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AUTOMATED RAINWATER HARVESTING SYSTEM

Roshni Gannoju*[1], Nabiha Hasan, Nabeeha Sayeed[2], Ms. P R Anisha[3], Dr. B V Ramana Murthy[4] & Mr. C Kishor Kumar Reddy[5]

[*1,2,3,4&5]Stanley College of Engineering and Technology for Women, Hyderabad

ABSTRACT

With the alarming rate of consumption of water resources in today's world, water scarcity has become more prominent than ever. Harvesting rainwater is an area frequently tread upon but the concept of smart rainwater harvesting has only come in the form of ideas, not executions. This proposed system too is an idea to modernize rainwater harvesting but the work towards its implementation is underway & execution is a fairly easy task. The general setup although customizable, consists of an elevated surface upon which a water sensor powered by Arduino is fixed. A servo motor too is connected to the water sensor & is powered by the Arduino. Upon the occurrence of rainwater, the water sensor activates & signals are sent to the Arduino. The code on Arduino is processed resulting in the activation of servo motor such that an 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. Thus, our proposed system works towards the betterment of water management in cities, making it a new venture towards collecting water the smart way.

Keywords: *Arduino, servo motor, water sensor, water management.*

I. INTRODUCTION

According to the United Nations World Water Development Report, launched 19 March 2018 during the 8th World Water Forum, and in conjunction to the World Water Day, the global demand of water has been increasing at a rate of 1% per year over the past decades due to population growth, economic development and a change in consumption pattern among other factors and will continue to grow significantly in the foreseeable future. It's important to address the world's water challenges while simultaneously delivering additional benefits vital to all aspects of sustainable development. Sustainable development has been defined as "development that meets the needs of the present without compromising the ability of the future generations to meet their own needs". In elaborating the concept of sustainable development, the literature has constantly specified that people – including city inhabitants – are participants in ecosystems, and that they are ultimately responsible for resilience and renewability of ecosystem sources and services. Communities therefore need to look for ways to either live adaptively within the loading capacity offered to them or start conserving sources such as water. One of the most common methods to conserve water for general purposes or for groundwater recharge is rain water harvesting [1].

Rain Water Harvesting is an act of acquiring and storing rainwater for later use. As we know rainwater is the purest form of water, this water can be utilized for various purposes after necessary purification process as required. Water shortage is common in today's big cities and the typical system of rainwater harvesting is less likely to be used in today's modernly built homes. Hence even though rainwater harvesting can be very effective in these areas it's not popular enough due to its method of implementation which has not advanced with time [2].

1.1 History

The capturing and storing of rainwater is a technique that goes back thousands of years when humans started to farm the lands and needed ways to irrigate crops. In hot climates, acquiring rainfall often determined life or death for some communities. Whilst the need for conserving water fell away due to urbanization in the last thousands of years, we once again need to return to this age-old and indispensable part of greener living.

Civilizations in the Indus Valley were far more advanced than we may think nowadays. In many of the ancient cities that still remain, we can still find huge vats that were cut into the rock to collect water when there was torrential rainfall. These were used to keep the population and local vegetation going in hotter, dryer times and were fed by numerous stone gullies that weaved their way through the city. Some of these rock vats are still used today in parts of India.

Another technique that has been used for hundreds of years in India is to build water harvesting systems on top of the roofs of houses. It's a simple technology that has spread across the world, particularly to countries such as Brazil and China [3].

The technology of rainwater harvesting is deeply rooted in the social fabric of India with a variety of ancient methods still found today. These include:

- Talibs: Medium to large sized reservoirs that provide irrigation for plants as well as drinking.
- Johads: Dams that are used to capture and keep rainwater.
- Baoris: Wells dug into the ground that are often still used for drinking.
- Jhalaras: Specially constructed tanks that are used for the local community and religious purposes.

Apart from India, during the time of the Roman Empire, rainwater collection became something of an art and science, with many new cities incorporating state of the art technology for the time. The Romans were masters at these new developments and great progress was made right up until the 6th Century AD and the rule of Emperor Caesar [4].

One of the most impressive rainwater harvesting constructions can be found in Istanbul in the Sunken Palace which was used to collect rainwater from the streets above. It's so large that you can sail around it in a boat.

1.2 Present day

- In China and Brazil, roof rainwater harvesting is practiced for providing water for domestic use, drinking water, water for livestock, irrigation purposes and recharging ground water. Gansu province in China and semi-arid North East Brazil run one of the largest projects for rainwater harvesting.
- In Beijing. Some housing companies are now adding rainwater in its main water sources after proper treatment.
- In the United States, until 2009 in Colorado, rainwater harvesting was restricted but now owner of the resident is allowed to install a rooftop rain collection system as long as it meets the specified criteria.
- In Ireland, Professor Micheal Mcginley of Dublin University College founded a project to design a rain water harvesting prototype in the organic system design challenge module [5].

1.3 Types of rainwater harvesting

Rainwater Harvesting is broadly divided into two methods:

- Surface Runoff Harvesting
- Rooftop Rainwater Harvesting

In this paper, we will be mainly talking about rooftop rainwater harvesting as it is less expensive and more effective if implemented properly can help in augmenting the ground water level of the area.

The system mainly consists of catchments, transport and filter [6].
I. Catchments: The surface or inlet that directly receives the rainfall is termed the catchment of a rainwater harvesting system. It may be the terrace, courtyard, or paved or unpaved open ground. The terrace may be flat RCC/stone roof or sloping roof. The problems that arise here are:
i) The cleanliness of the roof and hence the water. An inlet that can be removed and cleaned regularly would mean less cost required for filtration.
ii) Houses in cities these days are not built with spacious and flat rooftops. The build of a rooftop usually depends upon factors such as climate, cost, appearance and functionality. Pitched roofs are typically used in climates with heavier rain and snowfall as they provide quicker and easier water shedding and drainage of the roof. For example,

more pitched roofs can be observed in the northern region of the US where more snow and rain accumulate and a great deal more flat roofs in the southern region of the US where less snow and water accumulates.
Once again, an inlet that be removed and attached as per the requirement can solve this issue. We will look more into this in our proposed system.
II. Transport: If needed, the collected rainwater can be transferred into another container for later use or directly transferred by pipes to an irrigation system.
III. Filter: There is always some skepticism regarding Roof Top Rainwater Harvesting since doubts are raised that rainwater may contaminate groundwater. There is remote possibility of this fear coming true if proper filter mechanism is not adopted [7].

II. LITERATURE SURVEY

Recent researches have contributed to the development in the area of IoT through this paper we will have a brief idea of a project which is to develop a smart rainwater harvesting process making the use of IoT. In our literature survey we have referred and studied different research papers regarding the basic concept of IoT. Using IoT in various fields to connect things, services and people for intelligent operations is a trend now a days in latest technology.

The Internet of Things can be used for getting the right amount of water at the right destination for the right duration and only when needed. This will be the job of special soil sensors and weather sensors that will communicate their readings to a particular server. Internet of Things technology also helps in scheduling the maintenance as well as the shutdown of pumps on a regular basis. There are optimization techniques that can beforehand convey to the residents of a city regarding the unavailability of water during any particular point in time. This helps the water regulation authorities not only in meeting the adequate water demands in a city; rather it also aids in the conservation of resources and energy [8].
The powers of IoT have been used extensively by some companies who have tried their hand at smart water management. The following list comprises of a few of their ventures towards the global efforts of conserving water using IoT:

- **Smart Monitoring-** To analyze water treatment system and control it from anywhere anytime
- **Smart Watering Techniques to crops-** Water the crops as per their requirement
- **Smart Water Meters Status-** Calculates the utility of water and as per the regular utility only that much amount of water is provided.
- **Potable Water Monitoring-** Monitors the quality of tap water
- **Chemical Leakage Detection in rivers-** Detects the amount of leakages or wastage thrown in river
- **Swimming pool remote measurement-** Controls the pool conditions and requirement of water
- **Pollution levels in the sea-** Controls the seawater to get contaminated
- **Water Leakages-** Detect the leakage and help to locate the faults
- **River Floods-** Monitors water level variations in water bodies

This paper in particular is devoted to the explanation and illustration of our new design of a rainwater harvesting system based on Internet of Things (IoT). The main purpose of this system is to modernize rainwater harvesting and make it more accessible to city dwellers and keep it adaptable to different situations [9].

III. IOT PROJECT

Architecture
To obtain the most sustainable, economical & efficient water management system, certain architectural requirements are to be fulfilled. Only upon the fulfilment of these requirements can the system produce successful results in the long run, thus enforcing more of its production in the market & enabling various companies & communities to study from it and go on to improvise upon already existing features so as to procure an even better model for smart water management. The body of Integrated Water Resources Management (IWRM) has laid down the following requirements that the architecture of a water management system using IoT devices will need to comprise of:

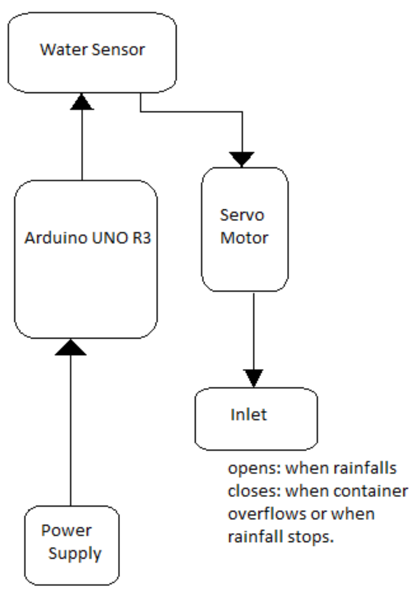
Requirement no. 1: The following water management functions should be covered by the system:

1) Remote management of physical elements and operation of basic units
2) Identification of resources in the water network
3) Definition of operations and conditions over the network.

Requirement no. 2: It should support interoperability with other applications such as geographic information systems and also databases containing information regarding soils, weather forecast, environment, farming, etc.

Requirement no. 3: It should provide a flexible and extensible architecture for the integration of various systems. To do that, it must define open interfaces among communication and process control layers, and also integrate IoT systems for a direct access to individual water management devices.

Requirement no. 4: It should support integration with legacy systems, controlling current equipment. Water management infrastructures currently deployed in the countryside consist of many interconnected and simple devices that must be managed using legacy systems. They integrate communication functions, data models, and protocols dependent on an specific technology of the manufacturer. Overriding these systems with new ones is not always a feasible solution [10].



Block Diagram

Hardware Components

1) Arduino Uno R3: The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). Programs can be loaded onto it from the easy-to-use Arduino computer program. The Arduino has an extensive support community, which makes it a very easy way to get started working with embedded electronics. The R3 is the third, and latest, revision of the Arduino Uno[11].

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Figure 1. Arduino Uno R3

2) Water Sensor: A water detector is an electronic device that is designed to detect the presence of water and provide an alert. A common design is a small cable or device that lies flat on a floor and relies on the electrical conductivity of water to decrease the resistance across two contacts. The device then performs the task specified by the Arduino Uno R3.

The sensor is basically a board on which nickel is coated in the form of lines. It works on the principle of resistance [12].

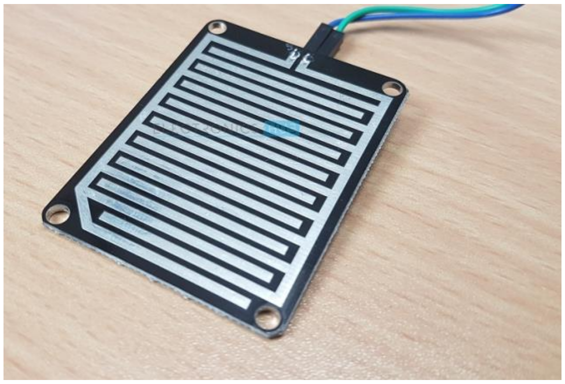

Figure 2. Water Sensor Board

If there is no rain, the resistance between the wires will be very high and there will be no conduction between the wires in the sensor. If there is rain, the water drops will fall on the rain sensor which will also decrease the resistance between the wires and wires on the sensor board will conduct thus triggering the connected DC motor [13].

3) Servo motor: We are using the 12 volts DC motor to operate the vents. The DC motor is connected to the shafts of the vent using gears so that the movement of the vent can be controlled. The power supply for the DC motor is given through the step-down transformer.

Figure 3. Servo Motor

4) Male-female jumper wires: The connections to be made require the use of male to female jumper wires.

Figure 4: Male-female jumper wires

Working Mode of Automated Rainwater Harvesting System

The set-up, although built to suit small-scale endeavors can also work on large scale provided the fundamental essence of the system is incorporated. This is described in detail below:

Firstly, the rain water falls upon the surface of the water sensor which is fixed onto the surface such that it faces the skies. Upon sensing the rain droplets, the water sensor activates and begins to send signals to the attached servo motor. A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. This sensor is in turned connected to the sliding door on the surface of the ground that slides open to reveal a collecting container for purpose of catching impending rainfall. As the rainwater collects into this container, signals are actively sent to the harnesser to denote water levels. On the events of overflow of rainwater into the container, the door automatically closes after alerting authorities that the container has been filled to the brim. This rainwater collected is finally used for various human & industrial activities. It can likewise also be sent for filtration if at all it gets dirtied upon removal from the ground layer [14].

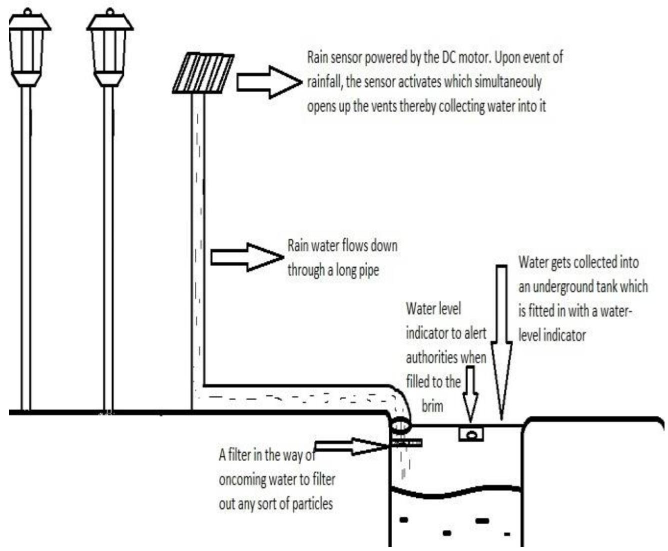

Figure 5: Proposed System

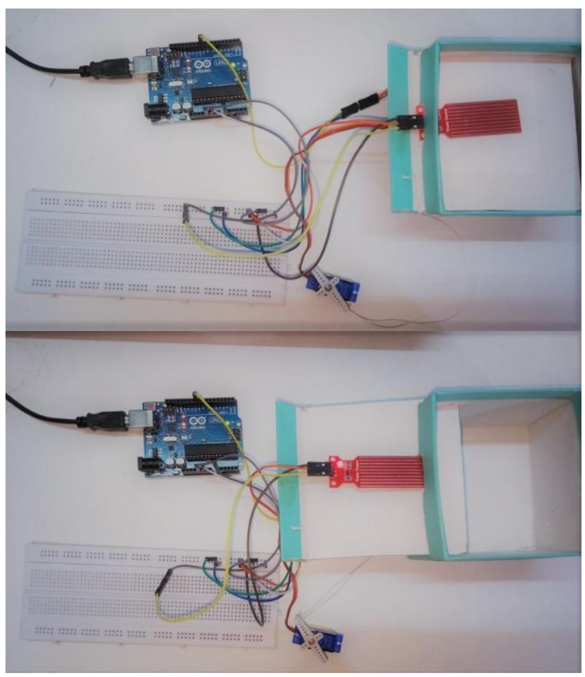

Figure 6: Opening of Inlet

Motivation

The provision of Internet of Things capabilities in water management scenarios can be achieved if we consider some considerations from the business, social and technical point of view. Here we list the main benefits of providing IoT in water management scenarios: Efficiency increase: water management companies and associations can use real-time operational control to make smarter business decisions and reduce operating costs. An IoT based reference architecture uses sensors and actuators to monitor and improve water management infrastructures, making them more efficient, reducing energy costs and minimizing human intervention. Cost savings which include water management costs can be reduced through improved asset utilization, process efficiencies and productivity.

Customers and organizations can benefit from improved asset utilization (e.g., smart water irrigation units that eliminate manual operation) and service improvements (e.g., remote monitoring of irrigation conditions) Asset utilization with improved tracking of assets (machinery, equipment, tools, etc.) using sensors and connectivity, companies can benefit from transparency and visibility into their assets and supply chains. They can easily locate assets and run preventive maintenance on critical pieces of infrastructure and machinery. Productivity increase: Productivity is a critical parameter that affects the profitability of any organization. IoT allows real-time control, new business models, process optimization, resource conservations, service time reduction, and the capability to do all of this globally, reducing the mismatch of required vs. available skills and improving labor efficiency. Expansion of new and existing business models: IoT is beneficial in any of the three defined layers. In the subsystem layer, IoT subsystems are able to execute processes and communicate using a standard communication interface; in the coordination layer, it can be useful to enable SMEs to design new coordination applications, with the purpose to orchestrate the management and exploitation layer with the subsystem layers; and finally, in the management and exploitation layer, IoT identification capabilities contribute to provide tailored information services for an specific water distribution network community [15].

The proposed system that we have developed draws inspiration from a combination of various existing smart water management systems that already exist. It is therefore not a direct emulation of said systems but rather a hybrid of the most efficient kind. Firstly, it takes inspiration from the IWCM that has come up with an elaborate water harvesting scheme suitable for both rural and urban areas. The system that it has proposed works in a similar fashion, except that the is collected in different containers that are spread over the entire locality. It also consists of water level indicators fixed to the inside of the containers in addition to vents that open up to catch rainwater. Second inspiration is drawn from Project ph 5.6 that deals with the act of rainwater harvesting but in a smart way [16].

IV. CONCLUSION

The Smart Rainwater Harvesting has to be used in an effective and conceivable aspect such that it can mitigate the effects of depleting groundwater levels and fluctuating climate conditions. This is relatively a modern research field and it is expected to grow in future. There is lot of work to be done on this emerging area. Here we get basic knowledge on how the water harvesting can be improved based on the results achieved from this system.

V. FUTURE SCOPE

When talking about impact we mainly focus upon the advantages, so here IOT places an important role since it helps each and every object, person or any other device to connect to the internet and helps to exchange the information. The main reason why IOT is included and is very important in this type of problems because there is a high success rate to overcome all types of problems[17].

Day by day the shortage of water is increasing because of lack of monitoring, maintaining the costs, controlling and etc., these all are the major reasons why there is increase in shortage of water. To overcome this IOT applications for smart water management system was developed/was brought into picture [18]. Now a days we can't even predict the weather, so if there is less amount of rainfall then the only way to fix this is to save the water that is to harvest the rainwater

i) When the rain water is being collected by the pits, the water collection goals will be recorded by that particular community region and will give us the total amount of the water collected by analyzing the weather pattern [19].

ii) Rain water which is stored can be used in many ways for example if we want to use the stored rainwater for gardening and watering the plants at a particular time then we can set an alarm to disperse the water where we want. And this will be the great advantage for us because we are watering the plants with zero effort. This will be the best idea for the one who love plantation but can't find time to do.

iii) The tanks and all the sensors which need power for working can get the power from solar panels which are exposed to the sunlight to collect the energy from it and converts it into the electric power which can be used by the

sensors and all. Using solar panels will be a plus point because we are not wasting the electricity but, we are saving it [20].
iv) A study tells that if the same situation is going to be followed in the coming years then the world will run out of fresh water by 2050. Rain water harvesting is the supportable process which can preserve/store the rain water and helps us to use in different purposes and also for future needs.

Effective water management & harvesting systems can be built through the structured interventions of IoT technologies from different industries. If implemented in an effective & conceivable aspect, it can mitigate the effects of depleting groundwater levels and fluctuating climate conditions. We can conclude that the implementation of IoT facilitates water management companies to access a wider global market and incorporates new benefits such as support systems, water governance and monitoring. This is a relatively modern research field & is expected to grow in the future [21]

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