5th Conference on Sustainability in Civil Engineering (CSCE'23)
Department of Civil Engineering
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DESIGNING THE REMOTE AND SUSTAINABLE WATER MANAGEMENT SYSTEM

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Abstract- Freshwater availability is a huge issue for downstream areas but the mismanagement practices and exploitation of freshwater leading towards scarcity is an absolute crisis right now and if the mismanagement practices continue to be like that, then by the end of 2047, the world would be left with less than 500 cubic centimeters per capita of water availability leading towards absolute scarcity. To solve the water mismanagement of the capital city, National University of Science and Technology (Nust) as the case study was chosen. A pilot scale prototype was made for this project which was basically a monitoring system and can be expanded to a controlling system with few sensors and a microcontroller (Arduino UNO) was installed which was used to monitor the water level in the overhead tank, water flow from the taps and water leakage from any tap. It stored the data and calculated the total water usage and was aligned with mobile application for data viewing and storage with just an internet connection. The user was able to analyze the real-time data and the stored data anytime and anywhere just by using the mobile application and internet connection. SONAR Sensor was installed to check the water level in the tank. It showed the water in percentage. Water flow sensor was installed to measure the water flow from the tap. These sensors directly sent the data to the microcontroller which was programmed according to the sensors and then the microcontroller interpreted the data and send it to the user to its application. Prototype resembled the complete water system of a house or any commercial building. Cost benefit analysis was done to check the feasibility of the project which showed that it was the most suitable system in the conservation of the water. Hostel building was selected for this project which had 4 floors. Two SONAR sensors and 140 water flow sensors were installed. Every single tap was attached to a water flow sensor. User was able to see each tap and its data and can monitor even single tap. This study addresses SDG 6 which is clean water and sanitation and SDG 12 which is responsible consumption and production.

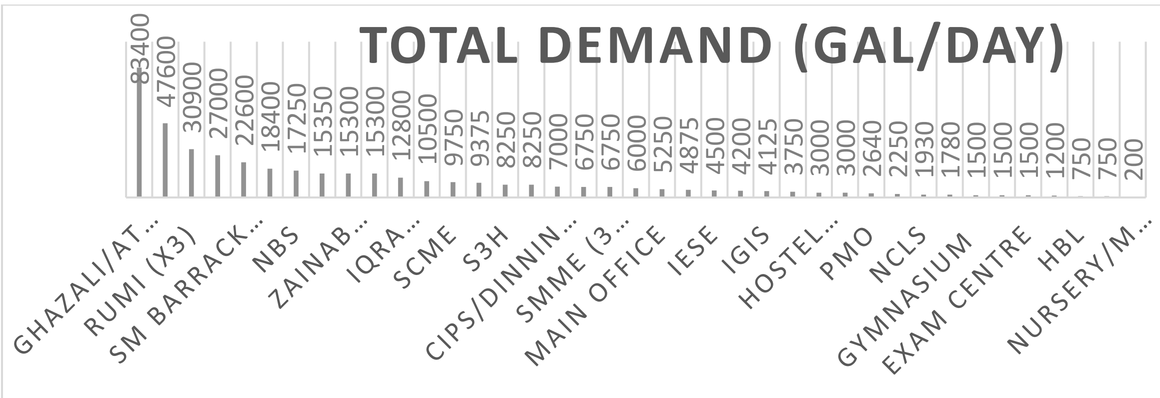
Keywords- Mobile application, remote sensing, SDG 6, SDG 12, sustainable solution, water management.

1 Introduction

Water is the basic necessity of life but world is constantly struck with the issue of access to clean water. There is not enough clean water, and the mismanagement practices are leading towards scarcity. 3 billion people lack access to drinking water that is safe. [1] 1/5th of the population lives in areas where water is physically scarce and 1/4th of the population lives in developing countries that face water shortages due to lack of infrastructure to transport water and weak governance, [1] so investing in improved water management and services is one prerequisite to reduce poverty and achieving sustainable economic growth. The relationship between water and poverty is a two-way street. Poor people receive direct benefits from improved water services and improved sanitation services through better health, reduced health costs, timesaving, and increase productivity. Access to adequate and safe water supply is essential for poverty reduction, yet poverty itself can be the driver of pollution and unsustainable use of water resources. 89% of people have access to drinking water 58% of people have access to water for sanitation and 60% [2]. of people have access to water for hygienic purposes. 21 million people lack access to clean water close to home. In 1947 per capita availability of water in Pakistan was 300 cubic centimeters and there was no stress of water whereas in 2017 it reduces to per capita availability of water up to 1000 cubic centimeters leading towards scarcity and extrapolating that it can be seen in the current situation that by the end of 2047 the per capita availability of water will reduce to less than 500 cubic centimeters leading towards absolute scarcity. [2] so to control mismanagement practices, the innovation in this project was development of mobile application with access to everyone and developing of smart water management system [1] which will be the first remote management water system in NUST.

Total water demand in National University of Science and Technology (NUST) H-12

This is the data that was collected from PMO, the graph 1 shows the water demand in respective areas, departments of NUST.



Graph 1: Total Water Demand

Objective

The objective of this project was to develop a sustainable water management system and remotely regulated water system for minimum water wastage keeping in mind future implementation on larger scale. The second objective was real time water usage data identification and accessibility for consumers and providing quantitative framework for making management decisions

2 Experimental Procedures

Construction of the Prototype

There were total of two sensors in the prototype, SONAR [3]-[4] sensor to sense the water level in the water tank and the other one was the water flow sensor which was attached to the water tap to measure the flow of the water flowing through the tap and leaving out the water tank and then there was a processor (Micro-Controller) which was the brain of the prototype which would be receiving the information from the sensors and sending it to the laptop and mobile application through its input-output peripherals.[8]

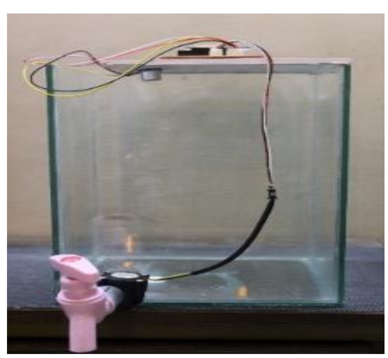


Figure 1: Prototype

2.1 The Process

2.1.1 Stage One (Sensor Stage)

The sensors were able to sense the change. SONAR [7] sensor was sensing the change in the water level and water flow sensor was sensing the flow of the water through the tap perfectly and both would give the feed to the micro-controller.

2.1.2 Stage Two (Micro-Controller Stage)

Micro-Controller decided what to do with the information. It interpreted the data and send it to the laptop and the mobile application using WIFI connection, which could remotely be accessed.

2.1.3 Stage three (Mobile Application stage)

Whoever was accessing the mobile application using its login and password, will get the notification and the data received from the sensors was showing on the mobile application.

2.1.4 Explanation of the Process

The prototype was composed of a water tank, microcontroller, SONAR Sensor, and water flow Sensor along with a water tap. The process worked in a systematic manner beginning with the sensor and then moving towards the microcontroller to receive and send the information to the user using WIFI which ultimately conveyed the command.

The sensors were programmed to do their basic job which is explained in the tabular form in Table 1. Followed by a detailed explanation and pictorial presentation.

Table 1 List of devices and their tasks

S. #	Devices	Tasks
1.	SONAR sensor	Detect the water level
2.	Water flow sensor	Measure the water flow
3.	Micro-controller	Interprets data it received

1. SONAR sensor was being used to detect the water level in the tank which ultimately detected any changes in the water level in the overhead tank with quite accuracy.
2. Water flow sensor was basically sensing the flow of water running through the tap. It measured the flow rate as well, which could be seen on the mobile application on a real-time basis. There was a few seconds delay in the information in the real-time which was not even noticeable.

2.1.5 SONAR Sensor

This was the SONAR sensor which basically was used to sense the water level in the tank. An ultrasonic sensor worked by emitting a sound wave that is above the human hearing range. It was working all the time and was sending the real time data to the micro-controller and it detected any change in the level of the water tank and fed the information to the micro-controller. [5]

Figure 2: SONAR sensor

2.1.6 Water Flow Sensor

Water flow sensor was installed just before the tap. Water flow sensor consisted of a plastic valve from which water could pass. A water rotor along with a hall effect sensor was present to sense and measure the water flow.

It basically detected the flow in the tap and measured the flow rate of the running water through the tap. It was feeding the micro-controller in real time. It was being used to get the flow rate and to calculate the total usage of water from that tap. Also, it was being used to detect the leakage in any of the tap as it was very sensitive and would sense the leakage of water from the tap and feed it to the micro-controller.

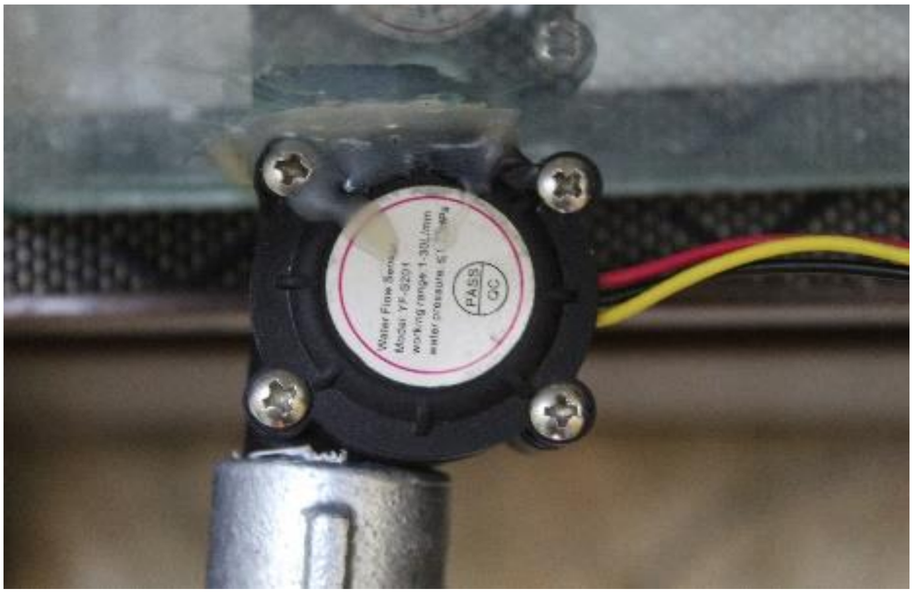


Figure 3: Water flow sensor

2.1.7 Micro-Controller

Microcontroller was embedded inside of a system to control a singular function in a device. It interpreted the data it received from its I/O peripherals using its central processor. The basic function of this microcontroller in the project was to get information from the sensors and send this information to the users/consumers wirelessly using WIFI. The mobile application was developed to show the data to the users.

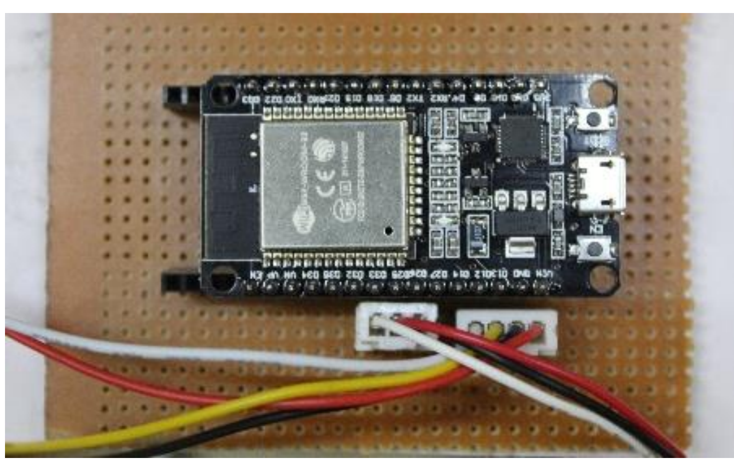


Figure 4: Microcontroller

2.2. Laptop's Interface

On the laptop screen the real-time data was showing. There were only two objects to show one was "Water Level in the Tank" and the other one was "Flow rate" of the water flowing from the tap. The water level was being measured in terms of percentage such that 44% of the water the water tank was filled with the water and flow was showing in L/min which was apparently 0 because no water was flowing from the tap.

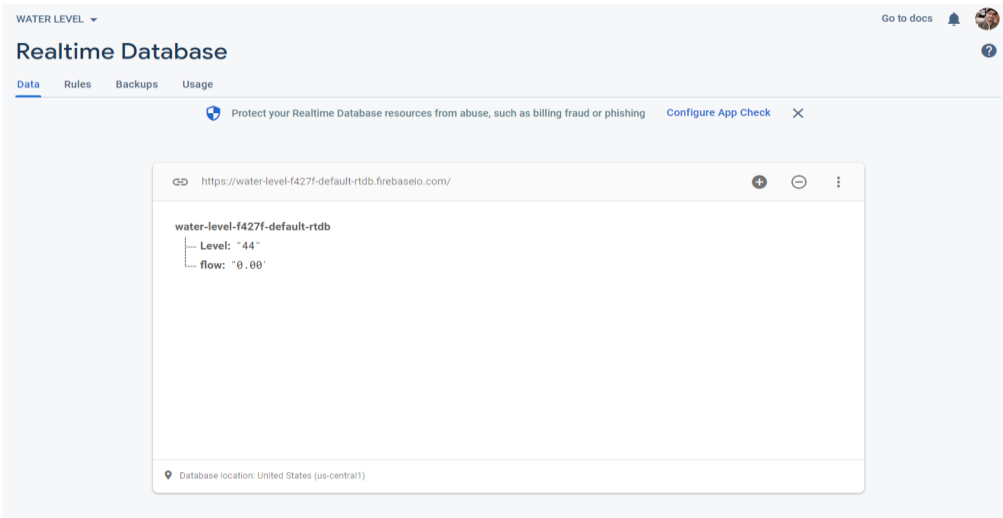
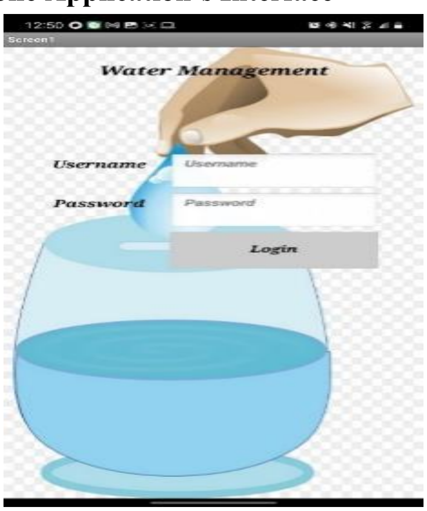


Figure 5: Laptop's Interface

2.2 Mobile Application's Interface



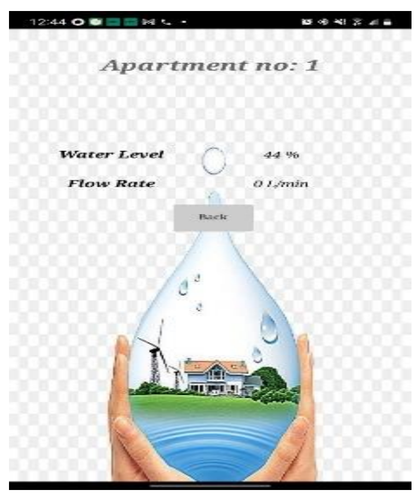


Figure 6 (a): Login Interface

Figure 6 (b): User Interface

These were the screenshots taken from the mobile phone where it can be seen in figure, user has its own login id to get into the application to get the information. While in the other figure user was getting the results from the micro-controller as can be seen water level was showing in percentages that was 44% of the water tank is filled with water or the 44% of the total water was remaining in the tank. And flow rate can also be seen which was showing in L/min.

3. Results

After several tests runs and trials, it was concluded that the device performance was very good, and assembly could be implemented in the hostel or any other building. Real-time data was received, and any leakage was detected immediately. Also, the data from the flow sensor could be stored in the laptop and so, it could determine the pattern of water usage. As water flow sensor will be installed on each tap it will show which tap is leaking. This would provide the quantitative framework to make management decisions. This will conserve water usage and will help to fight water scarcity in Pakistan. By this one could access the data from anywhere just by using the internet on the mobile phone.

This project was implemented on larger scale. Attar 1 hostel building was selected.

Distribution of Items

- Over Head Tank = 1
- Total No of Taps in Attar 1 Hostel = 140 (30 on each floor (4 floors in total) + 10 in the Dining Hall + 4 in the Kitchen + 6 miscellaneous)
- SONAR Sensors (Range 20cm - 400cm) Required for Over Head Tank = 2
- Arduino UNO (Micro-Controller) Required = 7 (1 for each Floor + 1 for the Dining Hall + 1 for the Kitchen + 1 Miscellaneous)
- Water Flow Sensors Required = 140 (There is a sensor for every single tap)
- Data Cables Required = 7 (Cable for every Micro-Controller)

Cost-Benefit Analysis:

Total cost of the prototype

Table 2: Cost of the prototype

	Item	**Quantity**	**Per Unit Cost**	**Total Cost**
1	Glass Sheet	6ft	600/-	3600/-
2	SONAR Sensor	1	350/-	350/-
3	Water Flow sensor	1	450/-	450/-
4	Data Cable	1	300/-	300/-
5	Arduino UNO	1	1050/-	1050/-
Total	*5750/-*			

Total cost for Attar 1 hostel

Table 3: Cost for Attar 1 Hostel

	Item	**Quantity**	**Per Unit Cost**	**Total Cost**
1	Arduino UNO	7	1050/-	7,350/-
2	SONAR Sensor	2	350/-	700/-
3	Water Flow sensor	140	450/-	63,000/-
4	Data Cable	8	300/-	2400/-
5	Miscellaneous			5000/-
Total	78,450			

Total Benefits

On average out of every 5 taps 2 were leaking.
There were total 140 taps in the Hostel building and considering the given statement, it had 56 leaking taps.
On average 10 drips per minute a single tap would waste 1 gallon per day.
So, 56 gallons of water was being wasted daily.
On monthly basis 1680 gallons of water was being wasted.
As one 1000 gallons water tanker costs 4000 rupees which means it costs 4 rupees per gallon.
So, it was saving

$$1680 \times 4 = 6720 \text{ Rupees per month}$$

And Wastewater treatment cost per gallon is 1.08 rupee.

$$1680 \times 1.08 = 1814 \text{ Rupees per month}$$

Total benefits in terms of money are = 6720+1814
= 8534 Rupees per Month

Break-Even Analysis

Total Cost = 78,450/-
And it was saving
Monthly basis = 8,534/-
So, it will achieve its Breakeven point within 10 months = 8,534 × 10 = 85,340/-

The results and Cost-Benefit Analysis clearly demonstrated that this Remotely Managed water system, will provide Economical, Environmental, and social benefits to society. This will reduce the carbon footprint in the environment. The Remotely Water Management system seems a favorable and feasible solution to the current water crises in terms of services as well as in terms of monetary value. Inadequacy of such a Water Management system causing the Water availability issue not only in the NUST but in Pakistan as well. Thus, this remote Water Management system is the most feasible solution in the current scenario.

4. Applications

This technology can have numerous applications some of them are given below.

i. On larger scale, this technology can be used in detection of leakage in fuel tanks, large water reservoirs, institutions, hotels, restaurants, malls, and public toilets etc. for determining and checking the usage ratio
ii. This technology can save lots of water in public places where the water use is consistent, but maintenance is irregular.
iii. The sensor technology was a step towards the sustainable use and proper management of water resources and thus can lead to a lot of savings on indirect costs by decreasing the water required through proper management and thus, the water pumped or supplied and less water requirement would also save on electricity bills of pumping water from groundwater sources or water transmission costs.

Conflict of Interest

This study has no conflict of Interest.

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