
SMART WATER LEVEL MONITORING SYSTEM USING ARDUINO AND ULTRASONIC SENSOR. (CASE STUDY: NASME BARRACK WATER WORKS MAKURDI).

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EXECUTIVE SUMMARY

Conservation of water resources and environmental protection are cardinal goals of the Millennium Sustainable Development Goals (SDGs). This can best be achieved when wastage is minimized and the environment is minimally exposed to harm. The importance of water supply to any organization can never be over emphasized, and this comes with water losses and environmental hazards if not properly handled. The use of modern methods is very important to minimize this loss and protect the environment. It also saves time and energy on the part of the workers who are operating the water facility.

In line with the foregoing, no human life should be put at risk nor should the environment be allowed to be over flooded leading to wastage, possible breeding of mosquitoes that can cause malaria and other inherent diseases that accompany ponding of excess water in the environment. It is against this background that has necessitated the introduction of the ultrasound empowered decoding system to sense, measure and communicate with the pumping system to automatically trip on or off depending on the water level. In simple terms, this project enables water supply level in the storage reservoir to be properly monitored, controlled and managed so that optimal benefit and usage is ensured. This saves time, cost of power and water supply and enhances safety.

ABSTRACT

The management of water resources is a critical challenge in today's world due to increasing demand and environmental changes. To address this issue, there is a growing interest in developing smart water level monitoring systems to efficiently monitor and manage water resources in various applications such as agriculture, industrial processes, and domestic water supply. This paper presents an innovative approach to smart water level monitoring, utilizing Arduino microcontrollers and ultrasonic sensors to achieve real-time and accurate water level measurements.

The proposed system consists of an Arduino microcontroller, an ultrasonic sensor, and a wireless communication module. The ultrasonic sensor is used to measure the water level in a tank or reservoir by emitting ultrasonic waves and calculating the time taken for the waves to bounce back after hitting the water surface. The Arduino microcontroller processes this data and transmits it to a centralized server or a cloud-based platform via the wireless communication module.

The advantages of this smart water level monitoring system include cost-effectiveness, ease of installation, and minimal maintenance requirements. The real-time data provided by the system empowers water resource managers and users to make informed decisions regarding water usage, conservation, and distribution. Additionally, the wireless communication capability enables remote monitoring, making it suitable for monitoring water levels in remote or inaccessible areas.

This paper reviews relevant literature on existing water level monitoring technologies, explores the design and implementation of the Arduino-based system, and presents the results of performance evaluations, including accuracy, reliability, and power consumption. Furthermore, the paper discusses the potential applications of the proposed system in various domains and highlights its significance in promoting sustainable water resource management.

Keywords: Water level, Smart Systems, Ultrasound, Arduino Sensor, Millennium Sustainable Development Goal, Environmental protection, Resources optimization.

1. INTRODUCTION

Water scarcity and inefficient management of water resources are critical challenges faced by many communities worldwide. In order to address these challenges, it is essential to develop smart and automated system for monitoring and managing water resources effectively. This project proposal aims to implement a Smart Water Level Monitoring System at NASME Barracks Water Works in Makurdi, Nigeria, using Arduino microcontrollers and ultrasonic sensors.

The proposed Smart Water Level Monitoring System using Arduino and Ultrasonic sensors directly contributes to several Sustainable Development Goals (SDGs) outlined by the United Nations. Here is how the project addresses specific SDGs:

1. SDG 6: Clean Water and Sanitation:

- The project aims to optimize water resource management by providing real-time monitoring of water levels.
- It helps ensure an adequate and sustainable supply of clean water to NASME Barracks Water Works, which can be extended to other communities.

- By preventing water wastage and improving water efficiency, the system contributes to achieving SDG 6.

2. SDG 9: Industry, Innovation, and Infrastructure:

- The project utilizes innovative technology such as Arduino microcontrollers and ultrasonic sensors to create an automated monitoring system.

- It improves the infrastructure of NASME Barracks Water Works by incorporating smart solutions for water management.

- By promoting technological innovation, the project aligns with SDG 9.

3. SDG 11: Sustainable Cities and Communities:

- The project enhances water resource management within the NASME Barracks, contributing to the sustainability of the community.

- It ensures the availability of clean water, reducing the risk of water scarcity and improving the quality of life for residents.

- The system can be replicated in other urban areas, promoting sustainable water management and supporting SDG 11.

4. SDG 13: Climate Action:

- Efficient water resource management facilitated by the project helps reduce water consumption and wastage, thus conserving a valuable natural resource.

- By promoting sustainability in water management, the system indirectly contributes to climate change mitigation efforts outlined in SDG 13.

5. SDG 17: Partnerships for the Goals:

- The project involves collaboration between stakeholders, including NASME Barracks Water Works, researchers, and developers.

- It demonstrates the importance of partnerships and multi-sectoral cooperation to achieve sustainable development.

Overall, the Smart Water Level Monitoring System aligns with multiple SDGs, focusing on clean water provision, innovation, sustainable cities, climate action, and partnerships. By addressing these goals, the project plays a vital role in promoting sustainable development and improving the quality of life for communities like NASME Barracks.

1.1 Description of study Area

With the introduction of Smart Water Level Monitoring System (SWLMS) in Nasme Barrack water works Makurdi. The staff and the society will benefit in the following ways

- Monitor water level on a regular basis in real-time
- Improve the way they manage their water resources
- Monitor water level at any location

2. METHODOLOGY

The Smart Water Level Monitoring System (SWLMS) using Arduino and ultrasonic sensor keeps users informed about the water level status in the tank. The ultrasonic sensor detects

the water level and then sends signal to microcontroller unit. The microcontroller circuit sends signal to GSM module and then GSM sends SMS alert to the registered user's mobile number for the current water level as set in the Atmega328p microcontroller. Atmega328p microcontroller is used as a central processor which create an open and closed electrical circuit to turn ON and OFF the water pump automatically when water level in the tank reaches a certain level limit.

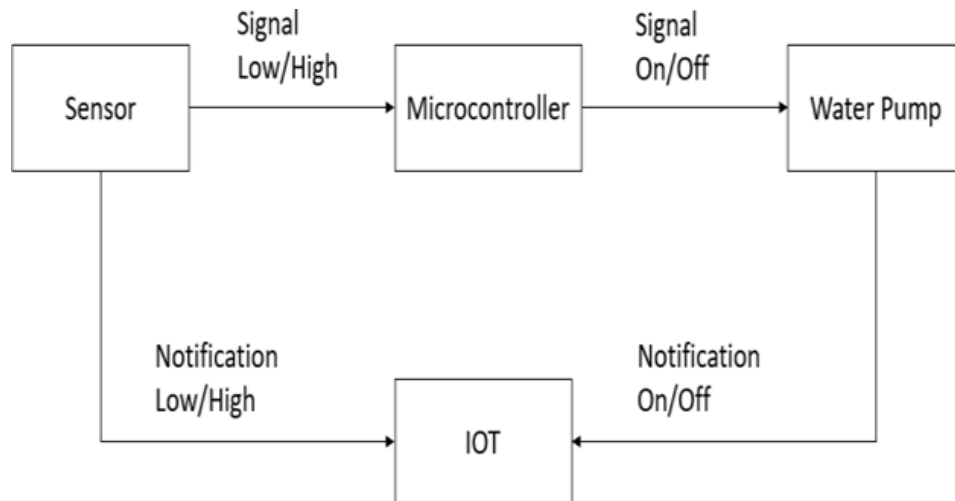


Figure 1 Block Diagram of the Project

2.1 SYSTEM DEVELOPMENT

The SWLMS as shown in the Figure 1 above composed of the water tank where the ultrasonic sensor and GSM shield will be placed, server that will store the captured data, internet and cell phone that will receive the captured data. The system consists of two devices: Arduino Uno, Ultrasonic sensor. The ultrasonic sensor sends ultrasonic waves to the water surface which reflects the waves back to the sensing head, the time it takes to receive the waves provides it with the distance.



Figure2 USE CASE DIAGRAM OF THE PROPOSED SYSTEM

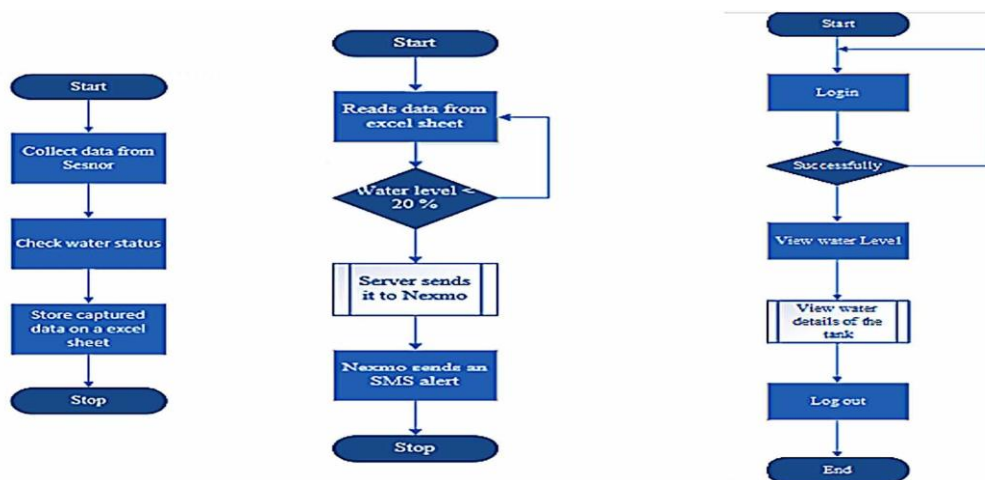


Figure 3 (A) Data capturing flow diagram; (B) SMS alert flow diagram; and (C) User interaction diagram

The screenshot shows a web interface for the SWLMS (Smart Water Level Monitoring System). At the top, the title "Login Form" is centered. Below it are two input fields: "Email" and "Password". A "Log in" button is positioned below the password field. At the bottom of the form, there is a logo for "SWLMS" (a blue water drop icon) and a copyright notice: "©2024 All Rights Reserved. The Application. Privacy and Terms".

Figure 4 Login page for SWLMS

The login page where the user logs in to view the current water status. Water status is displayed in a line graph or bar graph. User has to be registered on Nexmo and Firebase. Firebase is used to create an account for the users. The credentials the system administrator creates are then used to log in into the website.

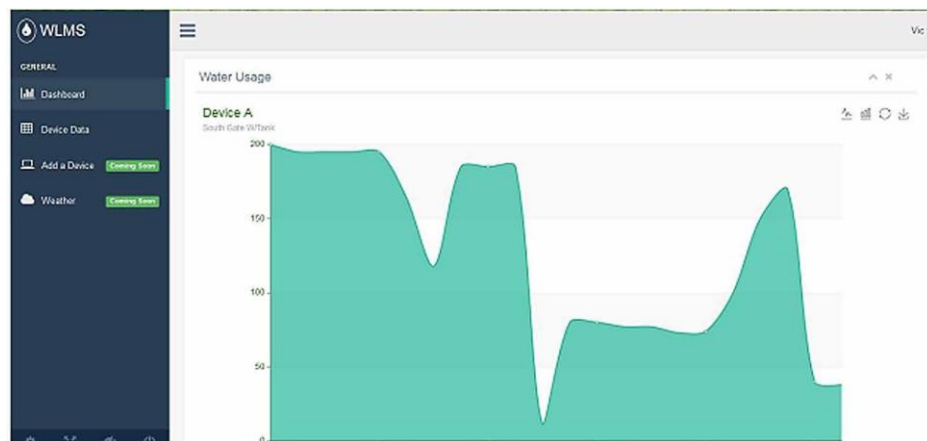


Figure 5 Bar graph view of the water status

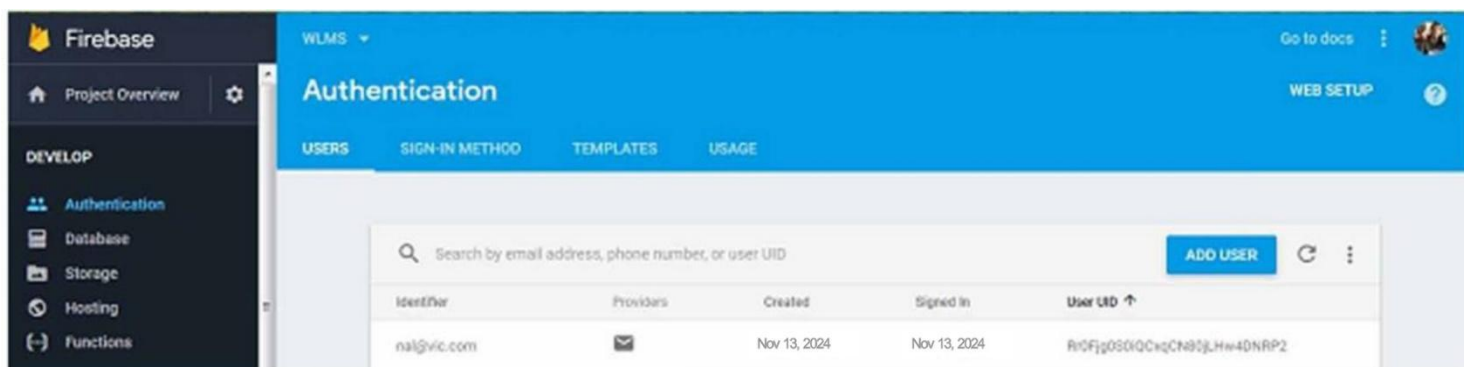


Figure 6 System administrator creates login into the Firebase Website

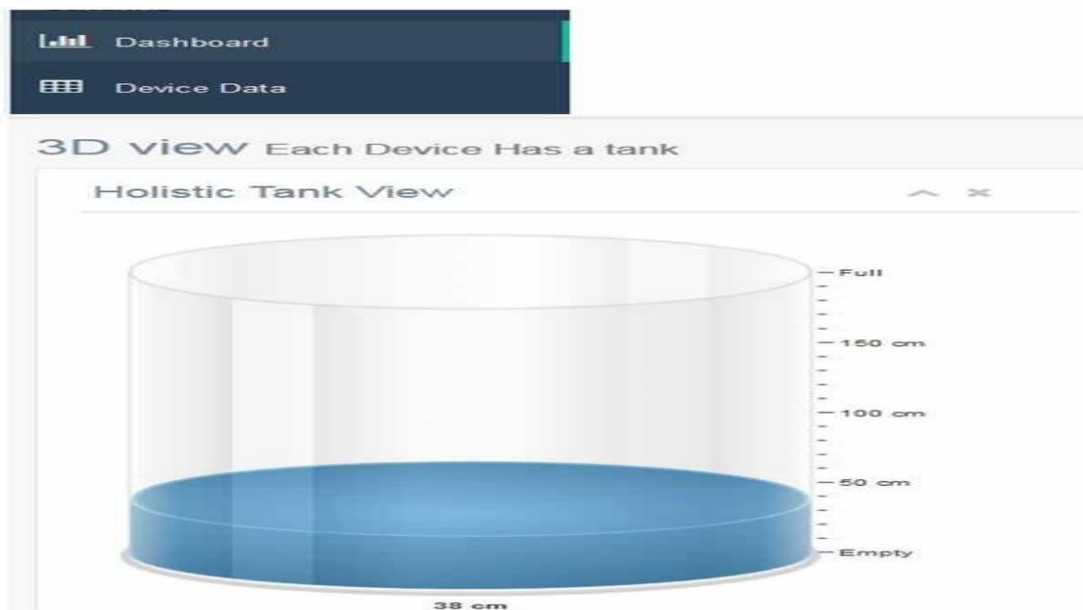


Figure 7 Water Tank view of the water status

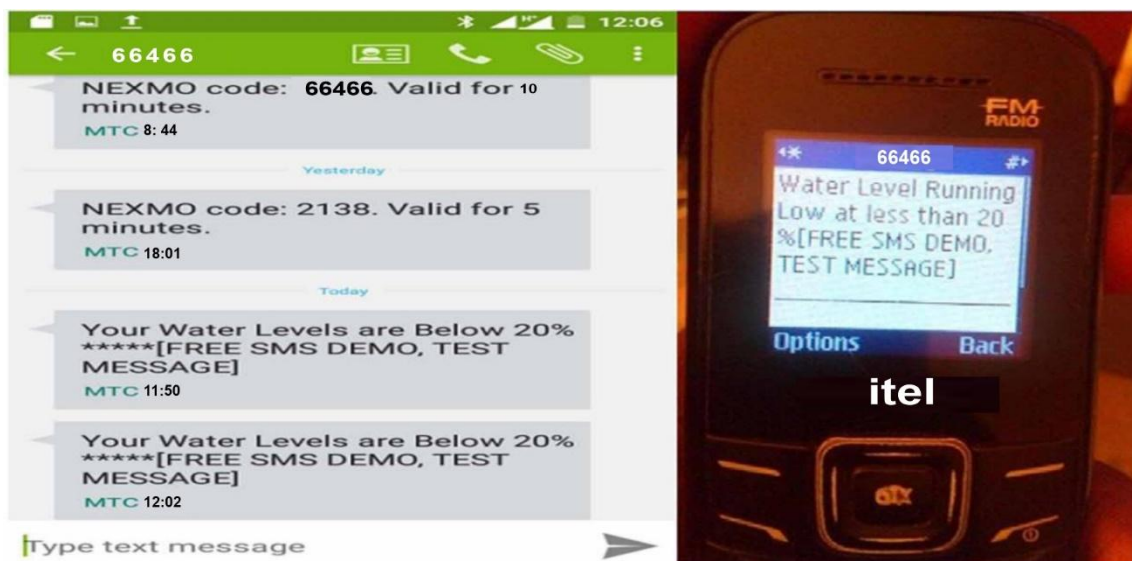


Figure 8 shows the critical point of the water tank and its SMS alert

A	B
Time	Distance_in_cm
14-12-2024 1:30:29 PM	0
14-12-2024 1:31:29 AM	6
14-12-2024 1:32:29 AM	16
14-12-2024 1:32:29 AM	16
14-11-2024 1:34:29 AM	20

Figure 9 captured data and its view deployed on an excel sheet

Only used for creating users as shown in Figure 9. Nexmo SMS API is used to send out alerts. So users are required to signup and register their numbers. Nexmo will provide an api key and api secret key that is used in the node.js server.

The user can view the water status in a holistic view by selecting the device data tab as depicted in the figure 7.

The water status of the figure 7 holistic view is at 40cm of 200cm which is 20%. This is the critical point of the water tank. When this happens, the user will get an SMS alert as shown in Figure 8.

The captured data can be viewed on Excel sheet as shown in figure 9. This data can be used to analyze past water levels. The Excel sheet records the distance from the sensor to the water head.

2.2 Method of Data Collection

The project primarily uses arduino and ultrasonic sensor to measure and monitor water level. Data are then transmitted to users via cloud.

3 RESULTS

- This system is easy for installation with low maintenance cost.
- This system has very compact elegant design.
- The Smart water level controller ensures no overflows.
- Dry running of the motor is stopped conserve electricity and water prevents the leakage of roofs and walls due to overflow of tanks.
- It shows clear indication of water levels in the upper tank.
- Fully automatic, saves human energy, consume very little energy, is ready for continuous operation.

4 CONCLUSIONS /RECOMMENDATION

The proposed Smart Water Level Monitoring System using Arduino and Ultrasonic sensors will provide NASME Barracks Water Works with an efficient and automated solution for real-time water level monitoring. By implementing this system, water resource management can be optimized, ensuring the availability of adequate water supply while preventing

wastage. The system will contribute to sustainable water management practices and serve as a valuable case study for other water works in Nigeria.

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REFERENCES

- Al-Hamdan, M. A., Mafuta, M., & El-Sheimy, N. (2018). An Arduino-Based Smart Water Level Monitoring System Sensors, 18(7), 2230.doi:10.3390/s18072230
- Dey, N., Nasipuri, M., & Mandal, J. K. (2019). Smart Water Level Monitoring and Control System Using Arduino and IoT. In: International Conference on Computational Intelligence and Data Science (ICCIDS). doi:10.1109/ICCIDS47382.2019.9056943
- Du, Z., Jin, G., Li, L., & Gao, Y. (2019). A Remote Monitoring System of Water Level Based on Arduino. In: 2019 11th International Conference on Measuring Technology and Mechatronics Automation (ICMTMA). doi:10.1109/ICMTMA.2019.28
- Gupta, N., Meena, M., & Meena, Y. K. (2018). Smart Water Monitoring System for Drought Prediction in Precision Agriculture using Arduino. In: 2018 2nd International Conference on Trends in Electronics and Informatics (ICOEI). doi:10.1109/ICOEI.2018.8553782
- Khan, M. S., Hossain, M. F., Ali, M. S., & Rahman, M. S. (2019). IoT-Based Smart Water Level Monitoring System with Rainwater Harvesting Integration for Urban Drainage Management. In: 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST). doi:10.1109/ICREST.2019.8666213
- La, H. M., Jung, S. B., & Kim, Y. J. (2018). Low-Cost Arduino-Based Water Level Monitoring System. In: 2018 15th International Conference on Control, Automation, Robotics and Vision (ICARCV). doi:10.1109/ICARCV.2018.8581348
- Rashid, M. H., Rahman, M. F., Khan, M. T. H., & Rahman, M. M. (2019). An Arduino Based Smart Water Level Monitoring System for Agriculture in Arid Areas. In: 2019 4th International Conference on Electrical, Computer and Communication Engineering (ECCE). doi:10.1109/ECACE.2019.8679041
- Rawat, D. S., Asudani, K., & Sahu, S. (2020). Design and Development of Smart Water Level Monitoring and Control System using IoT with Arduino and ThingSpeak. In: 2020 International Conference on Computer Communication and Informatics (ICCCI). doi:10.1109/ICCCI49289.2020.9112792

- Sridhar, R., Thiyagarajan, D., Raj, G. R., &Jeevanandham, S. (2020). Smart Water Level Monitoring and Control System using Arduino for Domestic Applications. In: 2020 International Conference on Communication and Signal Processing (ICCSP). doi:10.1109/ICCSP49018.2020.9112746
- Zhang, Y., Chen, H., Li, J., & Yan, J. (2019). Smart Water Level Monitoring System Based on Arduino for River Basin Flood Detection and Warning. In: 2019 4th International Conference on Mechanical, Control and Computer Engineering (ICMCCE). doi:10.1109/ICMCCE47755.2019.00096