Smart Rainwater Harvesting System Using IoT

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Abstract- ***Water is essential for life, fundamental resource for various sectors such as agriculture, industrial. Water plays a vital role in maintaining ecosystems and maintaining climate. As population grows and increase in urbanisation the sustainable management of water resources becomes difficult. Rainwater plays a major role in sustaining water bodies, it replenishes groundwater level and reduces the reliance on treated water. Rainwater harvesting is the process of accumulating, storing and reusing the rainwater for day to day activities as well as increasing the ground water levels. Water harvesting systems are used as a tool to increase groundwater level however, the lack of modernisation in these systems make it difficult to monitor and avoid unnecessary losses. Integration of Arduino microcontroller and sensors like temperature sensor, ultrasonic sensor, water float sensor resolves the issue of avoiding losses. While monitoring is done with the help of IoT technology, IoT allows smart devices to exchange data over a medium using internet. In this context a smart rainwater harvesting system using IoT is proposed in this paper. System includes a creative solution to avoid water runoff and to make monitoring simple over a website, which can be accessed by any smart device with internet connectivity. As a result, the proposed system can be used as an application in households and industries.***

Indexed Terms- ***Water Management, IoT, Arduino Microcontroller, Temperature Sensor, Ultrasonic Sensor.***

I. INTRODUCTION

Water is the fundamental need for all living beings, water is also used in daily household chores like cleaning, drinking [1]. The demand for water across the world has rapidly increasing by 1% due to population growth, economic development and change in consumption patterns. The concept of sustainable development is interlinked to water management, rainwater harvesting is the effective method to deal with both the needs for day to day activities and to contribute in increasing groundwater levels [2]. Plants and animals depend majorly on Groundwater, human beings have also adapted to use groundwater because of the diverse demand. Rainwater gathering systems are needed to maintain the groundwater levels as well as the dependency of ecosystem on rainwater [3]. Efficient methods are to be used to collect, store, reuse the rainwater and drain them into the ground responsibly. Rainwater is collected via catchment areas like the rooftops, flat surfaces and the rock catchments [4]. Rainwater is the pure form of water, in rainwater harvesting the rainwater is acquired from the catchment areas, the collected rainwater is sent into a sump/reservoir to store the collected water and the stored water is then reused and discharged into the recharge pit [5]. In this context we have developed a rainwater harvesting system utilizing various sensors like temperature sensor for measurement of temperature and humidity in the air, ultrasonic sensor to measure the distance and water float sensor to maintain the desired water level in the tank. The proposed system is equipped with Arduino microcontroller.

Arduino microcontroller is the heart of an integrated system, it can read signals sent from devices like sensors and responds with counter action interpreting the data. Arduino is easier to operate with simple coding languages like C and C++. Arduino board includes a USB port for easy connectivity between devices runs with 5V power, digital and analog pins which read the data and write data when connected to sensors, power and ground pins with 3.3 and 5V power [6]. Arduino microcontrollers are used in various applications like robotics and home automation. Arduino can incorporate a Wi-Fi module

through which it can communicate with other devices over internet using IoT (Internet of Things).

Internet of Things or IoT is a network of the collected data, which is communicated and acted upon different devices connected via internet. Any device with the ability to send and receive data over internet can be integrated into IoT. Each IoT device is equipped with sensors to gather information like the temperature sensor to gather information on temperature in the air. The sensors are connected to the microcontroller with the help of a Wi-Fi module, this connection allows devices to communicate openly. The collected data is processed and action will be taken by the system. IoT applications include smart home innovations like smart lights, security systems, healthcare devices, industrial equipment and transportation [7, 8].

II. LITERATURE SURVEY

Recent researches have contributed to the development of rainwater harvesting as well as IoT, in the literature survey, we have referred to the following journals.

Amraja Shivkar et al. [1] have proposed water tank monitoring system that can help reduce the wastage of water due to overflowing by automatically turning off the pump when the water level in the tank reaches upper threshold limit. System will also reduce human intervention as pump will be switched on automatically when water level falls below lower threshold limit. The proposed system for automatic rainwater harvesting can be utilized to store rainwater by automatically opening lid of the tank when rain fall is detected and lid will be closed automatically when rainfall stops, maintaining quality of the water. With IOT, the entire activity can be monitored through the mobile application. Roshni Gannoju et al. [2] have expressed the concern for water scarcity and water management. In views of these problems, an automated rain water harvesting system is proposed as an idea to modernize rainwater harvesting but the work towards its implementation is underway & execution is a fairly easy task. The general setup consists of an elevated surface upon which a water sensor powered by Arduino microcontroller is fixed. A servo motor is connected to the water sensor. Upon the occurrence of rainwater, the water sensor activates & signals are sent to the microcontroller. The servo motor is activated such that the inlet for collecting rainwater opens up. Simultaneously, an email is sent to the user's mobile to notify him/her whenever the inlet opens upon detection of rainfall and consequently closes once it's over. Mohammed Golam Sarwar Bhuyan et al. [3] have presented an innovative solution for the water scarcity with the help of IoT, the proposed system includes a pH neutralizer used to differ pure water to impure water and idea here is to use purified water for drinking and the impure water for household chores. ESP32 microcontroller is used in the system to perform tasks efficiency driven.

V S P Chandrika Kota et al. [4] have explained the effective way of monitoring the rain water and analyze the data using IoT (internet of things).Rainwater harvesting (RWH) is the accumulating and storing of rain for reprocess. Rain collected from the roofs of homes, tents and native establishments will build a very important contribution to the supply of potable water. The proposed rain water harvesting home (RWH) system prototype is analyzed at various supply of water locations at K L University in the state of Andhra Pradesh, India. The proposed model is solar based rainwater harvesting monitoring using IOT technology, it uses the solar panel to charge the battery via charge controller. IOT (internet of things) is adopted to visualize the data over the cloud. Thing speak website is used by the cloud platform to collect the whole data of the rainwater. D.Srinath reddy et al. [5] have identified the need of Manual intercession for conventional farmland procedures. Human intervention can be constrained with the motorized development of water framework. By utilizing soil dampness sensor, levels of soil dampness/mugginess can be checked. At whatever point there is an adjustment in stickiness in the dirt. Soil dampness sensor detects the change and signal is passed to the Arduino microcontroller and relying upon this the water system framework works. The mechanized water system framework gives a web interface to the client with the goal that the client can screen and control the framework remotely i.e., can make the water system framework ON and OFF remotely. The rainwater harvesting system can reduce the water

shortage and useful in various situations. Alisher Shakirovich Ismailov et al. [6] have discussed in detail about Arduino microcontroller its working principle and its applications. In this paper software and hardware of Arduino is discussed and how Arduino can be a tool for future applications.

Anukriti Sharma et al. [7] have explained in detail about sensors and the integration of sensor applications with Internet of things (IoT). Arun Francis G et al. [8] have demonstrated detection system which utilizes radio waves to decide the range, angle or velocity of objects. Primary objective of this system is to utilize ultrasonic sensors to detect objects and alert for any potential collision. System is integrated with Arduino microcontroller and UART. Praveen Talari et al. [9] have developed a water harvesting system utilizing the IoT (Internet of Things) technology to provide better water treatment capabilities. Sodium hydroxide and soda ash are used to treat the unusable water and a pH sensor is provided to measure the acidity of water after treatment. The proposed system uses raspberry pi 4 microcontroller and various sensors like water level sensor, rainfall sensor, ultrasonic sensor and servo motor. Priyanca Gonsalves et al. [10] have demonstrated an effective method for collecting rainwater in rural areas with the help of an IoT (Internet of Things) based model, which is used for monitoring water quality and water level. The collected data via sensors are made available for real-time viewing on a website. The proposed system includes an Arduino as the main controller along with a number of sensors used such as water level sensor, pH sensor, and water flow sensor .A microcontroller processes the data it receives from the sensors and then uses a wireless connection module to update it to the cloud. Mohd Rizwan Sirajuddin Shaikh et al. [11] have utilized the concept of solar energy to generate electricity using solar panels. This paper discussed how electricity is calculated from the solar panels, solar energy applications. The need of clean energy is vital for environment.

III. METHODOLOGY

3.1 PROPOSED SYSTEM

Rainwater harvesting (RWH) is the process of collecting the rainwater through a catchment area, storing the collected water in a reservoir later using it for daily chores and to harvest the remaining water into the recharge pit. When rain starts pouring a collecting tank is used to collect all the rainwater which was supposed to be drained, the collected rainwater is directed into a sump/reservoir from the house roof to the level below. Sump is a place where all the collected water is stored for further usage. A water pump is used to send water from sump/reservoir to the overhead tank. Overhead tank is another storage tank, water from the overhead tank is used for household chores. The excessive water after both the sump/reservoir and overhead tank are filled is left into the recharge pit. The recharge pit is a huge underground dug pit to allow recharge of the underground water levels or aquifers, recharge pits are effective in areas where water shortages are found. Figure 3.1 shows the block diagram of the proposed system.

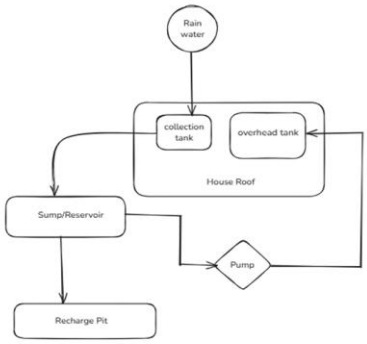

Fig 3.1: Block Diagram

Sensors are vital to read and interpret any information. Figure 3.2 shows the architecture of the system and the sensors position. Temperature sensor collects the temperature of the air and it is placed directly facing the clouds on the house roof. Ultrasonic sensor is used to measure the distance of water in the sump/reservoir, ultrasonic sensor is placed in a way that it faces into the sump to show the level of water. Pump starts sending water into the overhead tank when

the ultrasonic sensor detects the water level is at 10. Water float sensor is used to maintain water levels in a container at the desired level, in this system water float sensor is placed at the top most of the overhead tank to maintain tank full of water. Once the water float sensor detects the water level is reached the trigger in the sensor floats up and the pump in the sump/reservoir stops pumping the water into the overhead tank. Ultrasonic sensor detects the level rise in the sump/reservoir, at level 3 ultrasonic sensor sends signals to the solenoid valve to change its valve to open position and the excessive water is send into the recharge pit. Recharge pit helps in increase of groundwater level. Arduino microcontroller is the heart of this system every sensor is operated by this via connectivity.

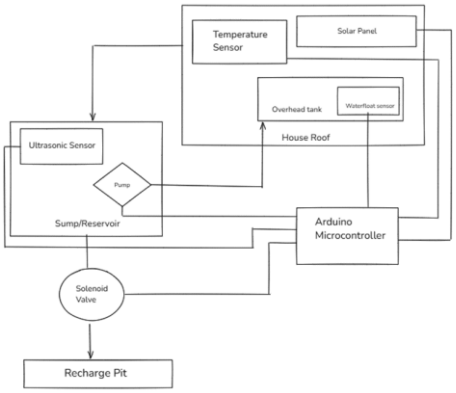

Fig 3.2: System Architecture

Figure 3.3 shows the circuit diagram of the rainwater harvesting system.

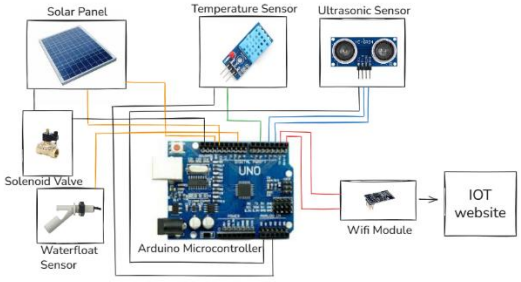

Fig 3.3: Circuit Diagram

3.2 HARDWARE COMPONENTS

1. Arduino Microcontroller: Arduino Uno microcontroller is ATmega328 type with 16MHz clock speed. It has 20 input and output pins, from which 6 pins are power pins and 6 are analog pins. Power and ground pins operate at 3.3 and 5V. Arduino microcontroller is user friendly and can be integrated into embed systems with ease [9]. Figure 3.4 shows the Arduino microcontroller.

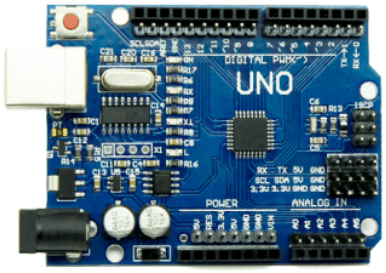

Fig 3.4: Arduino Microcontroller

2. Temperature Sensor: A temperature sensor is a device that measures heat or thermal energy and converts it into a signal that can be read or recorded. It helps monitor temperature changes in environments, machines, or systems. Humidity can also be measured using this sensor. Operates in 3.3 to 5V power. Range -40^0 to 80^0C. Humidity range is from 0 to 100% RH. Figure 3.5 shows the temperature sensor.

Fig 3.5: Temperature Sensor

3. Ultrasonic Sensor: An ultrasonic sensor is a device that uses sound waves to measure the distance between itself and an object. Sensor has two main parts transmitter and receiver, transmitter transmits the ultrasonic waves and receiver receives the reflected ultrasonic waves. Range of ultrasonic sensor is 3mm and it can measure distances from 2cm to 40cm, sensor can operate with 5V [10]. Figure 3.6 shows the ultrasonic sensor.

Fig 3.6: Ultrasonic Sensor

Water float Sensor: A water float sensor is a simple device used to detect the level of liquid in a container, tank, or reservoir. It works using a floating object (called a float) that moves up and down depending on the water level. Figure 3.7 shows the water float sensor.

Fig 3.7: Water Float Sensor

Solenoid valve: A solenoid valve is an electromechanical device used to control the flow of liquids or gases. It operates by using an electric current to generate a magnetic field that opens or closes the valve. Solenoid valves are widely used in industrial automation, water treatment systems, irrigation setups, HVAC systems, and medical equipment due to their fast response and reliability. Figure 3.8 shows the solenoid valve.

Fig 3.8: Solenoid Valve

Solar Panel: A solar panel is a device that captures sunlight and turns it into electricity. Promoting clean and renewable energy, solar panel is made up of small units called solar cells made up of silicon [11]. Figure 3.9 shows the solar panel.

Fig 3.9: Solar Panel

Wi-Fi Module: A Wi-Fi module is a smart electronic device which acts like a bridge to connect Arduino to a smart device using IoT. Each Wi-Fi module has a unique Ip address. Figure 3.10 shows the Wi-Fi module.

Fig 3.10: Wi-Fi Module

IV. RESULTS AND DISCUSSION

This section shows results data obtained by the prototype of the proposed system. Temperature and humidity measured for 3 different days and the readings recorded by the sensor is compared to the actual data to find accuracy and error. Table 4.1 shows the percentage error and accuracy of the recorded data.

Table 4.1. Accuracy Analysis of Temperature Sensor

No of Days	Measured Temperature By The sensor ^{0}C	Measured Humidity By The sensor %RH	Actual Temperature ^{o}C	Actual Humidity %RH	Error	%Error	Accuracy
Day 1	25	87	26	88	1	3	97
Day 2	28	77	30	79	2	6	94
Day 3	28	81	29	82	1	3	97

97, 94 and 97% accuracy are recorded, average % of 3 gives 96%

The accuracy of the temperature sensor is 96%.

Ultrasonic sensor is set to measure the water level inside the sump/reservoir in levels, each level is of 1cm (prototype) respectively. Total of 12 levels are in the sump/reservoir however, solenoid valve has to be opened when ultrasonic sensor records the distance level 3 (closer to the sensor). Table 4.2 shows the data recoded of solenoid valve opening to its counterpart ultrasonic sensor water level recordings.

Table 4.2. Solenoid valve Timing

No of Trials	Water level recorded by ultrasonic sensor (1 level =1 cm)	Solenoid valve opened
Trial 1	Level 3	True
Trial 2	Level 4	True
Trial 3	Level 3	True

Wi-Fi module connects the Arduino microcontroller to a smart device for easy transfer of data over internet medium. Wi-Fi module generates a unique ip address, upon accessing the website using the ip address sensor data can be seen. Figure 4.1 shows the webpage of the proposed rainwater harvesting system. 192.168.39.23 is the ip address.

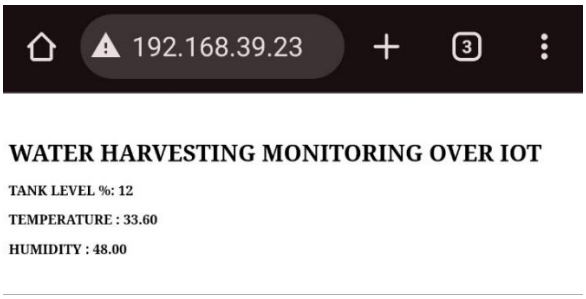

Fig 4.1: Webpage Data

The prototype of the rainwater harvesting system performed very well, all the required parameters like temperature, humidity, water float level and ultrasonic water level measurement have been successfully done. Figure 4.2 shows the prototype.

Fig 4.2: Rainwater Harvesting System

CONCLUSION

Water management is a need of today as well as the future, rainwater harvesting systems provide a solution to counter the decreasing groundwater levels. The proposed rainwater harvesting system is integrated with various sensors, this inclusion not only overcomes the problem of water overspill as well as the monitoring with the help of IoT technology. The proposed rainwater harvesting system can be used as an application in households and industries. The accuracy of the system when evaluated was found 96%. Based on this data the proposed rainwater harvesting system can be relied upon. The proposed system will contribute towards the increase in groundwater level and reduce the unnecessary losses.

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