos typically number 14.*
  b. *For more precise control, analogue pins, which can read a variety of values, are helpful. There are typically six of these analogue pins on an Arduino.*

  These pins are set up in a certain way so that if you purchase an add-on board made to fit into them, sometimes referred to as a "shield," it should fit into most Arduino-compatible devices without too much difficulty [18].
- A power connection that supplies power to the device itself as well as a low voltage that, if the linked components' power requirements are low enough, can power LEDs and different sensors. A tiny battery or an AC adaptor can be connected to the power connection [19].
- The Arduino's main component, called a microcontroller, enables programming so that you may program it to carry out orders and make decisions depending on various inputs. Depending on the kind of Arduino you purchase, the precise chip may vary, but they are often Atmel controllers, typically an ATmega8, ATmega168, ATmega328, ATmega1280, or ATmega2560. Although there are minor differences between these chips, a novice will mostly notice the variations in onboard memory sizes.
- On most contemporary boards, a regular USB port serves as the serial connection. With the help of this connector, you may talk with the board from your computer and download fresh software for it. A USB port may frequently be used to power Arduinos, eliminating the need for a separate power source.
- Several additional minor parts, such as an oscillator and/or a voltage regulator, which are crucial to the board's functionality but which you normally don't contact with directly; just be aware that they are there.

The fig.2 shows the arduino circuit design.

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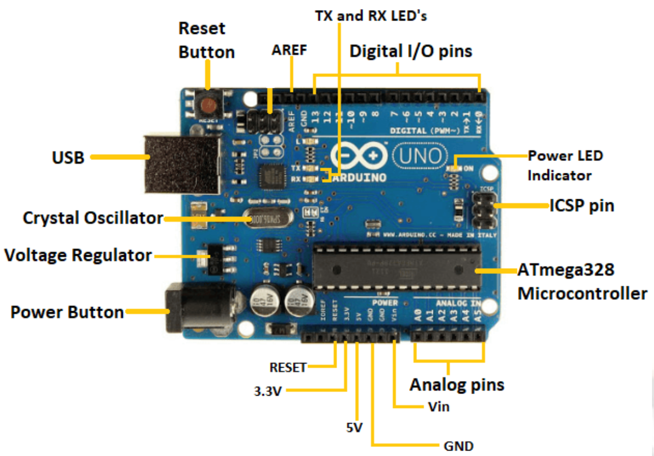

Figure 2. Arduino board

b. Logistic Regression:

An illustration of supervised learning is logistic regression. It is used to determine or forecast the likelihood that a binary (yes/no) event will occur. One use of machine learning to identify whether a person is likely to have the COVID-19 virus or not is an example of logistic regression. Binary categorization refers to the fact that there are only two answers to this question: either they are infected, or they are not.In this hypothetical illustration, the likelihood that a person may get COVID-19 could depend on the viral load, the symptoms, the existence of antibodies, etc. Our variables (Independent Variables) would include viral load, symptoms, and antibodies, which would have an impact on our result (Dependent Variable) [20] [21].

Logistic regression is used in a variety of contexts and industries in the real world. Logistic regression may be used in the medical field to determine whether a tumor is likely to be benign or malignant. Logistic regression may be used in the financial sector to determine if a transaction is fraudulent or not. Logistic regression may be used in marketing to determine if a target audience will respond or not.

Types of Logistic Regression:

1. *Binary logistic regression:* When there are only two possible outcomes, like in our initial example of whether a person is likely to have COVID-19 or not, we use binary logistic regression [22].
2. *Multinomial logistic regression:* When there are numerous possible outcomes, such as if we expand on our previous example to determine if a person could have the flu, an allergy, a cold, or COVID-19, we use multinomial logistic regression [22].
3. *Ordinal logistic regression:* It is used when the result is ordered, like in the instance when we extend our initial example to include grading COVID-19 infections into mild, moderate, and severe categories [22] [23].

Following equation represents the logistic regression to be applied for model development.

$$h\Theta(x) = 1/1 + e - (\beta o + \beta 1X)$$

*'**hΘ(x)**' is output of logistic function , where 0 ≤ hΘ(x) ≥ 1*
*'**β1**' is the slope*
*'**βo**' is the y-intercept*
*'**X**' is the independent variable*

*(βo + β1*x) - derived from equation of a line Y(predicted) = (βo + β1*x) + Error value*

IV. PROPOSED METHODOLOGY

The architecture of the system is made up of sensors with arduino board and the machine learning technique. The fig. 3 shows the flow architecture of the proposed system.

The approach gives advantage of the hardware-based system architecture to gather information on the crop type, weather, and soil moisture. The necessary sensors for the Arduino circuit, which senses the information pertaining to these properties, make up the hardware. The main goal of using IoT and machine learning were used to develop a low-cost smart irrigation system with the goal of making it easier for farmers to comprehend how much water is required for producing nutritious, disease-free crops. The agricultural field's data is collected by the sensors, who then feed it to the model.

Logistic regression is used to drive the automated system and prediction model, which forecasts water requirements. The sensor data will be fed into the logistic regression, which will then determine if the input causes the agricultural field's water demands or appropriate water supply. When the logistic regression determines that the water level is below the required level, the water pump switch is triggered to turn on, supplying the agricultural field with water. The water pump switch is turned off automatically if the logistic regression model concludes that there is sufficient water available in the agricultural field or has been reached, preventing water waste.

As shown in fig. 3, the sensors available at arduino kit, sense the environment data such as, water level available in the field which is soil moisture, the weather conditions and forecasting, type of crop available in the fields. This information is preprocessed and passed to the machine learning model built with logistic regression. The logistic regression model predicts for the water need of the crops based on the values of input parameters. If, the model detects deficiency of water in the crop field, then hardware mechanism drives the watering pump ON and based on prediction of water level needs, the watering will done to the crop fields. This prediction helps to avoid the water wastage which can happen in manual irrigation system as human work can be erroneous and does not

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consider the environmental parameters for decision making as mentioned in the methodology.

V. DATA

The research is carried out with the Kaggle dataset. This dataset was obtained from a device that continuously monitors and controls an irrigation system via a wireless sensor network. Temperature (C), humidity percentage, and soil moisture requirement are the variables in the dataset that were employed in the suggested methodology. While the required amount of water is an independent component, temperature, humidity, and soil moisture are dependent variables. Some water filtration systems employ the pH level as a filter when it is dirty to ensure good crop production. The dataset consists of 12 column and thousands of records. The important attribute names are temperature, moisture etc.

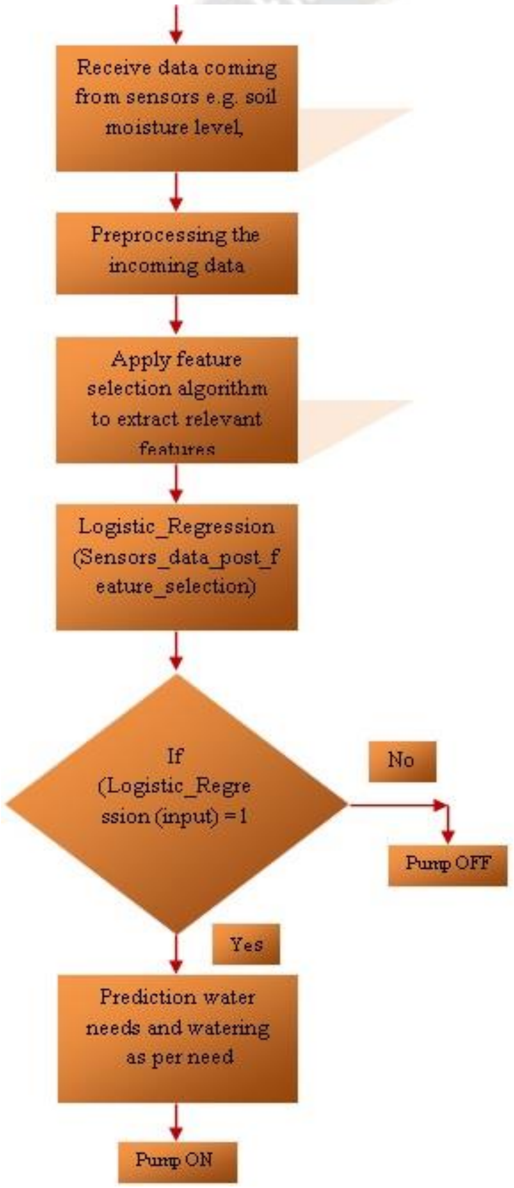

Figure 3. Proposed methodology architecture for "Smart Irrigation using IoT kit and Logistic Regression"

VI. RESULTS AND DISCUSSION

The model is trained with intelligent irrigation system dataset. It consists of all the records and the data of the cotton crop. The dataset is used for training and testing of the model. Total records are divided into 70% of the training dataset and 30% of the testing dataset. The model has shown better accuracy with increasing number of epochs. The fig. 4 shows the graph of accuracy achieved in the testing phase of the model.

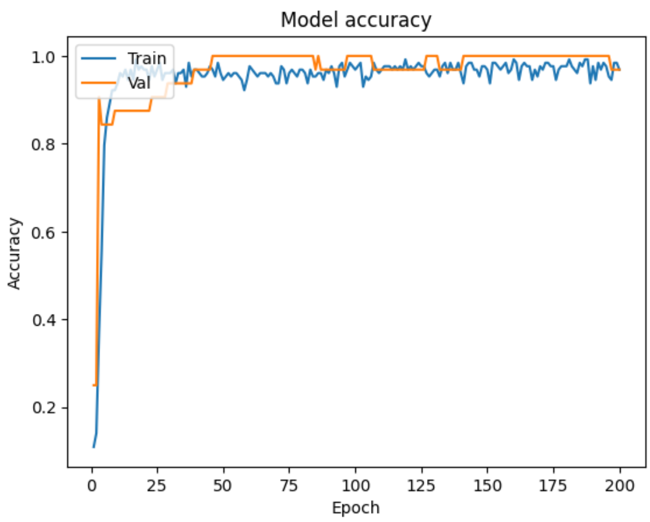

Figure 4. Accuracy of our model

The accuracy achieved is 97.84% for the cotton crop given in the dataset for detecting the water needs with the help of proposed logistic regression model. Also, the accuracy is generated with various accuracy parameters such as precision, recall, F1 score. The fig. 5 shows the confusion matrix generated for the accuracy validation of the proposed approach.

	precision	recall	f1-score	support
0	0.91	1.00	0.95	10
1	1.00	0.97	0.98	30
accuracy			0.97	40
macro avg	0.95	0.98	0.97	40
weighted avg	0.98	0.97	0.98	40

Figure 5. Confusion Matrix

The accuracy results are better as compared to the existing system. The fig. 6 shows the comparison of the proposed model with other smart irrigation approaches. The results have proven that the model is useful to save the water and excess watering to plants can be avoided. It has shown better automation scale and it reduces the human efforts required to greater extent. The execution speed of the system is also affordable. The results are generated for the only crop type of cotton. If the data size and

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various crop types are used, accuracy can be improved in future.

Hence, the logistic regression approach with ardiunoboard-based approach contributes better in forming smart irrigation system as compared to other systems.

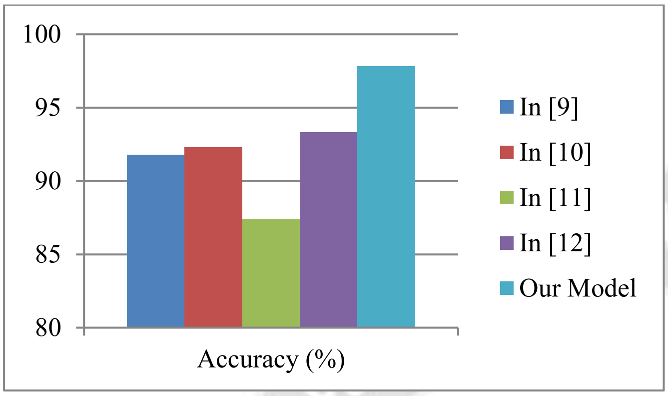

Figure 6. Accuracy Comparison of Irrigation systems

VII. CONCLUSION

Here, research on smart irrigation systems that employ IoT-based circuits and machine learning is concentrated on the fully automated method for watering farms and agriculture fields. It details the method without personal involvement and accurately based logistic regression methodology estimates of water demands. Since only an Arduino board is required, the solution is also relatively inexpensive and accessible to everyone who owns farms. The effort required from farmers to operate this system is reduced because they are not required to physically access the agricultural fields or to operate any other component of the system. The proposed approach has given the accuracy of 97.84%. The model helps to automate the water irrigation and reduces the human efforts; also, the accuracy ensures that water wastage will be avoided. The future scope of the system is that the dataset of various crop types can be generated, and model can be tested for different crop types as well as soil types.

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