**Original Research Article**

# DESIGN, DEVELOPMENT AND IMPLEMENTATION OF REAL TIME CANAL AND WEATHER MONITORING DEVICES


## ABSTRACT

In the present study, canal depth, velocity and weather monitoring sensors are designed and implemented in the field irrigation laboratory, Aditya Engineering College, Surampalem, Andhra Pradesh, India. The depth sensor which is used in this project is HC-SR04 Sensor and the velocity sensor is YF-S403. A method of data acquisition and transmission based on ThingSpeak IOT is proposed. To record weather data (i.e., temperature, humidity, rainfall depth and wind speed) DHT11 Sensor, ultrasonic sensor and IR sensors are used. The purpose of this project is to evaluate the performance of real time canal and weather Monitoring devices. A structure of real time weather Monitoring devices based on sensors and ThingSpeak IOT, a design was developed to realize the independent operation of sensors and wireless data transmission can help in minimizing the error in data collection. Arduino UNO is connected with canal depth and velocity sensor to generate the output, similarly NodeMCU is connected with weather Monitoring Device. The results revealed that observed sensor data showed good results when compared/calibrated with the existing conventional measurement system. In order to decrease the time and to get accurate value, it is recommended to consider the sensors for the proper use and to access weather data easily. The developed device worked satisfactorily with minimum or no errors.



**Keywords:** Arduino UNO; NodeMCU; DHT11 Sensor; Ultrasonic sensor; IR sensor; ThingSpeak IOT; Real Time Weather Monitoring Device; Canal Depth and Velocity.


## INTRODUCTION

Water resource challenges faced by India are considerable and can only be addressed by adopting an integrated approach that considers all uses and sources of water (surface water, groundwater, etc.) from the river basin/hydrologic perspective [13]. This requires sound information and knowledge on the water resource base and its uses, coupled with the availability of appropriate tools for analysis and decision making. Real time knowledge of water resources helps planners to make informed decisions for flood forecasting, water supply management, irrigation, hydro generation, as well as environmental monitoring and planning. The Government of India is cognizant of the need to forge an integrated approach to developing, managing, and regulating surface water and groundwater resources, both at the basin and aquifer scales.

Canal irrigation is widely used source of water for irrigation. So, management of irrigation canal water is crucial factor in overall irrigation development. The conventional method is used to deliver water as per demand by the water users/farmers in form of rotations. The conventional system involves lot of weaknesses, including forecast and actual flow or discharge. Errors may introduce in flow measurements and water content in reservoirs, also imbalances due to human and natural intervention are not considered in the conventional system. Due to this, users/farmers at the tail end endure more or shortage water [11].

Climate change is significantly transforming the water cycle [12]. These cumulative impacts on water resources make water availability harder to predict and manage. The collective information about the temporal dynamics of weather changes in any industry during certain hazards will be helpful in monitoring weather forecasting. Water is the primary medium through which we will feel one can realize the effects of climate change.

A water crisis can mean being flooded by too much water, or having enough water without the minimum quality needed to use it. A water crisis may also be the lack of water management [13]. The Food and Agriculture Organization of the United Nations indicates that for the year 2030 agricultural production will have to be increased by +80% to fulfill food demand, but it will have to be done without the possibility of increasing water withdrawals by more than +12%, which can be done by reducing spillages along canals [1].

The potential sophistication of on-farm water management is highly dependent upon the level of water delivery service provided to individual farms, which in turn, depends upon the conveyance manageability within the complete water distribution system [2]. Modern growth in electronics systems, communication system, and information technology assist in designing canal monitoring system to provide efficient delivery and avert imbalance.

In view of above reasons, it is to be made an attempt by introducing the project "DESIGN, DEVELOPMENT AND IMPLEMENTATION OF REAL TIME CANAL AND WEATHER MONITORING DEVICES" "Design, Development and Implementation of Real Time Canal and Weather Monitoring Devices" in which the irrigation will take place only when there will be intense requirement of water from open channels to the field and Real-Time Data for weather with the following objectives:

**OBJECTIVES**

1. To Design Sensor based Canal Depth and Velocity Measuring Device.
2. To Design Real Time Weather Monitoring Device.
3. To Evaluate the Performance of Real Time Canal and Weather Monitoring Device.

Chen [3] studied about the network structure of automatic weather station based on Internet of things technology was constructed to realize the independent operation of intelligent sensors and wireless data transmission. Natividad and Mendez [4] focused only on the water level detection and early warning system (via website and/or SMS) that alerts concern agencies and individuals for a potential flood event. Vrushali and Patkar [5] discussed on technical levels and control aspects of Automatic and grid Meteorological information system. The system provided timely and comprehensive meteorological information which was often related to the operation of grid to know monitoring, tracing, forecasting and warning of disastrous weather and also offers aid decision for load forecasting.

Kiran and Priti [6] proposed a microcontroller-based design for flow control system for gate in canal automation which reduces the water wastage and labour dependency. Omoze *et al.* [7] developed low-cost server-based automatic weather station for remote locations. Susmitha and Sowmyabala [8] developed an embedded system to design a weather monitoring system which enabled the monitoring of weather parameters in an industry. Amin *et al*. [9] proposed a river monitoring system based on a heterogeneous wireless sensor network to address the flow characteristics of river. Wahidah *et al.* [10] proposed a system that was not only able to detect the water level but also able to measure the rise speed of water level and alerted the resident.

This outcome of the review findings is utilized in framing up the methodology to be adopted in the present study, which is proposed to design, develop and implementation of the real time canal and weather monitoring system.

## 2. MATERIAL AND METHODS

### 2.1 Design of Sensor Based Canal Depth and Water flow Velocity Measuring Device

Developing a Device which Measures and Displays the Canal Depth using Ultrasonic Sensor (HC-SR04) and the water flow of the canal using water flow sensor (YF-S403) by interfacing these sensors and to Arduino UNO board and displaying the result on LCD I2C Display.

### 2.1.1 Ultrasonic Sensor HC-SR04

HC-SR04 is an Ultrasonic sensor which measures distance. It emits an ultrasound at 40000 Hz (40 kHz) which travels through the air and if there is an object or obstacle on its path, it will bounce back to the module. Considering the travel time and the speed of the sound, you can calculate the distance. The configuration pin of HC-SR04 is VCC (1), TRIG (2), ECHO (3), and GND (4). The supply voltage of VCC is +5V and you can attach TRIG and ECHO pin to any Digital I/O in your Arduino Board. The module includes Ultrasonic Transmitter, Receiver and Control Circuit. The specifications of Canal Depth Sensor were presented in table 1.

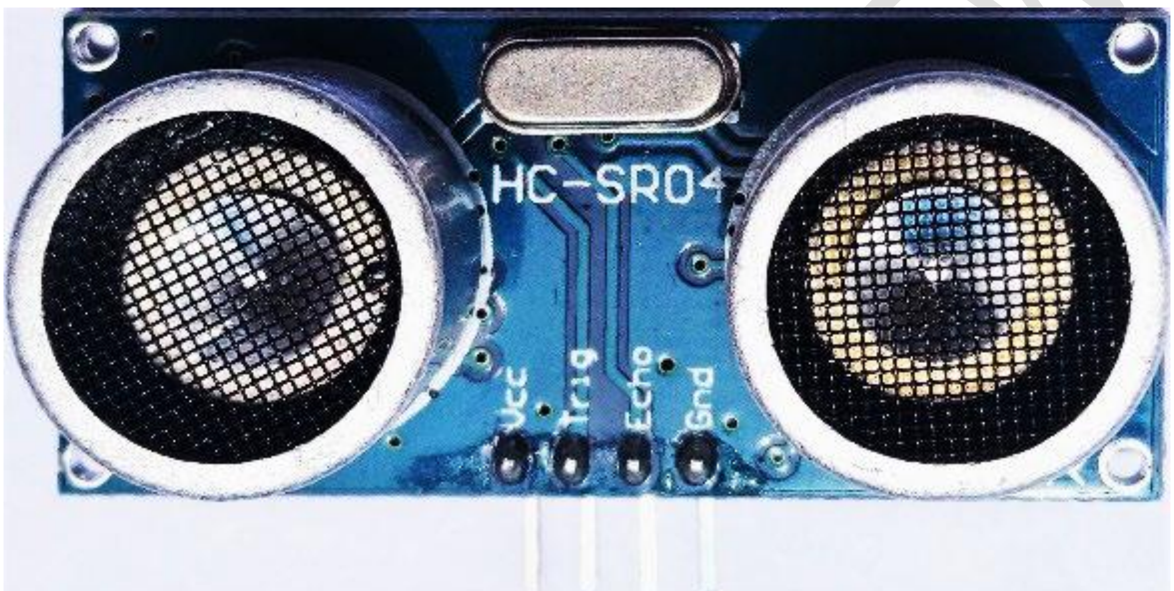



**Fig. 1 Ultrasonic Sensor HC-SR04**

**Table 1 Specifications of Canal Depth Sensor**

| **Parameter** | **Working range** |
|---|---|
| Voltage | DC 5 V |
| Current | 15mA |
| Frequency | 40Hz |
| Max Range | 4m |
| Min Range | 2cm |
| Measuring Angle | 15° |
| Trigger Input Signal | 10uS TTL pulse |
| Echo Output Signal | Input TTL lever signal and the range in proportion |
| Dimension | 45×20×15mm |

### 2.1.2 Arduino Uno

The Arduino Uno is a microcontroller board, embedded with the Atmega 328 Processor. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 Analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Arduino Uno Board can be programmed with the Arduino IDE Software.


**Fig. 2 Arduino UNO R3 Board**

### 2.1.3 Canal Velocity (Water flow) Measuring Device

Measuring Velocity of water flow in Canal using Water flow Sensor YF-S403 3/4" by Interfacing with Arduino Board and displaying the result on LCD I2C Display.

Water flow sensor mainly consists of Plastic valve body, rotor assembly and Hall Effect Sensor, which is installed between two pipes joining each other for detecting water flow. When water flow through the rotor assembly, magnetic rotor will rotate and speed will change as the flow change. Hall current sensor output corresponding pulse signal and feedback to controller, then the controller will indicate the waterflow reading on the LCD display which is connected. It can be used for water heaters, water vending machine, DIY coffee machines, flow measurement devices.

The main components are the Hall Effect sensor, turbine wheel, and magnet. The water flows in through the inlet and out through the outlet. The water current drove the wheel to turn, and the magnet on the wheel turned with it. Magnetic field rotation triggers the Hall sensor, which outputs high- and low-level square waves (pulse). For every round of the wheel, the volume of water flowing through is a certain amount, as is the number of square waves output. Therefore, we one can calculate the flow of water by counting the number of square waves (pulse).


**Fig. 3 Water flow sensor YF-S403 3/4"**

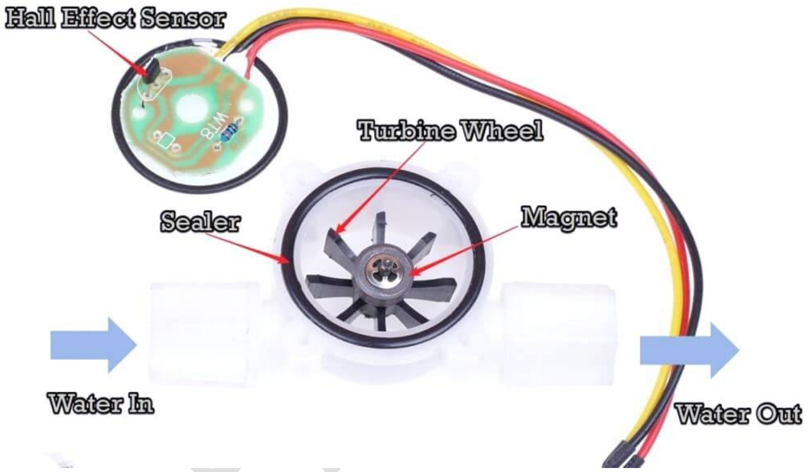



**Fig. 4 Internal components of water flow sensor**

**Table 2 Specifications of Velocity Measuring Sensor**

| Parameter | Working range |
|---|---|
| The lowest rated working voltage | DC 4.5 5V - 24V |
| Maximum Operating Current | 15 mA (DC 5V) |
| Working voltage range | DC 5 - 18V |
| Load capacity | ≤ 10 mA (DC 5V) |
| Working temperature | ≤ 80°C |
| Working humidity range | 35%-90% RH (no frost) |
| Allow Pressure | 1.75MPa |
| Storage temperature | -25 to + 80 ° c |
| Save Humidity | 25% - 95% RH |
| Insulation resistance | > 100MΩ |
| Flow range | 1-30L/min |

| | |
|---|---|
| pulse characteristics (4.5 * Q) | Q = L / Min ± 3% |
| External thread | 3/4 " |

### 2.2 Design of Real-Time Weather Monitoring Device

Interfacing DHT11 Sensor, IR Sensor (Active Type) and Ultrasonic Sensor (HC-SR04) with NodeMCU are used for Measuring Temperature, Humidity, Wind Speed and Rainfall Depth and Obtaining REAL-TIME data on THINGSPEAK website.

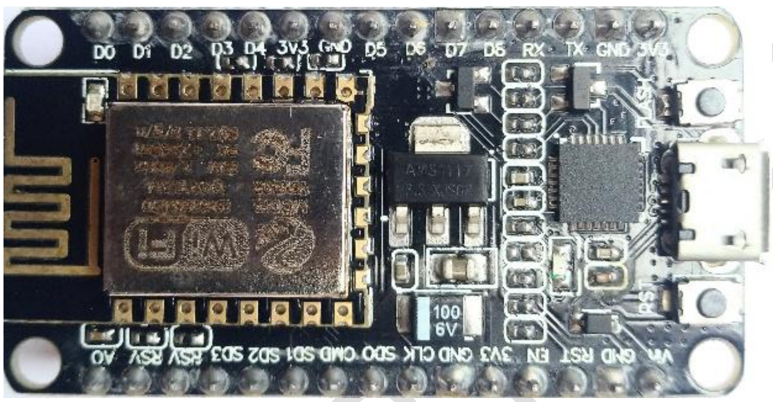



**Fig. 5 NodeMCU ESP8266 board**

#### 2.2.1 DHT11 Sensor

DHT11 digital temperature and humidity sensor is a calibrated digital signal output of the temperature and humidity combined sensor. It uses dedicated digital modules capture technology and the temperature and humidity sensor technology to ensure that products with high reliability and excellent long-term stability. Sensor includes a resistive element and a sense of wet NTC temperature measurement devices, and with a high performance 8-bit microcontroller connected. The specifications of humidity, temperature and electrical characteristics were presented in following tables 3 and 4.

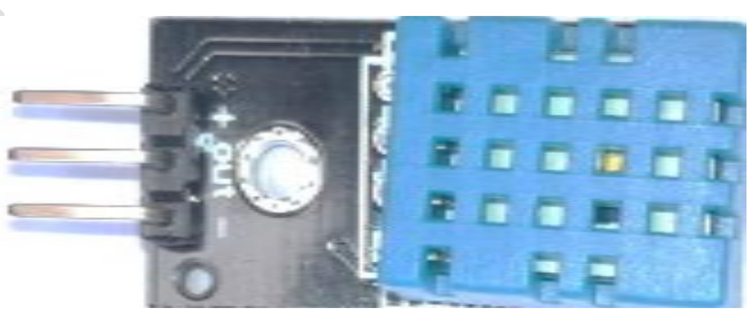


**Fig. 6 DHT11 sensor**

**Table 3 Specifications of humidity sensor**

| Parameter | Specification |
|---|---|
| Resolution | 16Bit |
| Repeatability | ±1%RH |
| Accuracy | 25°c ±5%RH |
| Inter changeability | Fully interchangeable |
| Response time | (a) 1/e(63%)25℃ 6s<br>(b) 1m/sAir6s |
| Hysteresis | <±0.3%RH |
| Long-term stability | <±0.5%RH/yr |

**Table 4 Specifications of temperature sensor**

| Parameter | Specification |
|---|---|
| Resolution | 16Bit |
| Repeatability | ±1°c |
| Accuracy | $25^0$c ±2°c |
| Response time | 1/e (63%) 10s |

**Table 5 Electrical characteristics of DHT11 Sensor**

| Component | Specification |
|---|---|
| Power supply | DC 3.3 ~ 5.5V |
| Supply current | Measure 0.3mA Standby 60μA |
| Sampling period | Secondary Greater than 2 seconds |

### 2.2.2 IR Sensor

An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. Infrared sensors are also capable of measuring the heat being emitted by an object and detecting motion. An IR sensor consists of an IR LED and an IR Photodiode; together they are called Photo–Coupler or Opto–Coupler. Infrared Obstacle Sensor has a built-in IR transmitter and IR receiver. Even though an IR LED looks like a normal LED, the radiation emitted by it is invisible to the human eye. When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver.

In this project, we have designing Digital Tachometer using an IR Sensor with NodeMCU for measuring the number of rotations of Anemometer in KMPH. The Tachometer is an RPM counter which counts the number of rotations per minute. We are designing a NodeMCU-based digital tachometer using an IR sensor module to detect objects for count rotation of any rotating body. IR transmits IR rays which reflect back to the IR receiver and then IR Module generates an output or pulse which is detected by the NodeMCU controller.

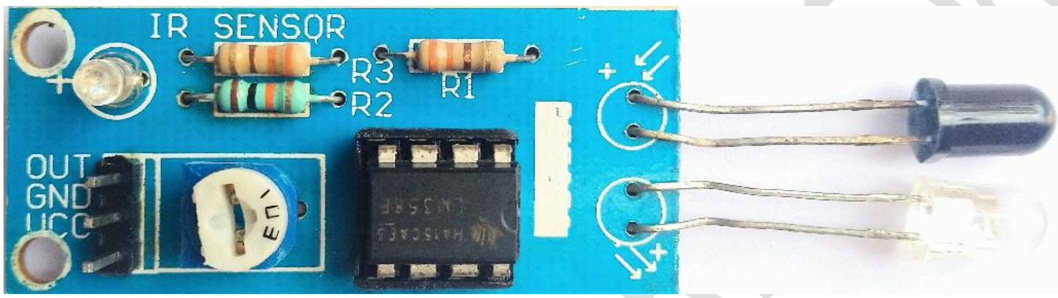



**Fig. 7 IR sensor (Infrared obstacle)**

### 2.2.3 Rainfall Depth Measuring Device

Interfacing Ultrasonic Sensor (HC-SR04) with NodeMCU for Measuring Rainfall Depth in a Pan Evaporimeter

#### 2.2.3.1 Ultrasonic Sensor (HC-SR04)

HC-SR04 is an Ultrasonic sensor which measure distance. In this project, we will have to mention the Height (Depth) of the Pan Evaporimeter in the Programming Code. When there is a Rainfall, the Ultrasonic Sensor detects the change in the Depth of the Pan Evaporimeter and displays the depth of Rainfall.

### 2.3 Performance Evaluation of Canal Depth Measuring Device

The Sensor Based Canal Depth Measuring Device is used to measure the Depth of the Canal in Non-Contact Method. The obtained Result which will be Compared with the Traditional Method of Measuring Canal Depth using Staff Guage. These results shows that the accuracy of the sensor.

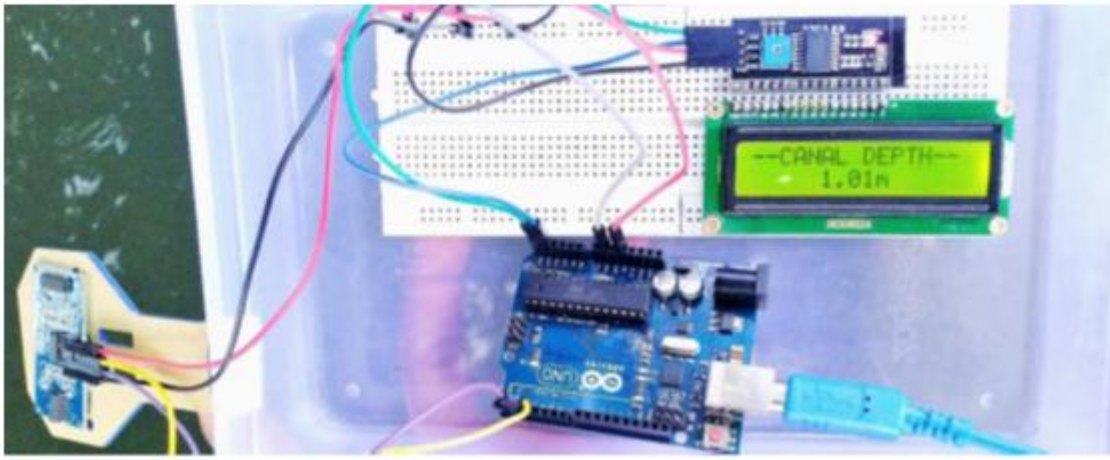



**Fig. 8 Sensor based canal depth measuring device**


**Fig. 9. Measuring canal depth with staff gauge**

### 2.4 Performance Evaluation of Real Time Weather Monitoring Device

The Weather Monitoring Device will be installed in the field and the Results of the Respective Sensor will be Observed and Evaluated with the Data available in the AP Govt. Website (http://www.apsdps.ap.gov.in/). The Data from the Sensors in THIINGSPEAK IOT Server and the Available Data from the, Andhra Pradesh AP Government website will be Compared and Plotted on a graph for analyzing the Accuracy of the Sensor Measuring Data

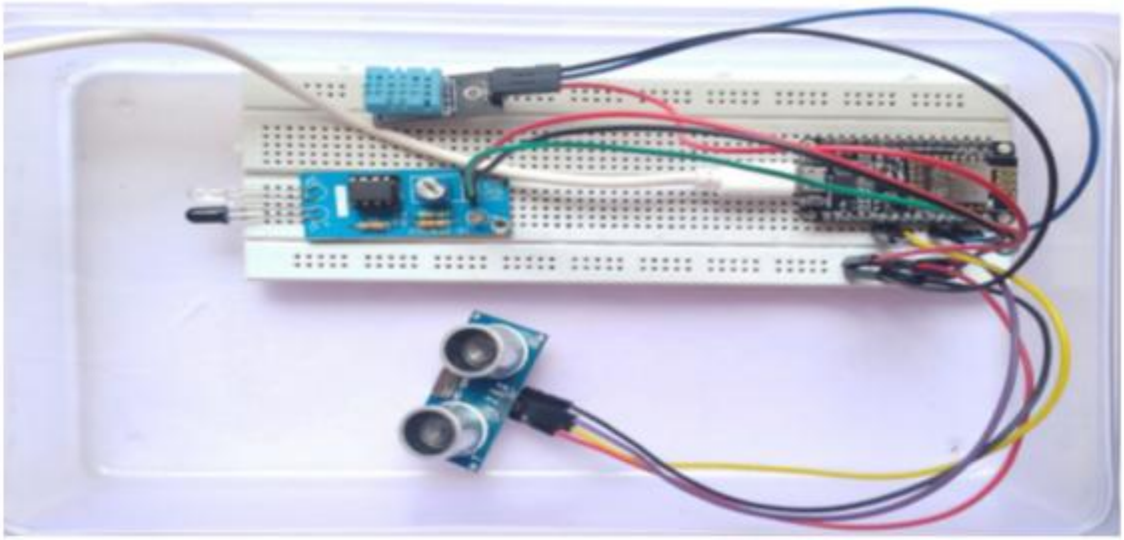


**Fig. 10 Real time weather monitoring device**

## 3. RESULTS AND DISCUSSIONS

### 3.1 DESIGN OF SENSOR BASED CANAL DEPTH AND WATERFLOW VELOCITY MEASURING DEVICE

#### 3.1.1 Canal Depth Measuring Device

Interfacing Ultrasonic Sensor (HC-SR04) and LCD I2C Display with the Arduino UNO Board and Uploading the Program for Measuring the Canal Depth. By Transmitting and Receiving signals returned to the Ultrasonic Sensor, the depth will be measured.

**Steps:**

1. Initially, do the wiring by following the Circuit Diagram and connect the Arduino Board to the PC/Laptop.
2. Open Arduino IDE Software in PC/Laptop and copy the code into the new file and save.
3. Select the Arduino board, by selecting Tools > Board > Arduino UNO
4. Select the COM Port, Tools > Port > COM...
5. Upload the code by pressing Ctrl + U or Sketch > Upload
6. After uploading successfully, make sure that the baudrate speed is 9600 on the Serial Monitor.
7. Results will be displayed on the LCD Display.

#### 3.1.2 Canal Velocity (Water flow) Measuring Device

Interfacing the water flow sensor YF-S403 3/4" with Arduino and LCD I2C Display, and uploading the program for displaying Velocity of water. The water flow sensor consisting a Hall Effect Sensor inside will sense the flow rate of the liquid.

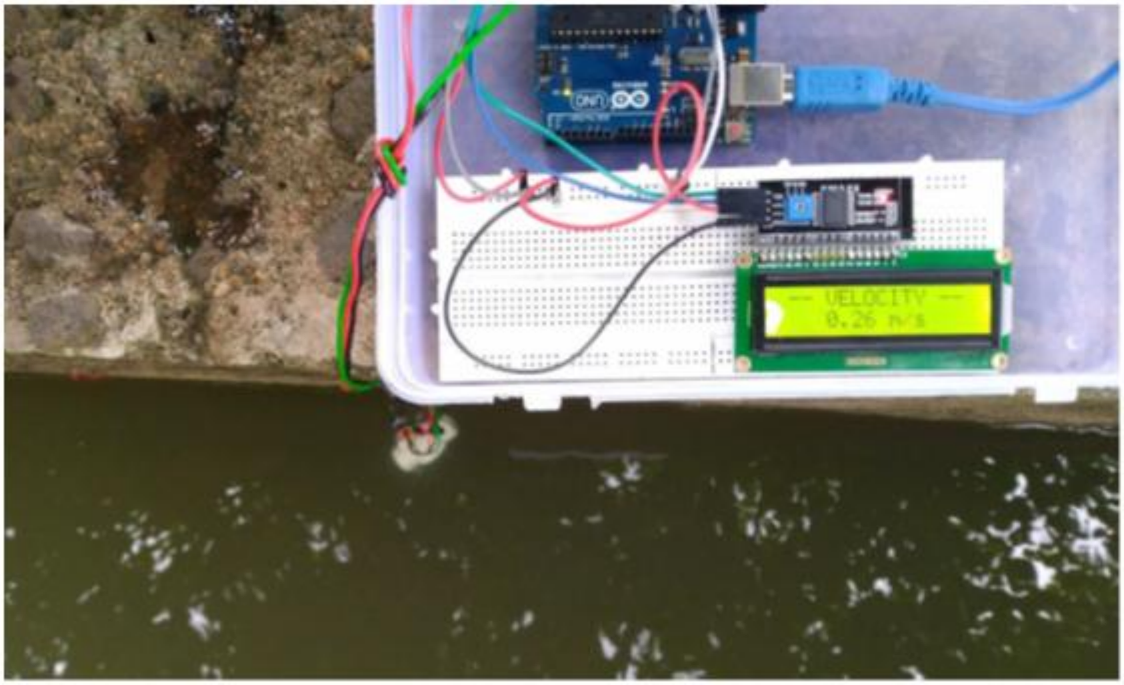



**Fig. 11 Interfacing YF-S403 sensor and LCD I2C display to Arduino Board**

### 3.2 DESIGN OF REAL-TIME WEATHER MONITORING DEVICE

#### 3.2.1 Temperature and Humidity Measuring Device

Interfacing DHT11 Sensor, IR Sensor (Active Type) and Ultrasonic Sensor (HC-SR04) with NodeMCU for Measuring Temperature, Humidity, Wind Speed and Rainfall Depth and obtaining REAL - TIME Data on THINGSPEAK website.

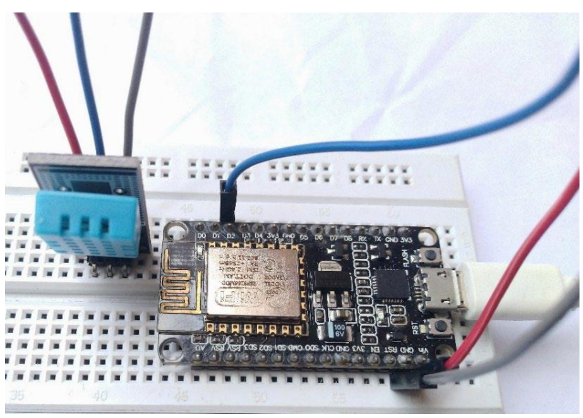
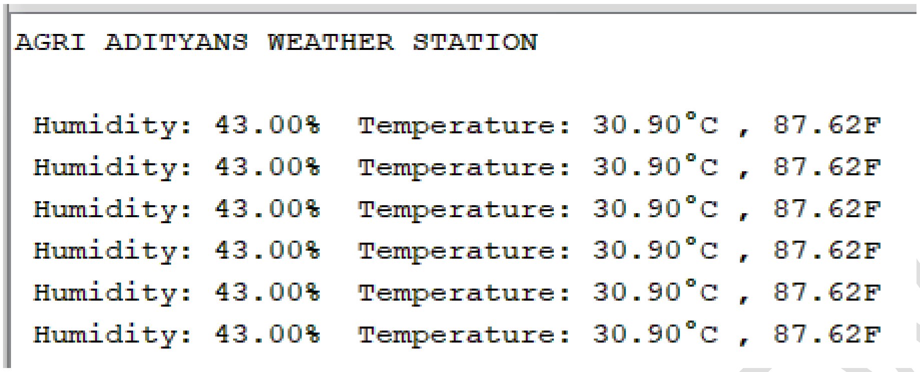


**Fig. 12 Interfacing DHT11 sensor to NodeMCU**



```
AGRI ADITYANS WEATHER STATION

 Humidity: 43.00%  Temperature: 30.90°C , 87.62F
 Humidity: 43.00%  Temperature: 30.90°C , 87.62F
 Humidity: 43.00%  Temperature: 30.90°C , 87.62F
 Humidity: 43.00%  Temperature: 30.90°C , 87.62F
 Humidity: 43.00%  Temperature: 30.90°C , 87.62F
 Humidity: 43.00%  Temperature: 30.90°C , 87.62F
```

**Fig. 13 DHT11 sensor output**

### 3.2.2 Wind Speed Measuring Device

Interfacing IR Sensor with the NodeMCU Board for Measuring wind Speed with Anemometer and Displaying the readings on the Serial Monitor.

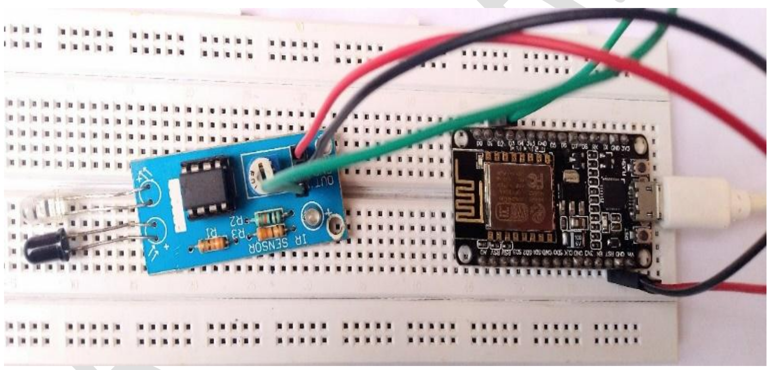
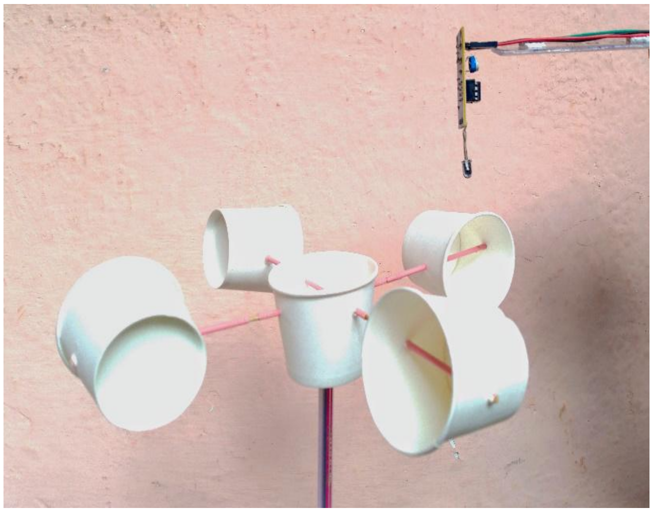



**Fig. 14 Interfacing IR sensor to NodeMCU**

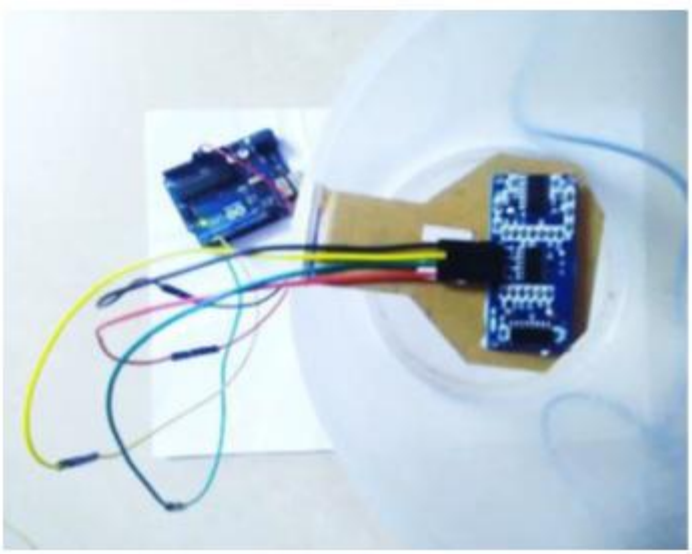


```
0.00 KMPH
0.44 KMPH
0.58 KMPH
0.74 KMPH
0.58 KMPH
0.88 KMPH
0.74 KMPH
0.44 KMPH
0.44 KMPH
0.58 KMPH
0.44 KMPH
0.74 KMPH
0.28 KMPH
0.00 KMPH
```

**Fig. 15 IR sensor positioned with Anemometer** **Fig. 16 IR sensor output**

### 3.2.3 Rainfall Depth Measuring Device

Interfacing Ultrasonic Sensor (HC-SR04) with the NodeMCU Board for Measuring Rainfall Depth and Displaying the values on the Serial Monitor.



```
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
Depth: 0.98cm
```

**Fig. 17 HC-SR04 sensor measuring rainfall depth** **Fig. 18 Ultrasonic sensor output**

### 3.3 Performance Evaluation of Canal Depth and Weather Monitoring Device

The $R^2$ values for different sensor-based parameters when compared with traditional method are presented in following table 6.

**Table 6. $R^2$ values between observed and measured data**

| Parameter | $R^2$ |
|---|---|
| Temperature | 96 |
| Humidity | 92 |
| Wind speed | 89 |
| Rainfall depth | 97 |

The Cost of making Sensor based Canal Depth Measuring Device was approximately Rs.1530 and the cost of making Weather Monitoring Device was approximately Rs.660. In present market, the cost of Weather Station which are available in the India ranges from Min Rs.5000 to Max of 25000.

## 4. CONCLUSION

Technological change, particularly in developing countries, is not only about innovating at the frontier, but also about adapting existing products and processes to achieve higher levels of productivity as applicable to their local contexts. a great opportunity for developing countries to set-up monitoring systems with accessible technology at a low-cost, which could be used in future to address a number of practical issues including, but not limited to, flood-water and urban drainage management, climate change impact assessment, early warning and risk management, as well as now-casting and weather predictions.

The requirement of the release of water into a main canal can be predicted on a scientific basis and this will allow for a more flexible operation of the canal system. The linkage of real-time data collection and monitoring of climate crop-soil relation parameters with the canal automation of the conveyance and distribution system will be achieved. In view of the presented results, the proposed solution can be considered a valuable alternative to conventional weather systems in helping fill the gap in the monitoring system for low-income economy and developing countries. The evaluated parameters showed very promising results, with the existing conventional measurement system.

With this research we have proven that it is possible to implement a fully open weather monitoring solution based on open hardware, open software, open standard and open data, one that is capable of providing high quality data. Further activities will have to test this solution in a real case experiment, in order to evaluate the system's sustainability and durability in real conditions.

## Ethical APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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