Smart Irrigation System using IoT sensors for Agriculture Crops

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***Abstract*— In this paper implemented application-based solution for smart irrigation system using IoT sensors. The proposed model provides a prediction of the user's time before which plant must need spraying, to compare water content present in soil and measure surrounding temperature and humidity in real-time. This application provides intelligent predictions which depend on environmental factors. If water is required, the tank valve is automatically opened and will be closed if water is not necessary. Nutrients dissolved in water are transported to each part of the plant. Water also protects plants from both frost and hot air currents. To maintain moisture of soil for efficient plant growth, it must be watered regularly. Instead of watering a little every day, opting for a more thorough watering at intervals is comparatively better. water needs to trickle below surface and reach end of pot. This ensures better root development. In this paper, as a first level plants of rose are considered, and first performed statistical analysis to find out the relationship between soil moisture with temperature and humidity. On a day, data is collected at three instances that is at morning, afternoon, and evening on both rainy and normal. This categorization is done as soil moisture and rate of evaporation differs at each different instance. On a rainy day, rate of evaporation will be nearly 0.0384614 due to more humidity and will have soil moisture in between 70% to 78% so plant may not need water whereas on a normal day, during afternoon there will be rate of evaporation nearly equal to 0.051156 which is more among all other cases and less soil moisture of 52% to 63% so watering is required.**

Keywords— Smart Irrigation, Soil Moisture Sensor, Soil monitoring, Smart Agriculture, Linear Interpolation, Agriculture Crops, IoT.

I. INTRODUCTION

To ensure optimal plant growth with efficient water usage, this paper discusses a smart irrigation system which involves a data collection process and examining collected data. Model uses DHT11 (Temperature and humidity) sensor and soil moisture sensors to prepare a data set on temperature, soil moisture, and humidity content every 10 minutes for both dry day and a rainy day, then recorded this data in an Excel sheet, which is later used to calculate per moist value. This value represents the percentage of moisture content of soil, then plotted linear regression graphs every 3 hours for both dry and rainy days. By examining, slope of graphs, which represented rate of evaporation, is used to predict number of hours left until plants would require watering again. To ensure that plants receive appropriate water content, an optimum moisture level of 35% required for plants is configured in this model. The calculated difference between per moist value and required 35% moisture level using formula difference = permoist-35. If the difference is greater than zero, indicate that moisture content in soil was enough, and keep servo motor in a 90-degree position. However, if difference was less than or equal to zero, indicating that moisture content was extremely low, closed servo motor closed by taking it into a 180- degree position. Overall, this process of data collection, analysis, and servo control allowed us to automate irrigation system and ensure that plants receive sufficient amount of water at right time. This can lead to better plant growth and conservation of water bodies, making it an efficient and long-lasting approach to irrigation.

Advantages of proposed system

The main objective is to save water by avoiding or reducing water loss and this can be achieved using this model. Model is an automation of water tank so, no need of manual work or involvement. It can avoid watering plants during rain to avoid water loss. It can even predict the duration after which a plant must be watered. According to research, continuous supply of water, supplying water after discrete amount of time of sufficient quantity saves water and is exceedingly good for plant growth and this implemented by present systems. This model is very useful in places with scarcity of water.

II. LITERATURE SURVEY

Bakare,T.C *et al.* [1]This paper elaborated the design of a smart irrigation system that will properly irrigate farmland. Irrigation is artificial supply of water to roots of plants. In this paper, the model used contains some sensors to measure light, temperature, and soil moisture. These are also taken as parameters to make decision of whether to irrigate or not. There will be no irrigation if moisture or sunlight or isolation is high. There will be irrigation only if both sunlight and soil moisture level are below optimum level for proper plant growth and when farm is fully irrigated, the system stops irrigation process. Developed an app written in VB.NET language in visual studio IDE which is run in windows OS. This system will show irrigation requirements values also. Subhajit das *et al.* [2] The model here used is designed to provide an advanced irrigation system which provides an automatic irrigation system to reduce water loss or wastage in areas with water scarcity. This paper explains monitoring some parameters and their behavior. Parameters are soil moisture, air

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humidity, and air temperature and explain how it contributes to evaluate need of water in a plant. Use of machine learning to compare real values obtained from sensors with threshold value which they found using data analysis of data from sensors and result decides whether irrigation to be done or not. S. Shobana *et al.* [3] The system implemented in this paper will monitor soil moisture content at both dry and wet conditions with help of a moisture sensor and it is analyzed in think speaks which will provide visualization of data from system and perform analysis. This system is automated such that it will monitor and control water requirement by providing an automated water inlet is used along with it. It will also monitor and record temperature, humidity etc. The goal of the system is to provide an automated smart irrigation system which is reliable and provides communication from websites, authorized to users to interact with it from wherever in world in very less time. S. Velmurugan *et al.* [4] uses an Arduino and statistical data like temperature, humidity, moisture, and light intensity acquired from sensors and it is compared with weather forecast for decision making. Kalman filter is used to eliminate noise sensors. Main principle of system is to measure soil moisture using sensor and information forwarded to Arduino which controls pump using relay module by comparing it with threshold value taken from test analysis. The pump stops working once enough water is available. Threshold values are different according to soil conditions like dry, damp, and wet conditions. Even data is analyzed to predict soil moisture of future days Yomna Gamal *et al.* [5] This paper describes methods for improving irrigation efficiency in smart agriculture, including real-time irrigation scheduling systems, irrigation techniques, and monitoring. Artificial intelligence will be used for irrigation scheduling to predict crop water requirements. Different irrigation techniques such as surface, drip, and sprinkler irrigation are covered, with insights into which is best for different crops and soils. Soil moisture sensing techniques including volumetric and tensiometric methods are explored. Volumetric techniques are used to find the amount of water in soil using dielectric sensors and neutron moderation. Tensiometric techniques measure the tension of water in soil using temperature distribution and microwave. Implementing these techniques can reduce water waste, optimize crop growth, and increase yields. Wafa difallah *et al.* [6] This paper describes implementation of a smart irrigation system using a wireless sensor network. The system contains sensor nodes, a sink node, a transmission network, and terminal monitoring. Sensor nodes collect data on soil moisture and temperature. The sink node acts as a gateway between sensor nodes and transmission network. Transmission network relays data to a central monitoring system. A hybrid topology is proposed to address power management and network topology challenges. Implementing this system can improve efficiency of irrigation, reduce water waste, and increase crop yields. Sami Touil *et al.* [7] This paper describes case studies on different conventional techniques for water savings and crop yield, including SMS controllers, ET controllers, RS-based irrigation management, optical sensors, and DI strategies. Results showed that SMS controllers were most effective in saving water, with a range of 20 to 92 percent. Other techniques, such as ET controllers and RS-based irrigation management, also showed significant water savings. Overall, this paper provides a comprehensive overview of different conventional techniques for water savings and crop yield, which can inform implementation of smart irrigation systems to optimize water usage and crop growth. Lina Ownino *et al.* [8] This paper discusses three various approaches used for irrigation control. It includes Soil-based approaches where modelling is done by type of soil and moisture content in soil, Plant-based approach where modelling is done by type of plant and atmosphere-based approach where modelling is done by atmospheric conditions. This paper also discusses advances in sensing, data processing and control, actuation. Finally, challenges in implementing these approaches are described in a detailed manner. Pushkar Singh *et al.* [9] An affordable and simple to use controlled irrigation system built on an Arduino platform is proposed and demonstrated in this article. The system's design uses sensors like temperature sensors, water flow sensors, and soil moisture sensors for dealing with different environmental variables like moisture, temperature, and quantity of water, crops need. Arduino gathers and receives data, and it can be connected to an interactive webpage that displays both current values and average values of various crop-related factors. This enables users to operate irrigation pumps and sprinklers remotely via a website and adhere to standards that will aid farmers in producing the most abundant and high-quality harvests. Studies on a laboratory prototype indicated that the system was useful. Kiranmai pernapati *et al.* [10] Thus, this is emerging as a common barrier. The outdated irrigation system uses a lot of water, so it requires clever methods to lower the quantity of water that is wasted during watering. Demand for internet of things has been rising dramatically across all industries, from small and straightforward applications to many and complicated ones. Putting a smart irrigation system into practice is a very complicated process, but when it is combined with IoT and smart wireless sensors, a wonderful management system result. water vapor concentration and temperature around plant are both sensed by humidity and temperature sensor. If a plant's soil moisture is less than the minimal requirement, soil moisture sensor detects this and reservoir's water level is measured using a relay and an ultrasonic sensor, and information is then sent to an ESP8266 Node MCU. A microcontroller called ESP8266 Node MCU collects data from intelligent wireless sensors, processes it, and sends it to its target using Message Queue Telemetry Transport (MQTT) protocol. Chandan Kumar Sahu *et al.* [11] This paper focuses on a clever irrigation system that a middle-class farmer uses in his farmland and is cost- effective. In the 21st century, where we currently live, automation plays a significant part in human life. Automation enables automatic management of appliances. It not only makes it more comfortable, but it also saves time and energy. Automation and control equipment used in today's industries is expensive and inappropriate for use in a farm area. As a result, created a smart irrigation system that is affordable and usable by Indian farms. The goal of this paper is to use a soil moisture sensor to autonomously regulate water motor and choose pipe's water flow direction. Send information regarding agricultural field's water and motor operations to user's mobile message and Gmail account. Renkuan Liao *et al*. [12] In this study, smart irrigation system was implemented for tomato cultivation in a greenhouse in northern China. A greenhouse tomato cultivation experiment implemented an automatic drip irrigation system comprising wireless moisture sensors, wireless control nodes, and a central irrigation controller. Unlike previous irrigation approaches, the system determined irrigation depth for each event based on real-time soil moisture data, enabling dynamic irrigation depth estimation. This system has considered spatiotemporal soil moisture distribution characteristics to optimize irrigation decisions. Khaled Obaidee *et al*. [13] Technological innovations are very crucial for businesses, and IoT and sensor systems play a significant role in improving irrigation efficiency and conserving resources in agriculture. Implementing SMART irrigation systems can enhance performance, reduce costs, and mitigate digital threats. However, organizations need to focus on security strategies to protect data and ensure sustainability through green practices aligned with sustainable development goals. Conducting substantial research and emphasizing effective management and communication systems are recommended for successful implementation of SMART irrigation in agriculture. Overall, these advancements offer opportunities for long-term effectiveness and improved agricultural practices. Sitharthan R *et al*. [14] This paper is about an automatic irrigation system using Artificial Intelligence (AI) and Internet of Things (IoT) which is purely based on prediction algorithm which uses data of weather using IoT to predict whether rain falls or not and irrigates field depending on it and moisture content of soil and supply required amount of water to field. Whenever, microcontroller gets power supply it checks moisture content, if moisture content is less then it pumps water and turns off naturally after some time and checks for moisture content. The above method shows an accuracy rate of 86.34%, sensitivity of 89.28%, and precision of 91%. Youness Tacea *et al*. [15] This paper describes various past different machine learning models used, features, experimental, and simulation. This paper has made a system where data is collected from sensors like soil moisture, temperature, and rainfall over a several months and that data set is used in various learning algorithms and created various models such as K-Nearest Neighbours (KNN), Logistic Regression (LR), Neural Networks (NN), Support Vector Machines (SVM), and Naive Bayes (NB) and found that KNN model has best recognition rate of 98.3% and a root mean square error (RMSE) of 0.12 than other models. Which means KNN model has highest accuracy among all models tested.

III. DESIGN AND IMPLEMENTATION

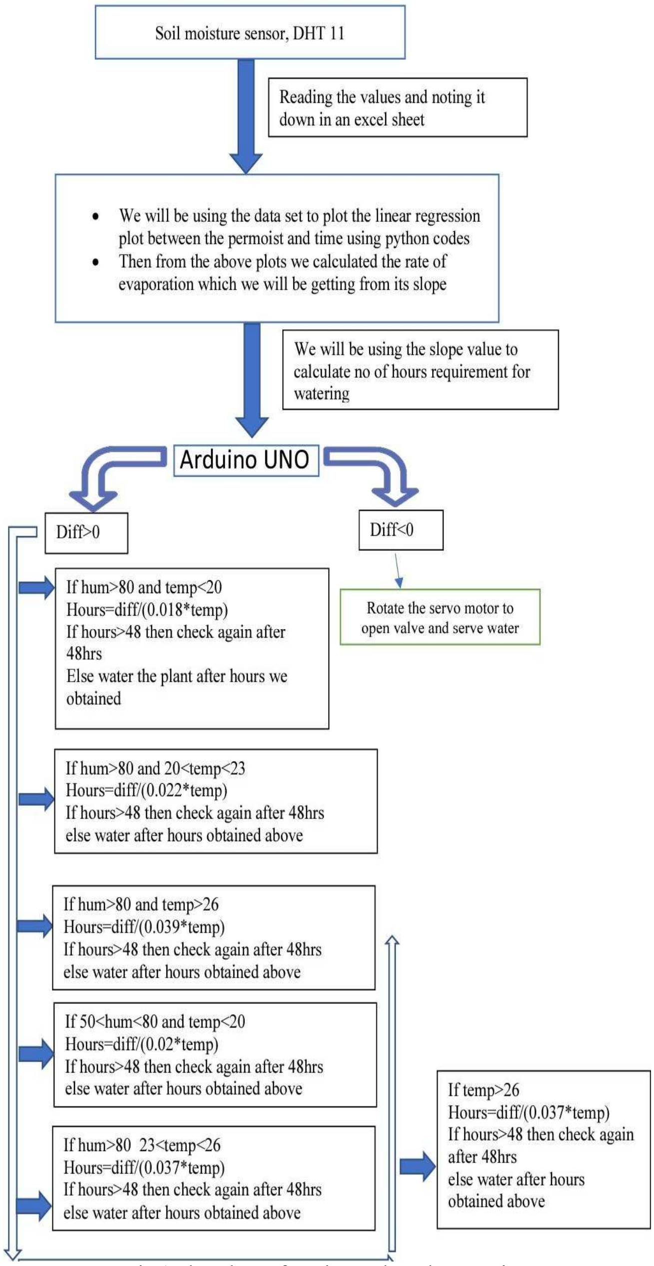

Fig.1 Flowchart of Design and Implementation

Figure 1 shows the flowchart of design and implementation the steps are Assembled the components. collected data points using simple DHT, Adafruit codes.

- Entered data into Tabular Format
- Data collection on different days.
- Generated equations to calculate approximate evaporation rate for data sets at different intervals using linear regression.
- Mapped out above data sets to visualize variation.
- Created dashboard for real-time data display.
- Coded a logic to predict time left before the next watering session.

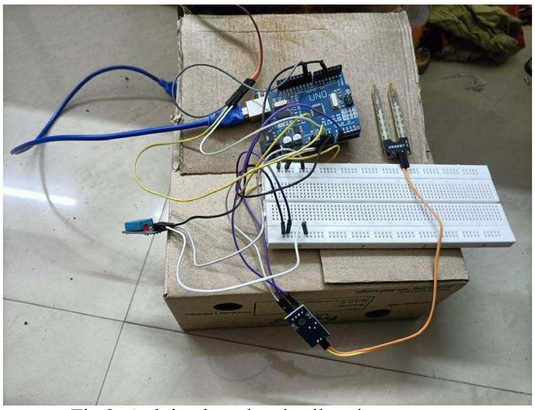

Fig.2. Arduino board and soil moisture sensor

Fig.3. Arduino board connected to water source and servo motor

Figure 2 shows the Arduino board along with soil moisture sensor and DHT 11 sensor for measuring values of moisture, humidity, and temperature respectively. Then as shown in figure 3 Arduino board will be connected to a water source and a servo motor which helps in rotating valve whenever necessary for allowing water to be supplied to soil or not. which is determined from corresponding values of humidity, temperature, and soil moisture.

IV. RESULTS AND ANALYSIS

Fig.4 When valve closed.

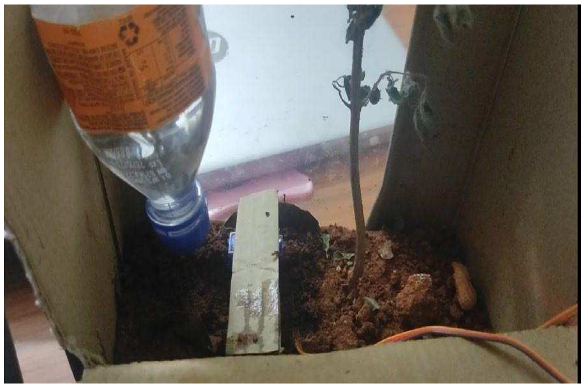

Fig.5. When valve is open

Figure 4 depicts a condition where moisture is less in soil, so code is uploaded to Arduino. It will detect values and this value is less than requirement water will be poured to soil. This is achieved by opening the valve using servo motor as shown in figure 5. In figure 5 shows a condition where amount of moisture or water in soil is good and there is no more requirement of pouring water to soil at that time so, valve must be closed this is achieved by moving valve back to its position using servo motor.

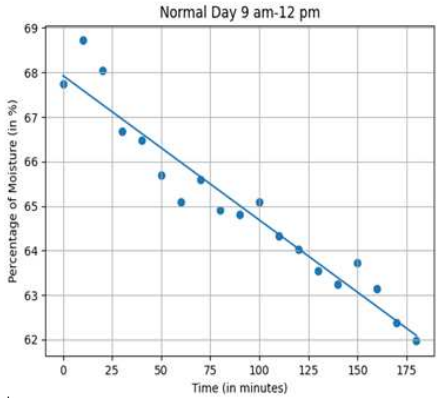

Fig.6. Morning time on normal day

The per moist value was calculated using formula.

Per moist = (1023-cell reading) *100/1023.

Figure 6 shows the analysis of time vs percentage of moisture, with time sample taken between every 10 minutes and time considered is morning, 9:00 am to 12:00 am on a normal day. It can be observed from graph, negative slope which means percentage of moisture is decreasing as time passes, but one thing which one can observe is less slope value which means place where we took. reading will generally have less rate of evaporation during morning time. The percentage of moisture ranges in between 62% to 69% during morning on normal day.

- Slope = Rate of Evaporation = -0.0324315
- Intercept = 67.9293

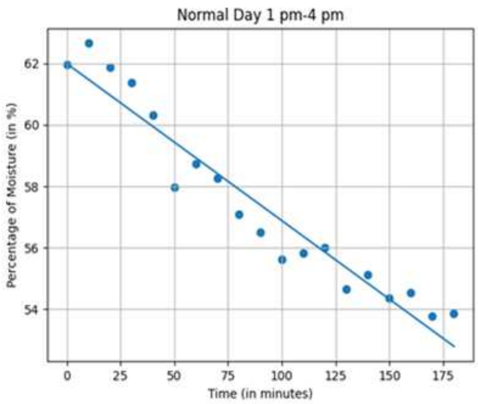

Fig.7. Afternoon time on normal day

Figure 7 shows the analysis of time vs percentage of moisture, with time sample taken between every 10 minutes and time considered is afternoon, 1:00 pm to 4:00 pm on a normal day. It can be observed from graph, negative slope which means percentage of moisture is decreasing as time passes and one can observe is more slope value than morning which means rate of evaporation is more compared to morning. The percentage of moisture ranges in between 52% to 63% during afternoon on a normal day.

Slope (Rate of Evaporation) = -0.0511456.

Intercept = 61.998894.

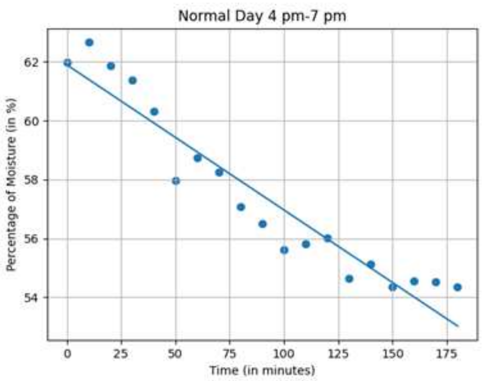

Fig.8.Evening time on normal day

Figure 8 shows the analysis of time vs percentage of moisture, with time sample taken between every 10 minutes and time considered is evening, 4:00 pm to 7:00 pm on a normal day. It can be observed from graph, negative slope which means percentage of moisture is decreasing as time passes and one can observe is more slope value than morning and less slope value than afternoon which means rate of evaporation is more compared to morning and less than afternoon. The percentage of moisture ranges between 52% to 63% during evening on a normal day. After analysis of three graphs of a normal day, one can observe the rate of evaporation is less during morning time and more during afternoon time. Throughout the day, the percentage of moisture on average goes on decreasing. The percentage of moisture ranges in between 52% to 69% on a normal day.

Slope = Rate of Evaporation = -0.04930526

Intercept = 61.8990526

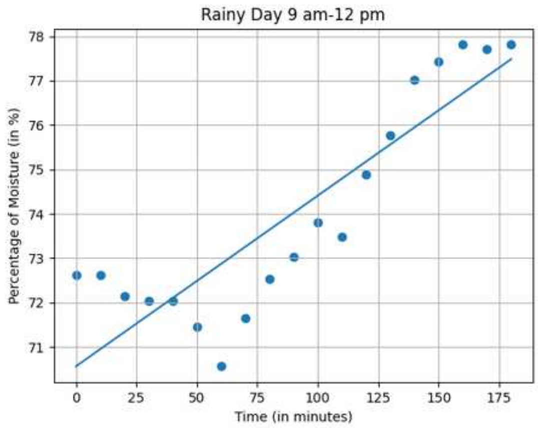

Fig.9. Morning time on Rainy day

Figure 9 shows the analysis of time vs percentage of moisture, with time sample taken between every 10 minutes and time considered is morning, 9:00 am to 12:00 am on a rainy day. One can observe a positive slope which means percentage of moisture is increasing as time passes. It is because due to rain moisture content is increasing. The percentage of moisture is ranging in between 70% to 78% during on morning a rainy day. On a rainy day, there will be more moisture so there is no need to water plants as moisture content is more and due to rain.

Slope = Rate of Evaporation = 0.0384614

Intercept = 70.561105

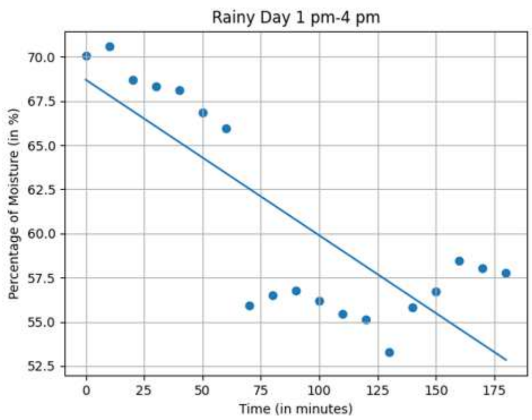

Fig.10. Afternoon time on a Rainy day

Figure 10 shows the analysis of time vs percentage of moisture, with time sample taken between every 10 minutes and time considered is afternoon, 1:00 pm to 4:00 pm on a rainy day. It can be observed from graph, negative slope which means percentage of moisture is decreasing as time passes it is because during taking reading on afternoon weather was cloudy with moderate sunlight no rainy so there was decreasing slope without increasing slope. The percentage of moisture ranges in between 52.5% to 71% during an afternoon a rainy day. On a rainy day, there will be more moisture so no need of watering plant as moisture content is more and due to rain. Above graph does not represent a straight line as readings are gathered at opposite ends as it will depend on rain time.

Slope = Rate of Evaporation = -0.0881315 Intercept = 68.707631

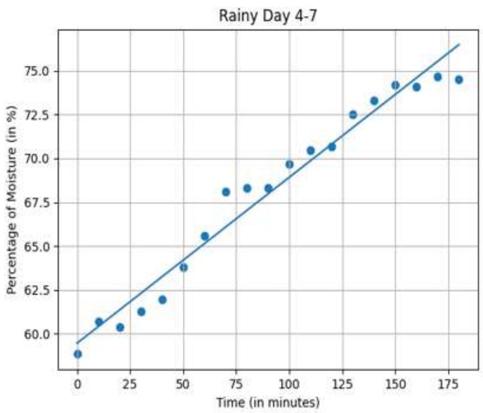

Fig.11. Evening time on Rainy day

Figure 11 shows the analysis of time vs percentage of moisture, with time sample taken between every 10 minutes and time considered is evening, 4:00 pm to 7:00 pm on a rainy day It can be observed from graph, positive slope which means percentage of moisture is increasing as time passes it is because due to rain moisture content is increasing. There is more slope compared to morning because it is due to heavy rain in the evening time. The percentage of Moisture ranges in between 58% to 77% during on a rainy-day evening. On a Rainy Day, there will be more moisture so there is no need to water plants as moisture content is more and due to rain.

Applications

The proposed irrigation system can be implemented in agricultural fields and gardens to optimize water usage for crops [16]. By collecting data on soil moisture levels and crop water requirements, an Arduino-based system can be used with a linear regression algorithm to predict optimal irrigation schedule depending on whether it is a rainy day or normal day. This ensures that crops receive required amount of water, leading to improved yield, reduced water waste, and cost savings for farmers and this system could be very useful at water scarcity places and to grow crops like millets and herbs like rosemary and lavender which are grown in garden as they need less water.

V. CONCLUSION

The variation of rate of evaporation with temperature was measured using statistical and regression analysis. It was identified that plants are essential to be watered every 48 hours under normal conditions, and that time may vary depending on change in parameters like temperature of surroundings, humidity level, wind speed and many other factors. The model also describes automatic tank open and close valve using servo which decreases manual work. Linear Interpolation has been performed for rose plants on both normal days and rainy days, and the most appropriate equation was found which was then employed for interpolating rate of evaporation for temperature readings. With in this investigation, numerous factors can affect soil moisture levels which in turn affects development rate of plant. considered humidity and temperature as parameters, there are several other factors that plant growth depends upon, like wind speed, depth of soil, altitude, type or species of plant, fertilizers used, and many more. This can be further extended to other house plants and to crops. This system can be hooked to sprinklers or other tools which can automate the process of watering plants or crops with still decreased wastage of water.

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